Preliminary Report

The R/V Hakuho Maru KH-15-3 Cruise

- ANDROMEDA Expedition -

AISIAN GEOTRACES_III (GP06)

Biogeochemical studies in the East China Sea and Kuroshio area

Tokyo, Oct 14 -- Nagasaki, Nov 2, 2015

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1. Introduction

The Hakuho Maru KH-15-3 cruise, which is also called the “ANDROMEDA Expedition,” was successfully conducted by the Atmosphere and Ocean Research Institute (AORI) of the University of Tokyo, and the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), from 14 October to 2 November 2015 (a total of 18 days) in the East China Sea and adjacent Kuroshio area. The cruise left Tokyo on 14 October and returned to Nagasaki on 2 November.

This project was proposed in the GEOTRACES Pacific Basin Workshop held in Hawaii 2007, and Asian GEOTRACES planning workshop in Taiwan October 2010. It was carried out collaboratively with the Ocean University of China, Xiamen University (China), Taiwan Academia Sinica, the Korea Institute of Ocean Science & Technology, and Singapore-MIT alliance for Science and Technology Center. The name “ANDROMEDA” of this cruise is based on a constellation because our cruise track is similar to the constellating shape.

GEOTRACES is an international study of marine biogeochemical cycles of trace elements and isotopes (TEIs) in the marine environment. It was officially approved by SCOR (Scientific Committees for Ocean Research) in 2006. The primary objectives of GEOTRACES are to determine global oceanic distributions of selected TEIs and to evaluate the cycling of these TEIs, and thereby characterize the physical, chemical, and biological processes regulating their distributions. GEOTRACES expeditions in the world ocean basins began in 2010, and the program will run for at least a decade and involve more than 35 nations.

The East China Sea and Kuroshio area are rich in the changes of bottom character and bathymetry. These areas are considered as one of the best for a regional GEOTRACES project, both in terms of process studies and transect observations. Asian-GEOTRACES is expected to become one of the largest programs to focus on the biogeochemistry of marginal seas. It will improve our understanding of past, present and future distributions of TEIs and their relationships with important global processes of material circulations.

The East China Sea shelf is a marginal sea with a wide area that has been rich in biological productivity, but its coastal marine ecosystems have significantly changed, such as jellyfish and frequent outbreaks of red tide in recent years due to global climate change and rapid growth in urban civilization. One of major reasons for these changes is that the conditions of nutrient transport patterns and river water discharge from surrounding countries to the East China Sea have dramatically changed. The objectives of this cruise are: (1) quantify the distribution of trace elements and isotopes in the East China Sea and their fluxes to the western North Pacific, (2) understand the biogeochemical/physical processes, spatial and temporal variations and cycles of nutrients in the East China Sea, and (3) reveal long-term biogeochemical changes in the East China Sea/Kuroshio area. This project belongs the Asian GEOTRACES program being led by Japan with the collaboration of surrounding countries, and includes interdisciplinary marine biogeochemical/physico, and atmospheric observation. The specific science objectives are

as follows:

1) To understand the spatial distribution of trace elements and their isotopes in the vertical profiles in the East China Sea and Kuroshio water;
2) To examine the distribution of trace metal concentrations and their speciation relating to biological activity and to elucidate their controlling mechanisms in the East China Sea and surrounding seas;
3) To clarify high resolution analysis of the structure of water masses and oceanic circulation using multiple chemical tracers, such as trace elements and their isotopes;
4) To study the dynamics of nutrients and trace metals, and evaluate their relationship between distribution and plankton variation;
5) To examine the plankton community composition and trace elements in the suspended particles, and to reveal the spatial and temporal distributions of nutrients which support primary production in the East China Sea;
6) To estimate primary production using chlorophyll a by satellite and field observation, to clarify the correlation between nutrient variation and primary production;
7) To evaluate boundary mixing and its contribution to the material transport in the marginal sea and slope area through measurements of microstructure;
8) To analyze stable and radioactive trace elements in the sediments to understand the temporal variations in the influence of terrestrial materials to the area around the Kuroshio in the past 6000 years.

We expect to draw a full picture of biogeochemical cycling in the East China Sea and its adjacent Kuroshio water, quantify the material transport fluxes from marginal sea to open ocean, and clarify the interaction between this marginal sea and the mid-latitude western North Pacific.

This cruise requires “clean work” to measure the key parameters of GEOTRACES. The detailed research contents are given in Section 10. Shipboard observations and sampling of water, sediments and plankton etc. were made during the cruise and detailed measurements of major and minor chemical components and their isotopes were partly done on board the ship and will be performed in detail in shore-based laboratories after the cruise.

A total of thirty-four scientists took part in the cruise to pursue international/regional collaborative studies on GEOTRACES, including twenty four Japanese and ten foreign scientists (including graduate students) from fifteen universities/institutions, and three technical supporting staff (two from AORI, one from Marine Work Japan Ltd.). GEOTRACES scientists are from eight Japanese GEOTRACES laboratories, and internationally come from China, Singapore (United States), Taiwan, and also five on-land international scientists from United Kingdom, Germany and China. Two South Korean scientists also joined this cruise for work in the South Korean EEZ.

As a regional ASIAN GEOTRACES study, three intercalibration stations with China and

Taiwan were planned during this cruise. Two clean stations on the GP06 line were successfully conducted by two research vessels in very similar date, R/V Hakuho-maru on 27-28 October and R/V Dongfaonghong2 (Ocean University of China) on 25-26 October. Unfortunately, the cross station G2 with Taiwan was cancelled due to a typhoon.

One of our aims of KH-15-3 cruise is educating the young scientists from Asia. We performed a water-sampling workshop for more than twenty analyses, and two onboard seminars (Science Coffee in Hakuho-maru) by Japanese and Chinese scientists.

We sincerely acknowledge ‘Monkasho’ (the Ministry of Education, Science, Sports and Culture) and the Ministry of Foreign Affairs for their great efforts to obtain the permissions for the studies/observations in the exclusive economic zones of South Korea. This was an immense group effort that deserves recognition. It is our great pleasure to thank Captain Kazuhiko KASUGA and the officers and the crew of the R/V Hakuho Maru for their invaluable and successful support of all shipboard operations. Sincere thanks are also due to the Office for Cruise Coordination of the Atmosphere and Ocean Research Institute, the University of Tokyo, and Research Vessel Operation Department 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 on Innovative Areas No. 15H05821; the Grant-in-Aid for Scientific Research (A) No. 26241009 from MEXT of Japan, and the Environment Research and Technology Development Fund S13, Ministry of the Environment in Japan.

Jing ZHANG (Chief Scientist)
and the Shipboard Scientific Party

2 November, 2015

2. Cruise data policies:

The KH-15-3 cruise is a GEOTRACES process study by the R/V Hakuho-Maru, The cruise data included herein follows the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

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-15-3 cruise.

Confidentiality and publication policies are as follows, mainly according to the data policy provided by the AORI Steering Committee on Cooperative Studies using the research vessels Hakuho Maru and Shinsen Maru (Tansei 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 the Atmosphere and Ocean Research Institute, the University of Tokyo.

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

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 scientist, who is responsible for distributing the correct information to the cruise participants and GEOTRACERS.

2-2. GEOTRACES Data Policy (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 <http://www.bodc.ac.uk/geotraces/cruises/documentation/documents/precruise_metadata.pdf>

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

<http://www.bodc.ac.uk/geotraces/cruises/documentation/documents/csr_form.doc
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 JODC and DAC
- Submit CTD and underway data (both raw and processed files; sensor information and calibration) to national DAC (e.g. JODC) and BODC.

As soon as possible, and no more than 2 years:

- 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.

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.

3.1. List of scientist

No.	Family Name	Given Name	Affilliation		Remark
1	ZHANG	Jing	University of Toyama	◎	Chief Scientist GEOTRACES_Japan (ZHANG)
2	HORIKAWA	Keiji	University of Toyama	○	GEOTRACES_Japan (HORIKAWA)
3	LIU	Qian	University of Toyama	○	Data Person/Cruise Secretary GEOTRACES_Japan (ZHANG)
4	KODAIRA	Tomohiro	University of Toyama	○	GEOTRACES_Japan (HORIKAWA)
5	JIANG	Kai	University of Toyama	○	GEOTRACES_Japan (ZHANG)
6	KAMBAYASHI	Shota	University of Toyama	○	GEOTRACES_Japan (ZHANG)
7	WAKISAKA	Etsuko	University of Toyama	○	GEOTRACES_Japan (HORIKAWA)
8	KAWANISHI	Ryosuke	University of Toyama	○	GEOTRACES_Japan (HORIKAWA)
9	OBATA	Hajime	University of Tokyo	○	Associate Chief Scientist GEOTRACES_Japan (OBATA)
10	TAKEUCHI	Makoto	University of Tokyo	○	Technician
11	TODA	Ryoji	University of Tokyo	○	Technician
12	RONALD	Muhammad	University of Tokyo	○	GEOTRACES_Japan (OBATA)
13	MAURE	Eligio de Raus	Nagoya University	○	Liason PICES/CREAMS (ISHIZAKA)
14	NAGANUMA	Hajime	Nagoya University	○	Liason PICES/CREAMS (ISHIZAKA)
15	ZHENG	Linjie	Kyoto University	○	GEOTRACES_Japan (SOHRIN)
16	TSUJISAKA	Makoto	Kyoto University	○	GEOTRACES_Japan (SOHRIN)
17	OKU	Natsumi	Kinki University	○	GEOTRACES_Japan (NAKAGUCHI)
18	IKEDA	Yoshinori	Kinki University	○	GEOTRACES_Japan (NAKAGUCHI)
19	MATSUNO	Takeshi	Kyushu University	○	Liason OMIX
20	TSUTSUMI	Eisuke	Kyushu University	○	Liason OMIX
21	LEE	Keun Jong	Kyushu University	○	Liason OMIX
22	KONDO	Yoshiko	Nagasaki University	○	GEOTRACES_Japan (KONDO)
23	WAKUTA	Yohei	Nagasaki University	○	GEOTRACES_Japan (TAKEDA)
24	ISHIDA	Akito	Nagasaki University	○	GEOTRACES_Japan (UMEZAWA)
25	NOZAKI	Ryu	Nagasaki University	○	GEOTRACES_Japan (UMEZAWA)
26	YAMAGISHI	Ryunosuke	Nagasaki University	○	GEOTRACES_Japan (TAKEDA)
27	TAKEUCHI	Akinori	Nal. Inst. Environ. Studies	○	
28	MARUMOTO	Kohji	Nal. Inst. Minamata Disease	○	
29	HONG	Chang Su	KIOST	○	Liason OMIX / In charge of Korean EEZ
30	BAEK	Gyu Nam	KIOST	○	Liason OMIX / In charge of Korean EEZ
31	MA	Hongliang	Ocean University of China	○	GEOTRACES_China (ZHAO&DAI)
32	LIAO	Wen-Hsuan	Res. Cen. Environ. Res. Aca. Sini.	○	GEOTRACES_Taiwan (HO)
33	ZHOU	Kuanbo	SMART	○	GEOTRACES_US (BOYLE&ZHOU)
34	HAYASHI	Hiroyuki	Marine Works Japan Ltd.	○	Technician
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3.2. Sharing of the routine shipboard tasks

Routing analysis (*: Leader) 2015.10.14 ~ 11.02

Salinity	H.Obata* W-H.Liao (Daniel)	M.Tsujisaka	L.Zheng	R.Muhammad
DO	K.Horikawa* Y.Ishida	T.Kodaira K.Jiang (Kai)	Y.Wakuta S.Kambayashi	H.Ma K.Marumoto
Nutrients	N.Oku*	Y. Ikeda		
pH	Y.Kondo* R.Kawanishi	E.Wakisaka K.B.Zhou	R.Nozaki A.Takeuchi	R.Yamagishi
Chl-a	E.R.Maure*	H.Naganuma		

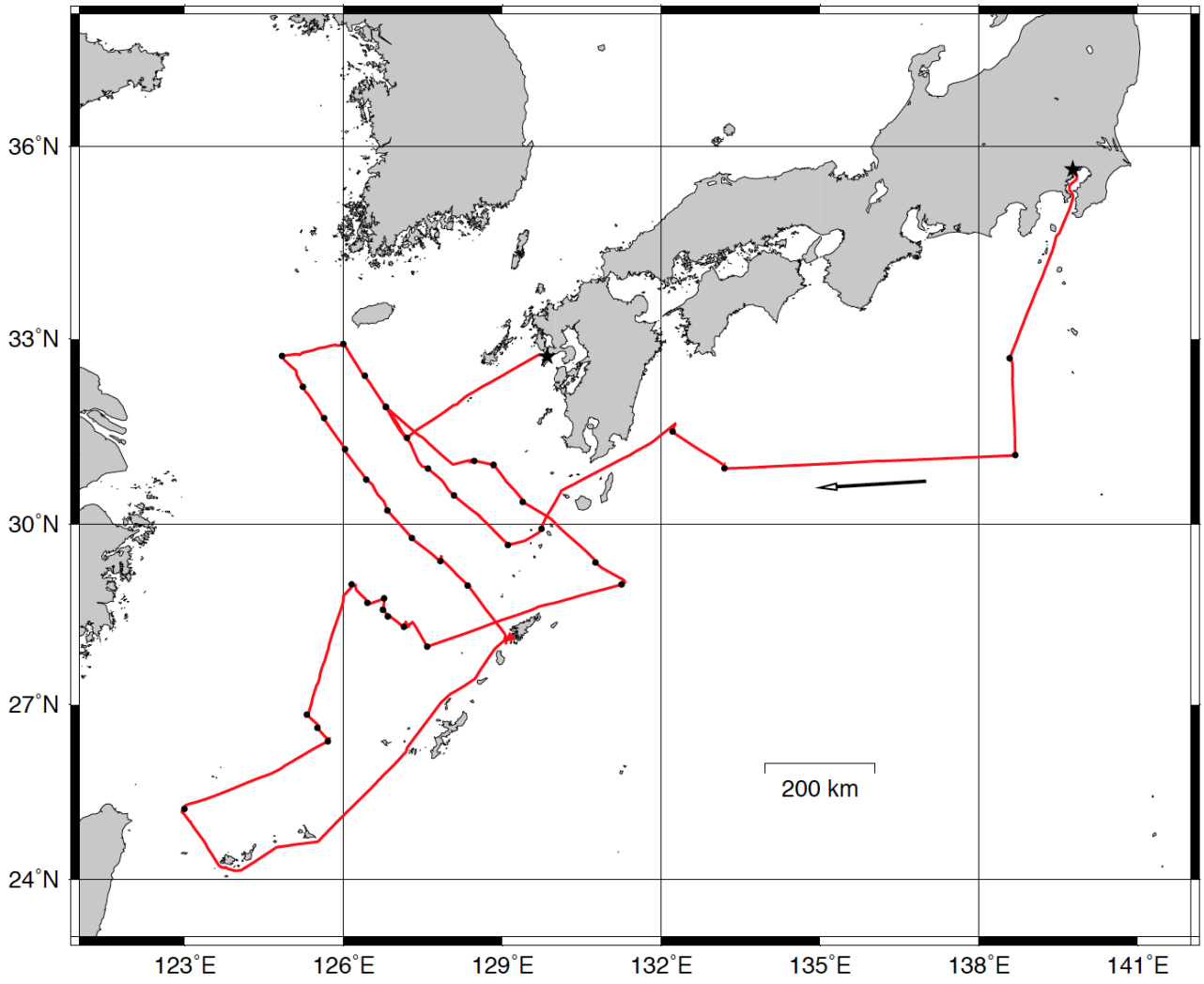
Working Group (*: Leader)

Standard CTD J3, J1, F1, I1, I2	All members			
Clean CTD	H.Obata* Y.Ishida	R.Muhammad L.Zheng	Y.Kondo M.Tsujisaka	Y.Wakuta
CTD Time Watch	3-15		15-3	
Standard CTD	A.Takeuchi*			
A, B, C, E, D line	K.Jiang (Kai)	E-R.Maure	E.Wakisaka	N.Oku
	Y.Ikeda	H.Naganuma	Q.Liu (Cassie)	R.Nozaki
	R.Yamagishi	H.Ma	K.Zhou	W-H.Liao (Daniel)
DO Sampling	H.Ma	K.Jiang (Kai)	N.Oku*	E.Wakisaka
Large Volume	W-H.Liao (Daniel)*	H.Ma	K. Jiang(Kai)	
MC	K.Horikawa*	T.Kodaira	S.Kambayashi	R.Kawanishi
	K.Marumoto	E.Wakisaka		
Turbo Map	T.Matsuno*	E.Tsutsumi	K-J.Lee	C-S.Hong
	G-N.Baek			
Net	H.Obata*	T.Kodaira	S.Kambayashi	K.Marumoto
Underway	Y.Kondo			

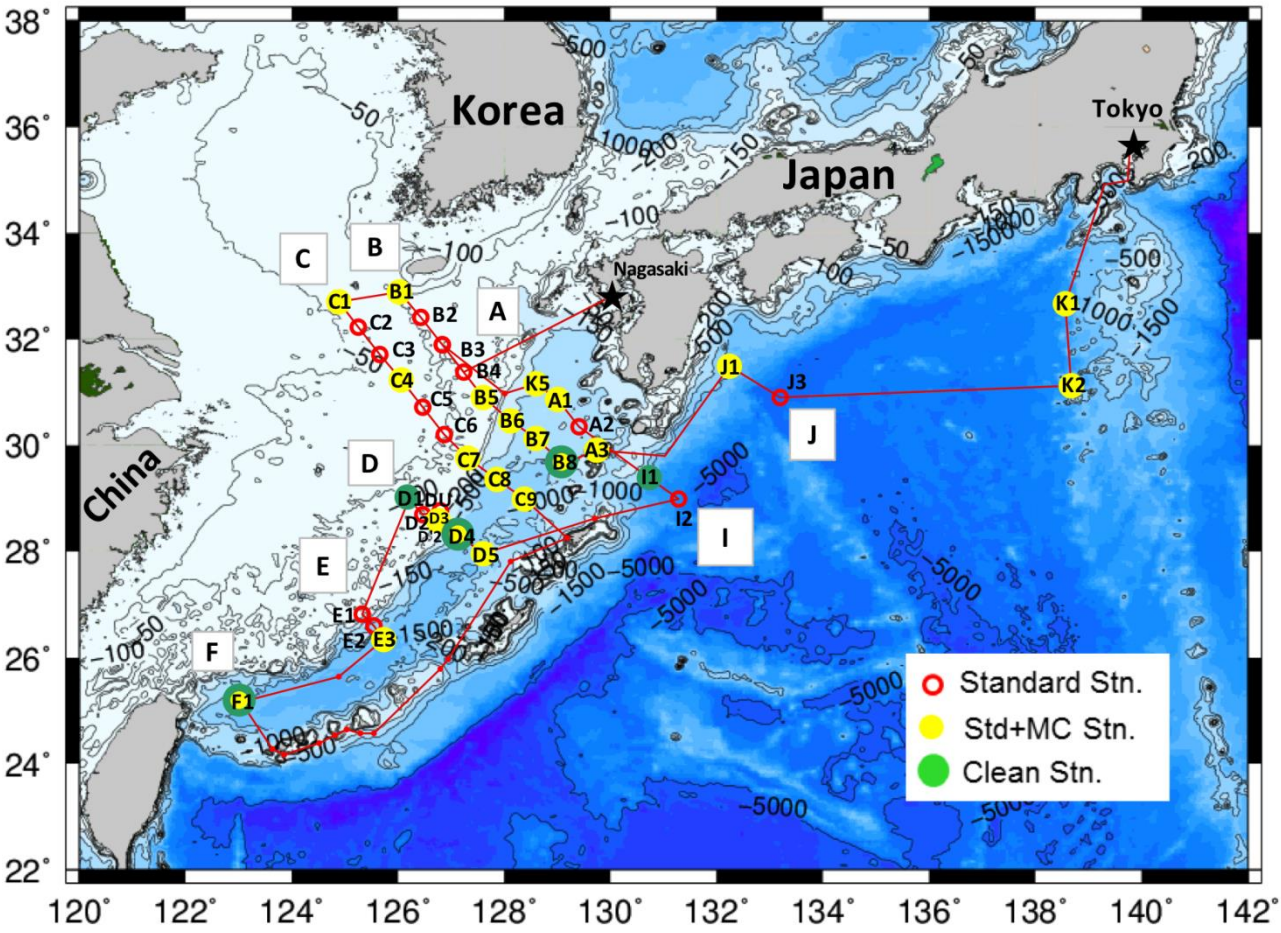
3.3. List of crew

No.	Family Name	Given Name	Ranking	
1	KASUGA	Kazuhiko	Captain	○
2	SAKAI	Naoto	Chief Officer	○
3	KIYOMIYA	Tomonori	First Officer	○
4	ITAHASHI	Kazuhiko	Second Officer	○
5	OZAKI	Nana	J. Second Officer	○
6	SHIBATA	Haruhiro	Third Officer	○
7	ISHII	Yusuke	J. Third Officer	○
8	SUGAWARA	Shinichi	Boatswain	○
9	URABE	Tsuyoshi	Associate Boatswain	○
10	KAWANA	Yukio	Associate Boatswain	○
11	TERASAKA	Yukihiro	Associate Boatswain	○
12	KATO	Naoki	Quarter Master	○
13	HANAZAWA	Jiro	Quarter Master	○
14	UENO	Shinya	Quarter Master	○
15	SOEJIMA	Takanobu	Sailor	○
16	TAKAHASHI	Yoshimitsu	Chief Engineer	○
17	TANAKA	Takashi	First Engineer	○
18	YAMANE	Tsukasa	J. First Engineer	○
19	SAKUMA	Yasuhiro	Second Engineer	○
20	USAMI	Koichi	J. Second Engineer	○
21	MIYAZAKI	Shohei	Third Engineer	○
22	SATO	Masayoshi	No.1 Oiler	○
23	OKAMOTO	Yasuyuki	No.2 Oiler	○
24	ISHII	Yoshihiko	No.3 Oiler	○
25	YAMANAKA	Takahiro	No.4 Oiler	○
26	YOSHIDA	Sakae	No.5 Oiler	○
27	SHIBATA	Kyohei	No.6 Oiler	○
28	SHIMOHATA	Shota	No.7 Oiler	○
29	HATAYA	Masahiro	Machine Man	○
30	MIURA	Takanori	Chief Electronics Officer	○
31	MORI	Hiroyasu	Electronics Operator	○
32	YAMADA	Yasutaka	Chief Steward	○
33	HONDA	Seiji	Associate Steward	○
34	OKAMURA	Shinya	Steward	○
35	SATO	Jun	Steward	○
36	SASAKI	Keigo	Steward	○
				36

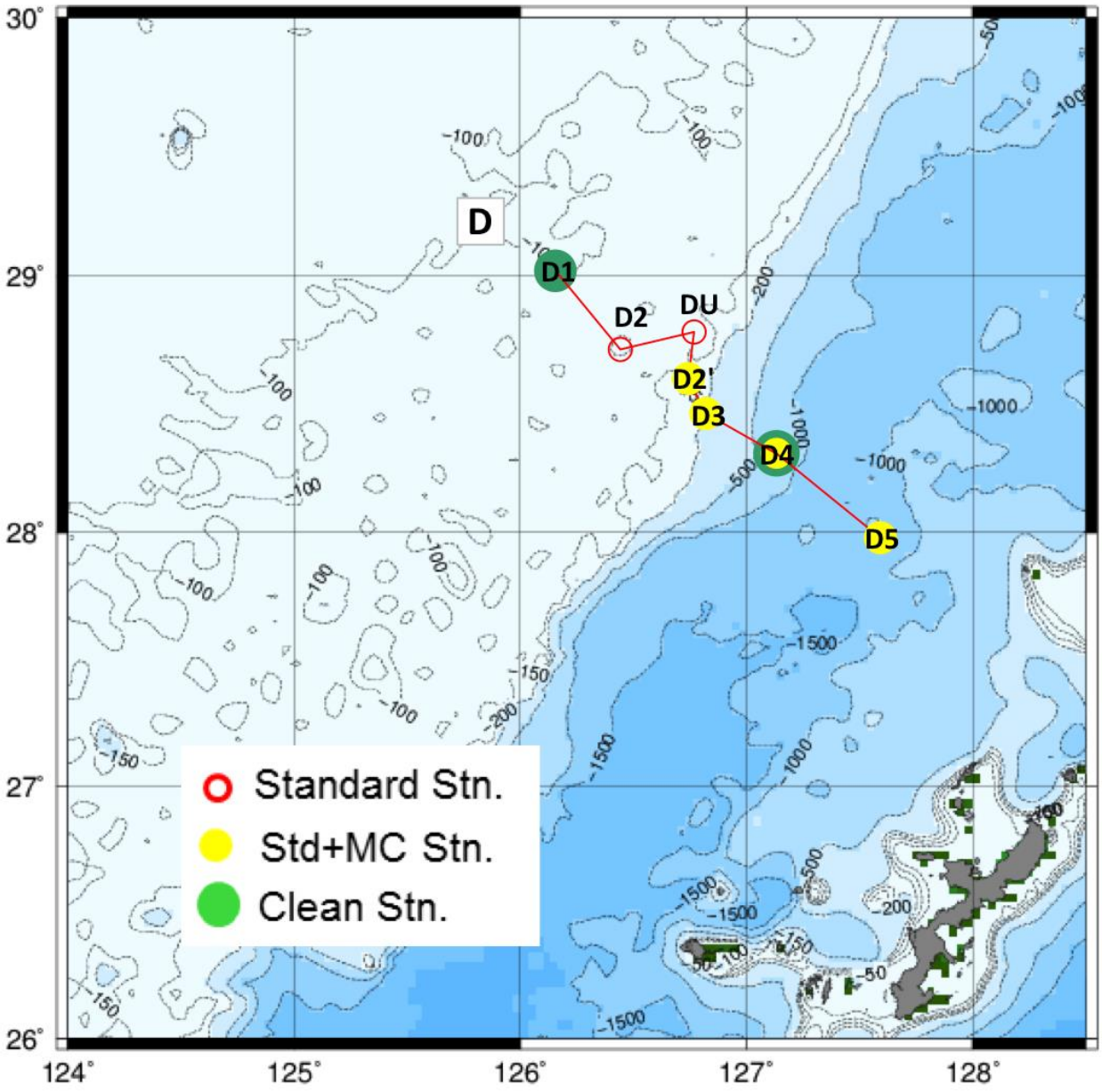
KH15-3 Track 1



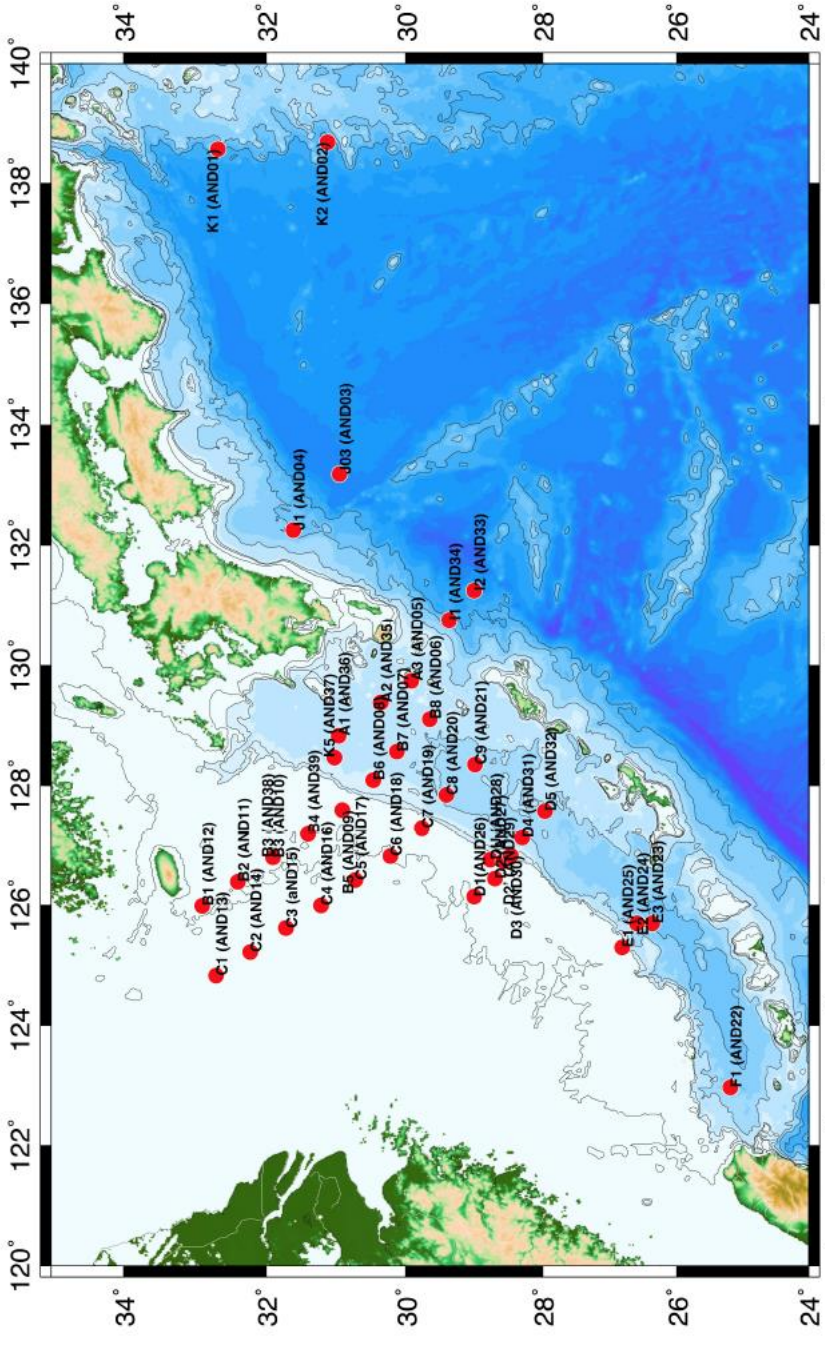
Track 2 with station information-1



Track 2 with station information-2



Bathymetric chart



Station map of the KH-15-3 cruise. The bathymetric contours represent 100, 200, 300, 1000, 2000, and 3000 m and the contour data is sourced from the ETOPO-1.

5. Station list

Stn. name (AND)	Stn.name	Latitude			Longitude			Depth (m)	CTD	CTD Clean	NO_3 Sensor	LIIST	Net	PRR	FRRF	Turbo MAP	MC
AND01	K1	32	41.50	N	138	34.00	E	3034					2				1
AND02	K2	31	7.50	N	138	41.25	E	3296									1
AND03	J3	30	54.42	N	133	11.49	E	4483	2				2			1	
AND04	J1	31	30.00	N	132	12.68	E	2261	2				2			1	1
AND05	A3	29	55.50	N	129	44.00	E	350	1				2			2	1
AND06	B8	29	39.00	N	129	6.00	E	827	2	1			2			1	1
AND07	B7	30	7.50	N	128	34.00	E	930									1
AND08	B6	30	27.98	N	128	5.19	E	407	2		1	1				2	1
AND09	B5	30	54.28	N	127	35.59	E	127	1		1	1	2			2	1
AND10	B3	31	54.28	N	126	47.80	E	105	1		1	1				2	
AND11	B2	32	24.29	N	126	23.89	E	108	1		1	1				2	
AND12	B1	32	54.28	N	126	0.00	E	106	1		1	1	2			2	1
AND13	C1	32	43.43	N	124	49.98	E	67	1		1	1	2		1	2	1
AND14	C2	32	13.43	N	125	13.92	E	59	1		1	1	2		1	2	
AND15	C3	31	43.43	N	125	37.81	E	61	1		1	1	2	1		2	
AND16	C4	31	13.43	N	126	1.71	E	71	1		1	1	2	1	1	2	1
AND17	C5	30	43.43	N	126	25.61	E	82	1		1	1		1		2	
AND18	C6	30	13.43	N	126	49.50	E	95	1		1	1				2	
AND19	C7	29	46.20	N	127	17.47	E	126	1		1	1	2			2	1
AND20	C8	29	23.00	N	127	49.50	E	1038	2		1	1	2			1	1
AND21	C9	28	59.40	N	128	21.00	E	1040	1							1	1
AND22	F1	25	10.00	N	123	0.00	E	1671	2	2			2			4	1
AND23	E3	26	22.00	N	125	42.00	E	1899	2							2	1
AND24	E2	26	35.50	N	125	30.00	E	1271	2							2	
AND25	E1	26	49.00	N	125	18.00	E	191	1							2	
AND26	D1	28	57.00	N	126	4.60	E	105	1	1	1	1	2	1	1	2	
AND27	D2	28	42.00	N	126	26.90	E	127	1		1	1			1	2	
AND28	DU	28	46.07	N	126	46.07	E	147	1							2	
AND29	D2'	28	35.10	N	126	44.77	E	178	1				2			2	1
AND30	D3	28	28.22	N	126	50.02	E	219	1						1	2	1
AND31	D4	28	17.8	N	127	8.3	E	965	2	1			2	1	1	2	1
AND32	D5	27	57.96	N	127	34.6	E	1315	2							2	1
AND33	I2	29	0.12	N	131	14.94	E	3998	3							2	
AND34	I1	29	21.97	N	130	45.25	E	2987	2	1			2			2	
AND35	A2	30	21.67	N	129	22.97	E	576	2							2	
AND36	A1	30	55.8	N	128	49.22	E	690	2				2			2	1
AND37	K5	31	1.75	N	128	27.989	E	318									1
AND38	B3	31	54.13	N	126	48.1	E	105	1			1				2	
AND39	B4	31	24.19	N	127	11.68	E	107	1			1				2	

6. Event log

Date (yymmdd)	TIME(GMT) hhmm	Latitude	Longitude	Depth(m)	Station	Ship Log
151014	340	35 39.095N	139 46.034E	0		
151014	431	35 39.095N	139 46.034E	0		S/B ENGINE
151014	437	35 39.095N	139 46.034E	0		CHANGED ENGINE TO S/M
151014	502	35 39.097N	139 46.032E	0		LET GO ALL SHORE LINES
151014	505	35 39.091N	139 46.016E	0		UP & DOWN ANCHOR
151014	512	35 38.689N	139 45.867E	0		CHANGED ENGINE TO T/M
151014	536	35 35.565N	139 46.948E	0		ENTERED TOKYO WEST PASSAGE
151014	556	35 32.970N	139 50.466E	0		CLEARED OUT TOKYO WEST PASSAGE
151014	707	35 19.757N	139 42.662E	0		ENTERED URAGA SUIDO TRAFFIC ROUTE
151014	746	35 12.689N	139 46.250E	0		CLEARED OUT URAGA SUIDO TRAFFIC ROUTE
151014	802	35 08.962N	139 45.078E	0		R/UP ENGINE
151014	807	35 07.588N	139 44.640E	0		S/CO ON 202°
151014	809	35 07.320N	139 44.579E	0		SUNSET & PUT ON REGULATION LIGHTS
151014	1835	32 42.546N	138 35.344E	3021	K1	S/B ENGINE
151014	1852	32 41.065N	138 34.730E	3055	K1	CHANGED ENGINE TO E/M
151014	1858	32 41.053N	138 35.056E	3051	K1	NORPAC NET STARTED
151014	1910	32 41.012N	138 35.711E	3029	K1	NORPAC NET FINISHED
151014	1913	32 40.967N	138 35.914E	3024	K1	NORPAC NET STARTED
151014	1924	32 41.000N	138 36.553E	2991	K1	NORPAC NET FINISHED
151014	2023	32 41.023N	138 33.698E	3107	K1	MULTIPLE CORER STARTED
151014	2049	32 41.009N	138 34.502E	977	K1	SUNRISE & PUT OFF REGULATION LIGHTS
151014	2132	32 40.982N	138 34.487E	1344	K1	MULTIPLE CORER HIT BOTTOM
151014	2135	32 40.979N	138 34.484E	1339	K1	MULTIPLE CORER LEFT BOTTOM
151014	2234	32 41.079N	138 35.301E	3046	K1	MULTIPLE CORER FINISHED
151014	2245	32 40.883N	138 36.021E	3019		CHANGED ENGINE TO T/M
151014	2254	32 40.161N	138 36.506E	2956		S/CO ON 177°
151014	2310	32 36.954N	138 37.429E	2699		R/UP ENGINE
151015	500	31 08.927N	138 41.126E	3241	K2	S/B ENGINE
151015	513	31 07.575N	138 41.273E	3268	K2	STOPPED ENGINE
151015	525	31 07.593N	138 41.216E	3267	K2	CHANGED ENGINE TO S/M
151015	536	31 07.493N	138 41.218E	3270	K2	MULTIPLE CORER STARTED
151015	649	31 07.432N	138 41.252E	3279	K2	MULTIPLE CORER HIT BOTTOM
151015	652	31 07.435N	138 41.253E	3275	K2	MULTIPLE CORER LEFT BOTTOM
151015	754	31 07.291N	138 41.049E	3286	K2	MULTIPLE CORER FINISHED
151015	805	31 07.401N	138 40.846E	3279		CHANGED ENGINE TO T/M
151015	806	31 07.412N	138 40.847E	3283		S/CO ON 267°
151015	815	31 07.289N	138 39.771E	3296		SUNSET & PUT ON REGULATION LIGHTS
151015	831	31 07.012N	138 35.203E	3375		R/UP ENGINE
151015	2100	30 58.788N	135 04.634E	4405		SUNRISE & PUT OFF REGULATION LIGHTS
151016	323	30 54.446N	133 13.116E	4552	J03	S/B ENGINE
151016	332	30 54.447N	133 11.676E	4514	J03	STOPPED ENGINE
151016	336	30 54.440N	133 11.604E	4503	J03	CHANGED ENGINE TO E/M
151016	351	30 54.560N	133 11.519E	4508	J03	CTD-CMS STARTED
151016	520	30 55.273N	133 11.528E	4552	J03	CTD-CMS DEEPEST
151016	700	30 56.015N	133 11.720E	4592	J03	CTD-CMS FINISHED
151016	715	30 56.133N	133 11.743E	4589	J03	NORPAC NET STARTED
151016	724	30 56.250N	133 11.717E	4582	J03	NORPAC NET FINISHED
151016	728	30 56.291N	133 11.704E	4579	J03	NORPAC NET STARTED
151016	741	30 56.484N	133 11.722E	4572	J03	NORPAC NET FINISHED
151016	747	30 56.558N	133 11.722E	4565	J03	NORPAC NET STARTED
151016	806	30 56.863N	133 11.676E	4544	J03	NORPAC NET FINISHED
151016	832	30 57.019N	133 11.485E	4532	J03	TURBO MAP STARTED
151016	837	30 57.021N	133 11.416E	4531	J03	SUNSET & PUT ON REGULATION LIGHTS
151016	847	30 57.064N	133 11.230E	4531	J03	TURBO MAP DEEPEST
151016	904	30 57.185N	133 10.948E	4529	J03	TURBO MAP FINISHED
151016	920	30 57.308N	133 10.866E	4536	J03	CTD-CMS STARTED
151016	933	30 57.508N	133 10.927E	4550	J03	CTD-CMS DEEPEST
151016	949	30 57.696N	133 11.031E	4562	J03	CTD-CMS FINISHED
151016	1004	30 57.681N	133 10.929E	4566		CHANGED ENGINE TO T/M

Date (yymmdd)	TIME(GMT) hhmm	Latitude	Longitude	Depth(m)	Station	Ship Log
151016	1009	30 57.790N	133 10.723E	4578		S/CO ON 305°
151016	1030	31 00.181N	133 06.557E	4705		R/UP ENGINE
151016	1403	31 29.264N	132 13.989E	2309	J1	S/B ENGINE
151016	1420	31 30.169N	132 12.659E	2278	J1	STOPPED ENGINE
151016	1421	31 30.173N	132 12.660E	2275	J1	CHANGED ENGINE TO E/M
151016	1428	31 30.366N	132 12.719E	2261	J1	CTD-CMS STARTED
151016	1530	31 31.229N	132 13.139E	2280	J1	CTD-CMS DEEPEST
151016	1634	31 32.165N	132 13.402E	2142	J1	CTD-CMS FINISHED
151016	1653	31 32.734N	132 13.570E	1924	J1	NORPAC NET STARTED
151016	1700	31 32.955N	132 13.636E	1919	J1	NORPAC NET FINISHED
151016	1705	31 33.122N	132 13.677E	1945	J1	NORPAC NET STARTED
151016	1721	31 33.632N	132 13.893E	1949	J1	NORPAC NET FINISHED
151016	1733	31 33.948N	132 13.978E	1948	J1	TURBO MAP STARTED
151016	1748	31 34.383N	132 14.032E	1920	J1	TURBO MAP DEEPEST
151016	1801	31 34.703N	132 14.066E	1894	J1	TURBO MAP FINISHED
151016	1823	31 35.432N	132 14.354E	1768	J1	CTD-CMS STARTED
151016	1834	31 35.770N	132 14.477E	1818	J1	CTD-CMS DEEPEST
151016	1851	31 36.270N	132 14.687E	1918	J1	CTD-CMS FINISHED
151016	1909	31 36.676N	132 14.948E	1926	J1	MULTIPLE CORER STARTED
151016	1958	31 36.976N	132 15.365E	1364	J1	MULTIPLE CORER HIT BOTTOM
151016	2000	31 36.977N	132 15.365E	1352	J1	MULTIPLE CORER LEFT BOTTOM
151016	2041	31 37.461N	132 15.709E	1952	J1	MULTIPLE CORER FINISHED
151016	2115	31 38.088N	132 16.083E	1967	J1	SUNRISE & PUT OFF REGULATION LIGHTS
151016	2129	31 38.298N	132 16.475E	1965		CHANGED ENGINE TO T/M
151016	2130	31 38.303N	132 16.484E	1964		S/CO ON 242
151016	2200	31 35.238N	132 11.845E	1973		R/UP ENGINE
151017	658	30 33.022N	130 07.116E	547		A/CO TO 210°
151017	848	30 09.985N	129 51.825E	604		SUNSET & PUT ON REGULATION LIGHTS
151017	913	30 04.722N	129 48.103E	507		A/CO TO 202°
151017	948	29 56.539N	129 44.470E	254		S/B ENGINE
151017	1000	29 55.416N	129 44.228E	351		STOPPED ENGINE
151017	1016	29 55.253N	129 44.282E	353		CHANGED ENGINE TO E/M
151017	1024	29 55.209N	129 44.345E	349	A3	CTD-CMS STARTED
151017	1043	29 55.158N	129 44.520E	347	A3	CTD-CMS DEEPEST
151017	1108	29 54.998N	129 44.770E	329	A3	CTD-CMS FINISHED
151017	1124	29 55.197N	129 44.495E	350	A3	NORPAC NET STARTED
151017	1140	29 55.171N	129 44.685E	342	A3	NORPAC NET FINISHED
151017	1141	29 55.168N	129 44.694E	341	A3	NORPAC NET STARTED
151017	1155	29 55.107N	129 44.906E	371	A3	NORPAC NET FINISHED
151017	1208	29 55.199N	129 44.891E	374	A3	TURBO MAP STARTED
151017	1229	29 55.116N	129 45.051E	354	A3	TURBO MAP FINISHED
151017	1230	29 55.111N	129 45.059E	353	A3	TURBO MAP STARTED
151017	1239	29 55.082N	129 45.093E	357	A3	TURBO MAP DEEPEST
151017	1248	29 55.058N	129 45.186E	362	A3	TURBO MAP FINISHED
151017	1309	29 55.300N	129 44.571E	353	A3	MULTIPLE CORER STARTED
151017	1334	29 55.150N	129 44.671E	352	A3	MULTIPLE CORER HIT BOTTOM
151017	1336	29 55.144N	129 44.673E	349	A3	MULTIPLE CORER LEFT BOTTOM
151017	1347	29 55.078N	129 44.719E	331	A3	MULTIPLE CORER FINISHED
151017	1357	29 55.034N	129 44.783E	342	A3	CHANGED ENGINE TO T/M
151017	1411	29 53.932N	129 43.649E	425	A3	S/CO ON 217°
151017	1417	29 52.975N	129 42.521E	541	A3	R/UP ENGINE
151017	1429	29 50.936N	129 40.059E	625	A3	A/CO TO 240°
151017	1527	29 43.997N	129 26.530E	376		A/CO TO 254°
151017	1644	29 39.315N	129 07.252E	830		S/B ENGINE
151017	1654	29 38.996N	129 05.940E	828	B8	STOPPED ENGINE
151017	1658	29 39.017N	129 05.926E	827	B8	CHANGED ENGINE TO E/M
151017	1707	29 39.079N	129 06.084E	827	B8	CTD-CMS STARTED
151017	1736	29 39.264N	129 06.643E	829	B8	CTD-CMS DEEPEST
151017	1813	29 39.511N	129 07.357E	830	B8	CTD-CMS FINISHED

Date (yymmdd)	TIME(GMT) hhmm	Latitude	Longitude	Depth(m)	Station	Ship Log
151017	1900	29 39.041N	129 06.126E	830	B8	CTD-CMS STARTED
151017	1932	29 39.294N	129 06.944E	830	B8	CTD-CMS DEEPEST
151017	2011	29 39.474N	129 07.799E	833	B8	CTD-CMS FINISHED
151017	2021	29 39.540N	129 08.063E	833	B8	NORPAC NET STARTED
151017	2032	29 39.633N	129 08.332E	834	B8	NORPAC NET FINISHED
151017	2032	29 39.634N	129 08.333E	835	B8	NORPAC NET STARTED
151017	2047	29 39.751N	129 08.693E	837	B8	NORPAC NET FINISHED
151017	2058	29 39.841N	129 08.933E	837	B8	TURBO MAP STARTED
151017	2114	29 39.828N	129 09.098E	838	B8	TURBO MAP DEEPEST
151017	2125	29 39.769N	129 09.245E	840	B8	SUNRISE & PUT OFF REGULATION LIGHTS
151017	2128	29 39.759N	129 09.284E	841	B8	TURBO MAP FINISHED
151017	2151	29 39.732N	129 08.370E	836	B8	CTD-CMS STARTED
151017	2205	29 39.827N	129 08.641E	836	B8	CTD-CMS DEEPEST
151017	2218	29 39.941N	129 08.924E	838	B8	CTD-CMS FINISHED
151017	2305	29 38.848N	129 05.626E	830	B8	MULTIPLE CORER STARTED
151017	2336	29 39.094N	129 06.140E	831	B8	MULTIPLE CORER HIT BOTTOM
151017	2338	29 39.101N	129 06.151E	830	B8	MULTIPLE CORER LEFT BOTTOM
151017	2358	29 39.306N	129 06.455E	827	B8	MULTIPLE CORER FINISHED
151018	11	29 39.358N	129 06.527E	827	B8	CHANGED ENGINE TO T/M
151018	14	29 39.526N	129 06.412E	825	B8	S/CO ON 316°
151018	24	29 40.841N	129 05.021E	797	B8	R/UP ENGINE
151018	259	30 06.477N	128 35.130E	905	B7	S/B ENGINE
151018	312	30 07.464N	128 34.064E	928	B7	STOPPED ENGINE
151018	317	30 07.483N	128 34.054E	928	B7	CHANGED ENGINE TO E/M
151018	321	30 07.495N	128 34.077E	929	B7	MULTIPLE CORER STARTED
151018	359	30 07.611N	128 34.093E	930	B7	MULTIPLE CORER HIT BOTTOM
151018	401	30 07.609N	128 34.093E	930	B7	MULTIPLE CORER LEFT BOTTOM
151018	425	30 07.853N	128 34.369E	934	B7	MULTIPLE CORER FINISHED
151018	440	30 07.900N	128 34.234E	932	B7	CHANGED ENGINE TO T/M
151018	658	30 27.961N	128 05.153E	406	B6	STOPPED ENGINE
151018	659	30 27.989N	128 05.114E	406	B6	CHANGED ENGINE TO E/M
151018	703	30 28.025N	128 05.063E	407	B6	CTD-CMS STARTED
151018	724	30 28.196N	128 04.926E	411	B6	CTD-CMS DEEPEST
151018	753	30 28.390N	128 04.742E	416	B6	CTD-CMS FINISHED
151018	801	30 28.464N	128 04.676E	417	B6	TURBO MAP STARTED
151018	827	30 28.499N	128 04.274E	421	B6	TURBO MAP FINISHED
151018	828	30 28.501N	128 04.260E	423	B6	TURBO MAP STARTED
151018	840	30 28.504N	128 04.082E	424	B6	TURBO MAP DEEPEST
151018	852	30 28.481N	128 03.944E	426	B6	TURBO MAP FINISHED
151018	855	30 28.476N	128 03.912E	425	B6	SUNSET & PUT ON REGULATION LIGHTS
151018	904	30 28.469N	128 03.864E	426	B6	CTD-CMS STARTED
151018	943	30 28.633N	128 03.945E	427	B6	CTD-CMS DEEPEST
151018	952	30 28.628N	128 03.940E	427	B6	CTD-CMS FINISHED
151018	1013	30 27.963N	128 05.306E	407	B6	MULTIPLE CORER STARTED
151018	1040	30 27.978N	128 05.152E	406	B6	MULTIPLE CORER HIT BOTTOM
151018	1041	30 27.980N	128 05.150E	406	B6	MULTIPLE CORER LEFT BOTTOM
151018	1053	30 28.035N	128 05.118E	407	B6	MULTIPLE CORER FINISHED
151018	1103	30 27.976N	128 05.062E	407		CHANGED ENGINE TO T/M
151018	1128	30 30.619N	128 01.881E	437		S/CO ON 316°
151018	1130	30 30.873N	128 01.582E	435		R/UP ENGINE
151018	1332	30 53.248N	127 37.048E	125	B5	S/B ENGINE
151018	1344	30 54.216N	127 35.568E	126	B5	STOPPED ENGINE
151018	1348	30 54.298N	127 35.528E	125	B5	CHANGED ENGINE TO E/M
151018	1350	30 54.317N	127 35.519E	126	B5	CTD-CMS STARTED
151018	1408	30 54.511N	127 35.446E	125	B5	CTD-CMS DEEPEST
151018	1422	30 54.681N	127 35.415E	126	B5	CTD-CMS FINISHED
151018	1435	30 54.530N	127 35.576E	125	B5	NORPAC NET STARTED
151018	1450	30 54.728N	127 35.617E	125	B5	NORPAC NET FINISHED
151018	1452	30 54.762N	127 35.624E	126	B5	NORPAC NET STARTED

Date (yymmdd)	TIME(GMT) hhmm	Latitude	Longitude	Depth(m)	Station	Ship Log
151018	1504	30 54.920N	127 35.637E	125	B5	NORPAC NET FINISHED
151018	1513	30 54.963N	127 35.609E	126	B5	TURBO MAP STARTED
151018	1519	30 54.988N	127 35.591E	126	B5	TURBO MAP DEEPEST
151018	1521	30 54.996N	127 35.585E	126	B5	TURBO MAP FINISHED
151018	1522	30 54.997N	127 35.584E	125	B5	TURBO MAP STARTED
151018	1526	30 55.012N	127 35.573E	126	B5	TURBO MAP DEEPEST
151018	1532	30 55.037N	127 35.562E	126	B5	TURBO MAP FINISHED
151018	1542	30 55.045N	127 35.571E	126	B5	MULTIPLE CORER STARTED
151018	1550	30 55.034N	127 35.565E	126	B5	MULTIPLE CORER HIT BOTTOM
151018	1552	30 55.035N	127 35.563E	126	B5	MULTIPLE CORER LEFT BOTTOM
151018	1557	30 55.043N	127 35.553E	126	B5	MULTIPLE CORER FINISHED
151018	1613	30 55.093N	127 35.534E	125	B5	CHANGED ENGINE TO T/M
151018	1700	30 59.500N	127 26.115E	120		R/UP ENGINE
151018	1831	31 20.512N	127 14.320E	106		S/CO ON 326°
151018	2112	31 53.316N	126 48.380E	105		S/B ENGINE
151018	2121	31 54.356N	126 47.742E	106		STOPPED ENGINE
151018	2123	31 54.356N	126 47.739E	106		CHANGED ENGINE TO E/M
151018	2131	31 54.344N	126 47.746E	106	B3	CTD-CMS STARTED
151018	2135	31 54.340N	126 47.758E	106	B3	SUNRISE & PUT OFF REGULATION LIGHTS
151018	2152	31 54.319N	126 47.837E	105	B3	CTD-CMS DEEPEST
151018	2208	31 54.206N	126 47.869E	105	B3	CTD-CMS FINISHED
151018	2215	31 54.197N	126 47.880E	106	B3	TURBO MAP STARTED
151018	2220	31 54.155N	126 47.845E	105	B3	TURBO MAP DEEPEST
151018	2222	31 54.135N	126 47.827E	106	B3	TURBO MAP FINISHED
151018	2223	31 54.130N	126 47.822E	105	B3	TURBO MAP STARTED
151018	2226	31 54.108N	126 47.802E	105	B3	TURBO MAP DEEPEST
151018	2229	31 54.087N	126 47.786E	105	B3	TURBO MAP FINISHED
151018	2241	31 53.950N	126 47.707E	105	B3	CHANGED ENGINE TO T/M
151018	2245	31 54.029N	126 47.583E	105	B3	S/CO ON 326°
151018	2300	31 56.009N	126 46.133E	106	B3	R/UP ENGINE
151018	2315	31 59.142N	126 43.711E	106		ENTERED KOREAN EEZ
151019	114	32 23.052N	126 24.701E	105	B2	S/B ENGINE
151019	124	32 24.226N	126 23.926E	108	B2	STOPPED ENGINE
151019	130	32 24.306N	126 23.907E	108	B2	CHANGED ENGINE TO E/M
151019	131	32 24.310N	126 23.886E	108	B2	CTD-CMS STARTED
151019	148	32 24.305N	126 23.643E	108	B2	CTD-CMS DEEPEST
151019	203	32 24.304N	126 23.449E	107	B2	CTD-CMS FINISHED
151019	217	32 24.350N	126 23.099E	108	B2	TURBO MAP STARTED
151019	221	32 24.352N	126 22.982E	108	B2	TURBO MAP FINISHED
151019	222	32 24.352N	126 22.963E	108	B2	TURBO MAP STARTED
151019	225	32 24.353N	126 22.873E	108	B2	TURBO MAP DEEPEST
151019	231	32 24.349N	126 22.696E	108	B2	TURBO MAP FINISHED
151019	240	32 24.325N	126 22.451E	107	B2	CHANGED ENGINE TO T/M
151019	246	32 24.608N	126 22.118E	106	B2	S/CO ON 326°
151019	300	32 27.187N	126 20.277E	107		R/UP ENGINE
151019	415	32 44.243N	126 07.669E	104		ENTERED CONTIGUOUS ZONE OF KOREA
151019	450	32 52.689N	126 01.582E	113		S/B ENGINE
151019	505	32 54.352N	126 00.025E	108		STOPPED ENGINE
151019	510	32 54.385N	125 59.960E	108		CHANGED ENGINE TO E/M
151019	518	32 54.461N	125 59.857E	108	B1	CTD-CMS STARTED
151019	533	32 54.792N	125 59.701E	107	B1	CTD-CMS DEEPEST
151019	546	32 55.054N	125 59.491E	107	B1	CTD-CMS FINISHED
151019	554	32 55.201N	125 59.452E	108	B1	NORPAC NET STARTED
151019	607	32 55.545N	125 59.323E	110	B1	NORPAC NET FINISHED
151019	608	32 55.563N	125 59.312E	111	B1	NORPAC NET STARTED
151019	617	32 55.785N	125 59.199E	112	B1	NORPAC NET FINISHED
151019	624	32 55.945N	125 59.093E	112	B1	TURBO MAP STARTED
151019	629	32 56.035N	125 59.006E	109	B1	TURBO MAP DEEPEST
151019	632	32 56.097N	125 58.940E	111	B1	TURBO MAP FINISHED

Date (yymmdd)	TIME(GMT) hhmm	Latitude	Longitude	Depth(m)	Station	Ship Log
151019	634	32 56.122N	125 58.909E	111	B1	TURBO MAP STARTED
151019	636	32 56.156N	125 58.864E	111	B1	TURBO MAP DEEPEST
151019	640	32 56.206N	125 58.794E	110	B1	TURBO MAP FINISHED
151019	718	32 54.344N	125 59.978E	108	B1	MULTIPLE CORER STARTED
151019	729	32 54.317N	125 59.953E	108	B1	MULTIPLE CORER HIT BOTTOM
151019	731	32 54.320N	125 59.949E	108	B1	MULTIPLE CORER LEFT BOTTOM
151019	737	32 54.347N	125 59.929E	108	B1	MULTIPLE CORER FINISHED
151019	746	32 54.424N	125 59.790E	108	B1	CHANGED ENGINE TO T/M
151019	759	32 53.799N	125 58.889E	112	B1	S/CO ON 260°
151019	823	32 53.373N	125 52.329E	101		R/UP ENGINE
151019	900	32 52.255N	125 41.801E	98		SUNSET & PUT ON REGULATION LIGHTS
151019	1204	32 43.394N	124 51.480E	69		S/B ENGINE
151019	1215	32 43.249N	124 49.989E	68		STOPPED ENGINE
151019	1222	32 43.282N	124 50.061E	68	C1	CTD-CMS STARTED
151019	1234	32 43.215N	124 50.136E	68	C1	CTD-CMS DEEPEST
151019	1245	32 43.160N	124 50.181E	68	C1	CTD-CMS FINISHED
151019	1253	32 43.137N	124 50.204E	68	C1	NORPAC NET STARTED
151019	1310	32 43.077N	124 50.261E	68	C1	NORPAC NET FINISHED
151019	1312	32 43.063N	124 50.269E	68	C1	NORPAC NET STARTED
151019	1321	32 43.001N	124 50.311E	68	C1	NORPAC NET FINISHED
151019	1325	32 42.969N	124 50.330E	68	C1	FRRF STARTED
151019	1332	32 42.918N	124 50.354E	68	C1	FRRF DEEPEST
151019	1345	32 42.816N	124 50.381E	68	C1	FRRF FINISHED
151019	1353	32 42.757N	124 50.389E	68	C1	TURBO MAP STARTED
151019	1358	32 42.730N	124 50.352E	67	C1	TURBO MAP DEEPEST
151019	1401	32 42.708N	124 50.324E	67	C1	TURBO MAP FINISHED
151019	1401	32 42.707N	124 50.322E	67	C1	TURBO MAP STARTED
151019	1403	32 42.689N	124 50.302E	67	C1	TURBO MAP DEEPEST
151019	1408	32 42.648N	124 50.262E	67	C1	TURBO MAP FINISHED
151019	1419	32 42.569N	124 50.192E	67	C1	MULTIPLE CORER STARTED
151019	1426	32 42.564N	124 50.153E	67	C1	MULTIPLE CORER HIT BOTTOM
151019	1427	32 42.566N	124 50.150E	67	C1	MULTIPLE CORER LEFT BOTTOM
151019	1430	32 42.571N	124 50.131E	67	C1	MULTIPLE CORER FINISHED
151019	1439	32 42.568N	124 50.054E	67	C1	CHANGED ENGINE TO T/M
151019	1452	32 41.701N	124 50.853E	67		S/CO ON 146°
151019	1500	32 40.225N	124 51.993E	67		R/UP ENGINE
151019	1710	32 14.974N	125 12.958E	59		S/B ENGINE
151019	1723	32 13.531N	125 13.851E	59	C2	STOPPED ENGINE
151019	1726	32 13.496N	125 13.854E	59	C2	CHANGED ENGINE TO E/M
151019	1735	32 13.508N	125 13.777E	59	C2	CTD-CMS STARTED
151019	1747	32 13.601N	125 13.652E	59	C2	CTD-CMS DEEPEST
151019	1757	32 13.704N	125 13.531E	59	C2	CTD-CMS FINISHED
151019	1804	32 13.799N	125 13.485E	59	C2	NORPAC NET STARTED
151019	1815	32 13.970N	125 13.447E	59	C2	NORPAC NET FINISHED
151019	1820	32 14.042N	125 13.410E	59	C2	NORPAC NET STARTED
151019	1828	32 14.126N	125 13.349E	59	C2	NORPAC NET FINISHED
151019	1835	32 14.169N	125 13.295E	59	C2	FRRF STARTED
151019	1842	32 14.220N	125 13.231E	59	C2	FRRF DEEPEST
151019	1851	32 14.304N	125 13.172E	57	C2	FRRF FINISHED
151019	1856	32 14.334N	125 13.109E	59	C2	TURBO MAP STARTED
151019	1900	32 14.355N	125 13.059E	59	C2	TURBO MAP DEEPEST
151019	1902	32 14.363N	125 13.042E	59	C2	TURBO MAP FINISHED
151019	1903	32 14.372N	125 13.028E	59	C2	TURBO MAP STARTED
151019	1905	32 14.386N	125 13.007E	59	C2	TURBO MAP DEEPEST
151019	1907	32 14.401N	125 12.980E	59	C2	TURBO MAP FINISHED
151019	1919	32 14.461N	125 12.866E	59		CHANGED ENGINE TO T/M
151019	1927	32 14.514N	125 13.302E	59		S/CO ON 146°
151019	2000	32 08.286N	125 17.501E	59		R/UP ENGINE
151019	2146	31 46.052N	125 34.930E	64		SUNRISE & PUT OFF REGULATION LIGHTS

Date (yymmdd)	TIME(GMT) hhmm	Latitude	Longitude	Depth(m)	Station	Ship Log
151019	2155	31 43.912N	125 36.290E	61		S/B ENGINE
151019	2206	31 43.421N	125 37.733E	62		STOPPED ENGINE
151019	2208	31 43.431N	125 37.759E	62	C3	CHANGED ENGINE TO E/M
151019	2211	31 43.423N	125 37.780E	62	C3	CTD-CMS STARTED
151019	2224	31 43.259N	125 37.912E	62	C3	CTD-CMS DEEPEST
151019	2240	31 43.116N	125 38.148E	62	C3	CTD-CMS FINISHED
151019	2248	31 43.049N	125 38.243E	62	C3	NORPAC NET STARTED
151019	2307	31 42.843N	125 38.353E	62	C3	NORPAC NET FINISHED
151019	2308	31 42.834N	125 38.362E	62	C3	NORPAC NET STARTED
151019	2319	31 42.697N	125 38.460E	62	C3	NORPAC NET FINISHED
151019	2327	31 42.591N	125 38.417E	62	C3	TURBO MAP STARTED
151019	2331	31 42.513N	125 38.377E	62	C3	TURBO MAP DEEPEST
151019	2334	31 42.455N	125 38.350E	65	C3	TURBO MAP FINISHED
151019	2334	31 42.454N	125 38.350E	65	C3	TURBO MAP STARTED
151019	2335	31 42.423N	125 38.336E	62	C3	TURBO MAP DEEPEST
151019	2341	31 42.312N	125 38.283E	63	C3	TURBO MAP FINISHED
151019	2350	31 42.139N	125 38.168E	64	C3	CHANGED ENGINE TO T/M
151019	2358	31 41.846N	125 38.487E	61	C3	S/CO ON 146°
151020	8	31 40.195N	125 39.639E	61	C3	R/UP ENGINE
151020	214	31 14.616N	126 00.721E	70		S/B ENGINE
151020	226	31 13.403N	126 01.613E	71		STOPPED ENGINE
151020	227	31 13.394N	126 01.607E	71		CHANGED ENGINE TO E/M
151020	231	31 13.344N	126 01.567E	72		CTD-CMS STARTED
151020	244	31 13.206N	126 01.476E	71		CTD-CMS DEEPEST
151020	255	31 13.143N	126 01.352E	71		CTD-CMS FINISHED
151020	301	31 13.071N	126 01.324E	72	C4	NORPAC NET STARTED
151020	303	31 13.057N	126 01.318E	71	C4	NORPAC NET FINISHED
151020	307	31 13.028N	126 01.286E	71	C4	NORPAC NET STARTED
151020	320	31 12.962N	126 01.157E	71	C4	NORPAC NET FINISHED
151020	320	31 12.961N	126 01.155E	71	C4	NORPAC NET STARTED
151020	330	31 12.931N	126 01.053E	71	C4	NORPAC NET FINISHED
151020	336	31 12.930N	126 01.023E	71	C4	FRRF STARTED
151020	339	31 12.929N	126 01.013E	71	C4	FRRF DEEPEST
151020	350	31 12.943N	126 00.969E	71	C4	FRRF FINISHED
151020	352	31 12.946N	126 00.958E	71	C4	PRR STARTED
151020	402	31 13.003N	126 00.809E	70	C4	PRR DEEPEST
151020	409	31 13.048N	126 00.674E	70	C4	PRR FINISHED
151020	416	31 13.057N	126 00.547E	69	C4	TURBO MAP STARTED
151020	420	31 13.055N	126 00.453E	69	C4	TURBO MAP DEEPEST
151020	422	31 13.050N	126 00.409E	69	C4	TURBO MAP FINISHED
151020	423	31 13.050N	126 00.394E	69	C4	TURBO MAP STARTED
151020	425	31 13.043N	126 00.337E	69	C4	TURBO MAP DEEPEST
151020	428	31 13.034N	126 00.275E	69	C4	TURBO MAP FINISHED
151020	434	31 13.028N	126 00.174E	69	C4	PRR STARTED
151020	441	31 13.048N	126 00.067E	69	C4	PRR DEEPEST
151020	442	31 13.051N	126 00.059E	69	C4	PRR FINISHED
151020	452	31 13.043N	126 00.056E	69	C4	MULTIPLE CORER STARTED
151020	457	31 13.036N	126 00.046E	69	C4	MULTIPLE CORER HIT BOTTOM
151020	500	31 13.034N	126 00.041E	69	C4	MULTIPLE CORER LEFT BOTTOM
151020	503	31 13.029N	126 00.023E	69	C4	MULTIPLE CORER FINISHED
151020	513	31 12.994N	125 59.857E	69	C4	CHANGED ENGINE TO T/M
151020	530	31 10.722N	126 01.940E	70	C4	R/UP ENGINE
151020	530	31 10.631N	126 02.026E	70	C4	S/CO ON 146°
151020	603	31 04.455N	126 07.646E	80		CLEARED OUT EEZ OF KOREA
151020	745	30 44.691N	126 24.712E	82		S/B ENGINE
151020	755	30 43.543N	126 25.464E	84		STOPPED ENGINE
151020	757	30 43.540N	126 25.478E	84		CHANGED ENGINE TO E/M
151020	800	30 43.547N	126 25.477E	84	C5	CTD-CMS STARTED
151020	813	30 43.615N	126 25.519E	84	C5	CTD-CMS DEEPEST

Date (yymmdd)	TIME(GMT) hhmm	Latitude	Longitude	Depth(m)	Station	Ship Log
151020	830	30 43.702N	126 25.569E	84	C5	CTD-CMS FINISHED
151020	833	30 43.706N	126 25.576E	84	C5	PRR STARTED
151020	844	30 43.819N	126 25.643E	84	C5	PRR DEEPEST
151020	845	30 43.825N	126 25.637E	84	C5	PRR FINISHED
151020	848	30 43.839N	126 25.623E	84	C5	TURBO MAP STARTED
151020	854	30 43.856N	126 25.599E	84	C5	TURBO MAP DEEPEST
151020	855	30 43.858N	126 25.593E	84	C5	TURBO MAP FINISHED
151020	855	30 43.858N	126 25.588E	84	C5	TURBO MAP STARTED
151020	858	30 43.863N	126 25.574E	84	C5	TURBO MAP DEEPEST
151020	859	30 43.864N	126 25.567E	84	C5	SUNSET & PUT ON REGULATION LIGHTS
151020	901	30 43.865N	126 25.557E	84	C5	TURBO MAP FINISHED
151020	921	30 43.672N	126 25.896E	84		CHANGED ENGINE TO T/M
151020	927	30 43.396N	126 26.379E	85		S/CO ON 145°
151020	1000	30 38.505N	126 32.514E	90		R/UP ENGINE
151020	1153	30 14.902N	126 48.825E	97		S/B ENGINE
151020	1204	30 13.452N	126 49.451E	97	C6	STOPPED ENGINE
151020	1208	30 13.410N	126 49.489E	96	C6	CHANGED ENGINE TO E/M
151020	1210	30 13.408N	126 49.482E	97	C6	CTD-CMS STARTED
151020	1224	30 13.471N	126 49.488E	97	C6	CTD-CMS DEEPEST
151020	1237	30 13.533N	126 49.487E	97	C6	CTD-CMS FINISHED
151020	1247	30 13.546N	126 49.399E	97	C6	TURBO MAP STARTED
151020	1250	30 13.553N	126 49.354E	97	C6	TURBO MAP DEEPEST
151020	1253	30 13.568N	126 49.304E	97	C6	TURBO MAP FINISHED
151020	1253	30 13.568N	126 49.302E	97	C6	TURBO MAP STARTED
151020	1257	30 13.595N	126 49.239E	97	C6	TURBO MAP DEEPEST
151020	1303	30 13.640N	126 49.151E	97	C6	TURBO MAP FINISHED
151020	1311	30 13.716N	126 49.007E	97	C6	CHANGED ENGINE TO T/M
151020	1319	30 13.606N	126 49.297E	97	C6	S/CO ON 138°
151020	1328	30 12.315N	126 50.568E	97	C6	R/UP ENGINE
151020	1548	29 47.283N	127 16.255E	122		S/B ENGINE
151020	1602	29 46.178N	127 17.411E	126	C7	STOPPED ENGINE
151020	1606	29 46.133N	127 17.395E	126	C7	CHANGED ENGINE TO E/M
151020	1612	29 46.095N	127 17.338E	126	C7	CTD-CMS STARTED
151020	1628	29 46.075N	127 17.341E	126	C7	CTD-CMS DEEPEST
151020	1642	29 46.086N	127 17.429E	126	C7	CTD-CMS FINISHED
151020	1648	29 46.059N	127 17.473E	125	C7	NORPAC NET STARTED
151020	1700	29 46.043N	127 17.529E	126	C7	NORPAC NET FINISHED
151020	1704	29 46.045N	127 17.552E	125	C7	NORPAC NET STARTED
151020	1717	29 46.050N	127 17.632E	126	C7	NORPAC NET FINISHED
151020	1727	29 46.042N	127 17.555E	126	C7	TURBO MAP STARTED
151020	1731	29 46.034N	127 17.512E	125	C7	TURBO MAP DEEPEST
151020	1733	29 46.035N	127 17.486E	125	C7	TURBO MAP FINISHED
151020	1737	29 46.043N	127 17.451E	126	C7	TURBO MAP STARTED
151020	1738	29 46.043N	127 17.442E	125	C7	TURBO MAP DEEPEST
151020	1741	29 46.046N	127 17.403E	125	C7	TURBO MAP FINISHED
151020	1758	29 46.008N	127 17.335E	126	C7	MULTIPLE CORER STARTED
151020	1806	29 46.006N	127 17.341E	126	C7	MULTIPLE CORER HIT BOTTOM
151020	1807	29 46.005N	127 17.341E	124	C7	MULTIPLE CORER LEFT BOTTOM
151020	1816	29 45.961N	127 17.373E	126	C7	MULTIPLE CORER FINISHED
151020	1827	29 45.900N	127 17.243E	125		CHANGED ENGINE TO T/M
151020	1842	29 44.133N	127 19.599E	128		S/CO ON 130°
151020	2109	29 23.159N	127 49.533E	1039		STOPPED ENGINE
151020	2111	29 23.189N	127 49.558E	1039	C8	CHANGED ENGINE TO E/M
151020	2116	29 23.304N	127 49.617E	1037	C8	CTD-CMS STARTED
151020	2137	29 23.962N	127 49.908E	1029	C8	SUNRISE & PUT OFF REGULATION LIGHTS
151020	2141	29 24.093N	127 49.957E	1027	C8	CTD-CMS DEEPEST
151020	2158	29 24.639N	127 50.118E	1019	C8	CTD-CMS FINISHED
151020	2204	29 24.846N	127 50.208E	1016	C8	NORPAC NET STARTED
151020	2214	29 25.141N	127 50.306E	1012	C8	NORPAC NET FINISHED

Date (yymmdd)	TIME(GMT) hhmm	Latitude	Longitude	Depth(m)	Station	Ship Log
151020	2219	29 25.298N	127 50.366E	1009	C8	NORPAC NET STARTED
151020	2236	29 25.796N	127 50.564E	1010	C8	NORPAC NET FINISHED
151020	2245	29 26.044N	127 50.652E	1018	C8	TURBO MAP STARTED
151020	2258	29 26.339N	127 50.602E	1028	C8	TURBO MAP DEEPEST
151020	2315	29 26.810N	127 50.477E	1031	C8	TURBO MAP FINISHED
151020	2339	29 26.891N	127 50.555E	1033	C8	CTD-CMS STARTED
151021	16	29 27.847N	127 50.714E	997	C8	CTD-CMS DEEPEST
151021	52	29 28.757N	127 50.776E	987	C8	CTD-CMS FINISHED
151021	204	29 24.581N	127 49.867E	1019	C8	MULTIPLE CORER STARTED
151021	252	29 24.725N	127 50.404E	1026	C8	MULTIPLE CORER HIT BOTTOM
151021	254	29 24.723N	127 50.404E	1022	C8	MULTIPLE CORER LEFT BOTTOM
151021	317	29 24.934N	127 50.823E	1020	C8	MULTIPLE CORER FINISHED
151021	328	29 25.154N	127 50.860E	1015	C8	CHANGED ENGINE TO T/M
151021	349	29 22.532N	127 53.976E	1058	C8	S/CO ON 131°
151021	617	28 59.039N	128 20.590E	1042	C9	STOPPED ENGINE
151021	621	28 59.016N	128 20.566E	1041	C9	CHANGED ENGINE TO E/M
151021	629	28 59.019N	128 20.518E	1040	C9	CTD-CMS STARTED
151021	700	28 59.255N	128 20.595E	1048	C9	CTD-CMS DEEPEST
151021	742	28 59.563N	128 20.725E	1055	C9	CTD-CMS FINISHED
151021	751	28 59.629N	128 20.736E	1055	C9	TURBO MAP STARTED
151021	804	28 59.714N	128 20.542E	1056	C9	TURBO MAP DEEPEST
151021	816	28 59.800N	128 20.360E	1056	C9	TURBO MAP FINISHED
151021	844	28 59.357N	128 20.992E	1050	C9	MULTIPLE CORER STARTED
151021	852	28 59.298N	128 21.057E	1041	C9	SUNSET & PUT ON REGULATION LIGHTS
151021	919	28 59.272N	128 21.008E	1226	C9	MULTIPLE CORER HIT BOTTOM
151021	921	28 59.275N	128 21.020E	1230	C9	MULTIPLE CORER LEFT BOTTOM
151021	945	28 59.151N	128 21.259E	1041	C9	MULTIPLE CORER FINISHED
151021	1012	28 59.038N	128 20.948E	1039		CHANGED ENGINE TO T/M
151021	1015	28 58.942N	128 20.984E	1035		S/CO ON 143°
151021	1030	28 56.651N	128 22.950E	1039		R/UP ENGINE
151021	1431	28 10.953N	129 02.268E	610		S/B ENGINE
151021	1505	28 04.728N	129 03.850E	333		STOPPED ENGINE
151021	1511	28 04.767N	129 03.840E	335		CHANGED ENGINE TO E/M
151021	2126	28 01.440N	129 03.820E	144		SUNRISE & PUT OFF REGULATION LIGHTS
151022	850	28 08.182N	129 11.030E	125		SUNSET & PUT ON REGULATION LIGHTS
151022	2127	28 08.085N	129 10.918E	132		SUNRISE & PUT OFF REGULATION LIGHTS
151023	848	28 06.911N	129 04.051E	423		SUNSET & PUT ON REGULATION LIGHTS
151023	907	28 06.844N	129 03.775E	437		CHANGED ENGINE TO T/M
151023	908	28 06.846N	129 03.771E	438		SLOW AHEAD ENGINE
151023	909	28 06.819N	129 03.743E	439		S/CO ON 227°
151023	930	28 03.685N	129 01.328E	378		R/UP ENGINE
151023	1019	27 55.628N	128 51.116E	638		A/CO TO 214°
151023	1241	27 25.986N	128 29.129E	1032		A/CO TO 236°
151023	1443	27 09.927N	128 00.754E	476		A/CO TO 228°
151023	1533	27 01.684N	127 50.520E	227		A/CO TO 217°
151023	1535	27 01.372N	127 50.234E	161		S/B ENGINE
151023	2015	26 15.771N	127 12.047E	101		A/CO TO 197°
151023	2042	26 10.961N	127 10.287E	236		A/CO TO 224°
151023	2132	26 02.130N	127 01.222E	1032		SUNRISE & PUT OFF REGULATION LIGHTS
151023	2144	25 59.960N	126 59.180E	1230		R/UP ENGINE
151024	540	24 38.845N	125 30.607E	436		A/CO TO 263°
151024	829	24 33.248N	124 44.201E	138		A/CO TO 237°
151024	830	24 33.117N	124 43.948E	145		S/B ENGINE
151024	908	24 30.058N	124 38.701E	302		SUNSET & PUT ON REGULATION LIGHTS
151024	1224	24 09.207N	124 03.628E	887		A/CO TO 269°
151024	1300	24 08.876N	123 56.129E	654		A/CO TO 287°
151024	1357	24 12.292N	123 46.055E	105		STOPPED ENGINE
151024	1400	24 12.289N	123 45.999E	105		CHANGED ENGINE TO E/M
151024	2107	24 12.354N	123 41.586E	204		CHANGED ENGINE TO T/M

Date (yymmdd)	TIME(GMT) hhmm	Latitude	Longitude	Depth(m)	Station	Ship Log
151024	2110	24 12.414N	123 41.456E	207		S/CO ON 328°
151024	2140	24 16.991N	123 36.547E	372		R/UP ENGINE
151024	2146	24 18.073N	123 35.814E	459		SUNRISE & PUT OFF REGULATION LIGHTS
151024	2200	24 21.127N	123 33.809E	645		S/B ENGINE
151025	102	24 49.824N	123 13.200E	942		A/CO TO 326°
151025	328	25 09.566N	122 56.665E	0		STOPPED ENGINE
151025	332	25 09.615N	122 56.707E	1645		CHANGED ENGINE TO E/M
151025	337	25 09.657N	122 56.769E	1646	F1	TURBO MAP STARTED
151025	353	25 09.838N	122 56.878E	1647	F1	TURBO MAP DEEPEST
151025	406	25 09.990N	122 56.961E	1649	F1	TURBO MAP FINISHED
151025	408	25 10.014N	122 56.977E	1650	F1	TURBO MAP STARTED
151025	420	25 10.161N	122 57.029E	1652	F1	TURBO MAP DEEPEST
151025	434	25 10.329N	122 57.094E	1653	F1	TURBO MAP FINISHED
151025	441	25 10.448N	122 57.176E	1653	F1	NORPAC NET STARTED
151025	453	25 10.714N	122 57.526E	1659	F1	NORPAC NET FINISHED
151025	500	25 10.841N	122 57.690E	1662	F1	NORPAC NET STARTED
151025	516	25 11.210N	122 58.127E	1670	F1	NORPAC NET FINISHED
151025	529	25 11.380N	122 58.337E	1672	F1	CTD-CMS STARTED
151025	615	25 12.096N	122 59.081E	1672	F1	CTD-CMS DEEPEST
151025	708	25 12.617N	122 59.529E	1671	F1	CTD-CMS FINISHED
151025	752	25 12.722N	122 59.447E	1670	F1	CTD-CMS STARTED
151025	838	25 13.296N	122 59.892E	1661	F1	CTD-CMS DEEPEST
151025	915	25 13.625N	123 00.062E	1649	F1	SUNSET & PUT ON REGULATION LIGHTS
151025	934	25 13.888N	123 00.215E	1651	F1	CTD-CMS FINISHED
151025	942	25 13.942N	123 00.267E	1652	F1	TURBO MAP STARTED
151025	957	25 13.977N	123 00.115E	1653	F1	TURBO MAP DEEPEST
151025	1010	25 14.058N	122 59.966E	1651	F1	TURBO MAP FINISHED
151025	1011	25 14.067N	122 59.953E	1652	F1	TURBO MAP STARTED
151025	1022	25 14.155N	122 59.811E	1636	F1	TURBO MAP DEEPEST
151025	1036	25 14.287N	122 59.644E	1633	F1	TURBO MAP FINISHED
151025	1116	25 11.858N	122 58.832E	1673	F1	CTD-CMS STARTED
151025	1144	25 12.317N	122 59.041E	1672	F1	CTD-CMS FINISHED
151025	1211	25 13.907N	122 59.602E	1645	F1	MULTIPLE CORER STARTED
151025	1256	25 14.122N	122 59.787E	1654	F1	MULTIPLE CORER HIT BOTTOM
151025	1258	25 14.119N	122 59.785E	1654	F1	MULTIPLE CORER LEFT BOTTOM
151025	1331	25 14.837N	123 00.257E	1622	F1	MULTIPLE CORER FINISHED
151025	1346	25 15.133N	123 00.324E	1617	F1	CTD-CMS STARTED
151025	1405	25 15.610N	123 00.489E	1612	F1	CTD-CMS DEEPEST
151025	1422	25 16.055N	123 00.714E	1608	F1	CTD-CMS FINISHED
151025	1440	25 16.438N	123 01.041E	1597	F1	CHANGED ENGINE TO T/M
151025	1447	25 16.674N	123 01.570E	1592	F1	S/CO ON 067°
151025	2120	25 48.663N	124 36.703E	1830		A/CO TO 061°
151025	2146	25 51.189N	124 42.815E	1895		SUNRISE & PUT OFF REGULATION LIGHTS
151026	216	26 21.991N	125 41.995E	1913		STOPPED ENGINE
151026	221	26 22.047N	125 42.023E	1911		CHANGED ENGINE TO E/M
151026	222	26 22.064N	125 42.029E	1910	E3	CTD-CMS STARTED
151026	312	26 22.753N	125 42.284E	1878	E3	CTD-CMS DEEPEST
151026	404	26 23.431N	125 42.621E	1822	E3	CTD-CMS FINISHED
151026	412	26 23.575N	125 42.685E	1808	E3	TURBO MAP STARTED
151026	428	26 23.754N	125 42.757E	1807	E3	TURBO MAP DEEPEST
151026	438	26 23.881N	125 42.804E	1799	E3	TURBO MAP FINISHED
151026	439	26 23.893N	125 42.810E	1806	E3	TURBO MAP STARTED
151026	456	26 24.108N	125 42.891E	1786	E3	TURBO MAP DEEPEST
151026	503	26 24.204N	125 42.924E	1782	E3	TURBO MAP FINISHED
151026	519	26 24.443N	125 43.060E	1788	E3	CTD-CMS STARTED
151026	532	26 24.723N	125 43.261E	1813	E3	CTD-CMS DEEPEST
151026	550	26 24.982N	125 43.511E	1786	E3	CTD-CMS FINISHED
151026	632	26 22.789N	125 42.294E	1873	E3	MULTIPLE CORER STARTED
151026	720	26 22.722N	125 42.239E	1888	E3	MULTIPLE CORER HIT BOTTOM

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151026	722	26 22.719N	125 42.237E	1885	E3	MULTIPLE CORER LEFT BOTTOM
151026	801	26 22.900N	125 42.409E	1858	E3	MULTIPLE CORER FINISHED
151026	811	26 22.982N	125 42.379E	1845	E3	CHANGED ENGINE TO T/M
151026	822	26 23.763N	125 42.011E	1814		S/CO ON 319°
151026	901	26 30.519N	125 35.082E	1608		SUNSET & PUT ON REGULATION LIGHTS
151026	932	26 35.481N	125 30.157E	1293		STOPPED ENGINE
151026	934	26 35.535N	125 30.150E	1287	E2	CHANGED ENGINE TO E/M
151026	938	26 35.604N	125 30.173E	1284	E2	CTD-CMS STARTED
151026	1017	26 36.071N	125 30.405E	1275	E2	CTD-CMS DEEPEST
151026	1102	26 36.595N	125 30.558E	1260	E2	CTD-CMS FINISHED
151026	1111	26 36.719N	125 30.616E	1256	E2	TURBO MAP STARTED
151026	1124	26 36.866N	125 30.653E	1247	E2	TURBO MAP DEEPEST
151026	1140	26 37.068N	125 30.711E	1237	E2	TURBO MAP FINISHED
151026	1141	26 37.080N	125 30.712E	1236	E2	TURBO MAP STARTED
151026	1155	26 37.244N	125 30.739E	1243	E2	TURBO MAP DEEPEST
151026	1206	26 37.386N	125 30.774E	1235	E2	TURBO MAP FINISHED
151026	1218	26 37.557N	125 30.882E	1227	E2	CTD-CMS STARTED
151026	1241	26 37.934N	125 31.189E	1213	E2	CTD-CMS FINISHED
151026	1251	26 38.035N	125 31.260E	1214	E2	CHANGED ENGINE TO T/M
151026	1300	26 38.551N	125 31.028E	1182	E2	S/CO ON 321°
151026	1417	26 48.958N	125 17.962E	187	E1	STOPPED ENGINE
151026	1419	26 49.001N	125 17.975E	190	E1	CHANGED ENGINE TO E/M
151026	1422	26 49.026N	125 18.036E	193	E1	CTD-CMS STARTED
151026	1436	26 49.093N	125 18.342E	220	E1	CTD-CMS DEEPEST
151026	1456	26 49.168N	125 18.782E	183	E1	CTD-CMS FINISHED
151026	1505	26 49.154N	125 18.920E	183	E1	TURBO MAP STARTED
151026	1512	26 49.103N	125 19.027E	190	E1	TURBO MAP DEEPEST
151026	1516	26 49.079N	125 19.090E	191	E1	TURBO MAP FINISHED
151026	1517	26 49.072N	125 19.109E	192	E1	TURBO MAP STARTED
151026	1523	26 49.041N	125 19.235E	195	E1	TURBO MAP DEEPEST
151026	1528	26 49.036N	125 19.330E	190	E1	TURBO MAP FINISHED
151026	1539	26 49.033N	125 19.507E	180	E1	CHANGED ENGINE TO T/M
151026	1601	26 52.358N	125 20.704E	146	E1	S/CO ON 018°
151026	1610	26 54.733N	125 21.564E	148	RUE	R/UP ENGINE
151026	2146	28 14.703N	125 48.680E	108		SUNRISE & PUT OFF REGULATION LIGHTS
151027	55	28 58.761N	126 08.214E	111	D1	S/B ENGINE
151027	105	29 00.052N	126 09.054E	106	D1	STOPPED ENGINE
151027	109	29 00.126N	126 09.066E	106	D1	CHANGED ENGINE TO E/M
151027	113	29 00.161N	126 09.113E	105	D1	CTD-CMS STARTED
151027	122	29 00.181N	126 09.222E	106	D1	CTD-CMS DEEPEST
151027	136	29 00.194N	126 09.394E	107	D1	CTD-CMS FINISHED
151027	158	28 59.990N	126 09.285E	106	D1	CTD-CMS STARTED
151027	208	28 59.983N	126 09.440E	106	D1	CTD-CMS DEEPEST
151027	221	28 59.960N	126 09.690E	105	D1	CTD-CMS FINISHED
151027	233	28 59.924N	126 09.905E	106	D1	NORPAC NET STARTED
151027	243	28 59.894N	126 10.107E	106	D1	NORPAC NET FINISHED
151027	247	28 59.876N	126 10.207E	106	D1	NORPAC NET STARTED
151027	258	28 59.818N	126 10.427E	106	D1	NORPAC NET FINISHED
151027	303	28 59.775N	126 10.519E	106	D1	FRRF STARTED
151027	308	28 59.735N	126 10.644E	106	D1	FRRF DEEPEST
151027	325	28 59.600N	126 11.101E	107	D1	FRRF FINISHED
151027	331	28 59.520N	126 11.273E	106	D1	PRR STARTED
151027	337	28 59.459N	126 11.498E	106	D1	PRR DEEPEST
151027	355	28 59.460N	126 12.256E	107	D1	PRR FINISHED
151027	356	28 59.467N	126 12.279E	107	D1	TURBO MAP STARTED
151027	402	28 59.471N	126 12.520E	107	D1	TURBO MAP DEEPEST
151027	404	28 59.474N	126 12.575E	107	D1	TURBO MAP FINISHED
151027	406	28 59.472N	126 12.650E	108	D1	TURBO MAP STARTED
151027	409	28 59.472N	126 12.764E	107	D1	TURBO MAP DEEPEST

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151027	412	28 59.474N	126 12.898E	108	D1	TURBO MAP FINISHED
151027	422	28 59.490N	126 13.235E	107		CHANGED ENGINE TO T/M
151027	600	28 42.140N	126 26.725E	126	D2	STOPPED ENGINE
151027	607	28 42.042N	126 26.904E	127	D2	CHANGED ENGINE TO E/M
151027	613	28 41.959N	126 27.026E	126	D2	CTD-CMS STARTED
151027	623	28 41.755N	126 27.065E	128	D2	CTD-CMS DEEPEST
151027	640	28 41.557N	126 27.066E	127	D2	CTD-CMS FINISHED
151027	648	28 41.538N	126 27.094E	128	D2	FRRF STARTED
151027	656	28 41.486N	126 27.158E	128	D2	FRRF DEEPEST
151027	715	28 41.306N	126 27.212E	128	D2	FRRF FINISHED
151027	724	28 41.189N	126 27.211E	128	D2	TURBO MAP STARTED
151027	730	28 41.023N	126 27.286E	128	D2	TURBO MAP DEEPEST
151027	734	28 40.946N	126 27.339E	129	D2	TURBO MAP FINISHED
151027	735	28 40.925N	126 27.355E	128	D2	TURBO MAP STARTED
151027	739	28 40.840N	126 27.414E	129	D2	TURBO MAP DEEPEST
151027	744	28 40.732N	126 27.493E	129	D2	TURBO MAP FINISHED
151027	755	28 40.536N	126 27.646E	129		CHANGED ENGINE TO T/M
151027	801	28 40.368N	126 27.902E	127		S/CO ON 076°
151027	855	28 44.364N	126 40.656E	142		SUNSET & PUT ON REGULATION LIGHTS
151027	922	28 46.111N	126 45.837E	147		STOPPED ENGINE
151027	924	28 46.108N	126 45.851E	147	DU	CHANGED ENGINE TO E/M
151027	930	28 46.115N	126 45.869E	147	DU	CTD-CMS STARTED
151027	949	28 46.341N	126 45.779E	147	DU	CTD-CMS DEEPEST
151027	1005	28 46.528N	126 45.706E	146	DU	CTD-CMS FINISHED
151027	1014	28 46.594N	126 45.773E	146	DU	TURBO MAP STARTED
151027	1019	28 46.565N	126 45.831E	147	DU	TURBO MAP DEEPEST
151027	1023	28 46.556N	126 45.872E	146	DU	TURBO MAP FINISHED
151027	1025	28 46.556N	126 45.886E	146	DU	TURBO MAP STARTED
151027	1029	28 46.536N	126 45.944E	147	DU	TURBO MAP DEEPEST
151027	1035	28 46.493N	126 45.995E	147	DU	TURBO MAP FINISHED
151027	1045	28 46.434N	126 46.128E	147		CHANGED ENGINE TO T/M
151027	1047	28 46.419N	126 46.156E	147		S/CO ON 186°
151027	1150	28 35.160N	126 44.827E	173	D2'	STOPPED ENG
151027	1321	28 34.781N	126 44.450E	176	D2'	CTD-CMS STARTED
151027	1333	28 34.846N	126 44.621E	178	D2'	CTD-CMS DEEPEST
151027	1422	28 35.276N	126 45.064E	174	D2'	CTD-CMS FINISHED
151027	1440	28 34.972N	126 44.593E	178	D2'	CTD-CMS STARTED
151027	1519	28 35.174N	126 44.844E	164	D2'	CTD-CMS DEEPEST
151027	1539	28 35.181N	126 45.022E	182	D2'	CTD-CMS FINISHED
151027	1547	28 35.095N	126 45.214E	181	D2'	TURBO MAP STARTED
151027	1554	28 35.004N	126 45.417E	182	D2'	TURBO MAP DEEPEST
151027	1558	28 34.955N	126 45.520E	183	D2'	TURBO MAP FINISHED
151027	1559	28 34.940N	126 45.555E	182	D2'	TURBO MAP STARTED
151027	1603	28 34.878N	126 45.701E	185	D2'	TURBO MAP DEEPEST
151027	1609	28 34.809N	126 45.858E	186	D2'	TURBO MAP FINISHED
151027	1619	28 34.662N	126 46.122E	189	D2'	NORPAC NET STARTED
151027	1631	28 34.645N	126 46.468E	193	D2'	NORPAC NET FINISHED
151027	1635	28 34.624N	126 46.576E	196	D2'	NORPAC NET STARTED
151027	1649	28 34.558N	126 46.892E	198	D2'	NORPAC NET FINISHED
151027	1736	28 35.125N	126 44.860E	178	D2'	MULTIPLE CORER STARTED
151027	1749	28 35.143N	126 44.847E	175	D2'	MULTIPLE CORER HIT BOTTOM
151027	1751	28 35.144N	126 44.848E	174	D2'	MULTIPLE CORER LEFT BOTTOM
151027	1758	28 35.150N	126 44.839E	177	D2'	MULTIPLE CORER FINISHED
151027	1809	28 34.976N	126 45.000E	180	D2'	CHANGED ENGINE TO T/M
151027	1858	28 27.142N	126 49.300E	216	D3	STOPPED ENGINE
151027	1901	28 27.078N	126 49.308E	216	D3	CHANGED ENGINE TO E/M
151027	1911	28 27.035N	126 49.319E	217	D3	MULTIPLE CORER STARTED
151027	1925	28 27.074N	126 49.298E	216	D3	MULTIPLE CORER HIT BOTTOM
151027	1927	28 27.079N	126 49.293E	217	D3	MULTIPLE CORER LEFT BOTTOM

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151027	1943	28 27.094N	126 49.342E	217	D3	MULTIPLE CORER FINISHED
151027	1946	28 27.073N	126 49.374E	217	D3	TURBO MAP STARTED
151027	1952	28 27.092N	126 49.442E	217	D3	TURBO MAP DEEPEST
151027	1957	28 27.120N	126 49.494E	217	D3	TURBO MAP FINISHED
151027	1957	28 27.123N	126 49.502E	219	D3	TURBO MAP STARTED
151027	2003	28 27.156N	126 49.555E	218	D3	TURBO MAP DEEPEST
151027	2009	28 27.195N	126 49.610E	218	D3	TURBO MAP FINISHED
151027	2019	28 27.254N	126 49.702E	220	D3	FRRF STARTED
151027	2027	28 27.474N	126 49.773E	218	D3	FRRF DEEPEST
151027	2045	28 27.952N	126 49.859E	219	D3	FRRF FINISHED
151027	2052	28 28.123N	126 49.968E	220	D3	CTD-CMS STARTED
151027	2107	28 28.469N	126 50.074E	221	D3	CTD-CMS DEEPEST
151027	2129	28 28.956N	126 50.126E	220	D3	CTD-CMS FINISHED
151027	2140	28 29.117N	126 50.246E	221		CHANGED ENGINE TO T/M
151027	2141	28 29.124N	126 50.251E	221		SUNRISE & PUT OFF REGULATION LIGHTS
151027	2146	28 28.985N	126 50.774E	225		S/CO ON 120°
151027	2318	28 17.461N	127 07.982E	942		STOPPED ENGINE
151027	2321	28 17.526N	127 08.067E	945		CHANGED ENGINE TO E/M
151027	2328	28 17.706N	127 08.246E	965	D4	CTD-CMS STARTED
151028	3	28 18.630N	127 08.686E	950	D4	CTD-CMS DEEPEST
151028	42	28 19.754N	127 09.196E	969	D4	CTD-CMS FINISHED
151028	105	28 19.850N	127 08.975E	968	D4	CTD-CMS STARTED
151028	142	28 20.958N	127 09.447E	986	D4	CTD-CMS DEEPEST
151028	239	28 22.306N	127 10.290E	1011	D4	CTD-CMS FINISHED
151028	404	28 17.102N	127 12.690E	977	D4	MULTIPLE CORER STARTED
151028	447	28 17.467N	127 12.783E	1006	D4	MULTIPLE CORER HIT BOTTOM
151028	449	28 17.470N	127 12.784E	1004	D4	MULTIPLE CORER LEFT BOTTOM
151028	512	28 17.894N	127 12.820E	998	D4	MULTIPLE CORER FINISHED
151028	524	28 18.142N	127 13.023E	997	D4	FRRF STARTED
151028	529	28 18.300N	127 13.185E	997	D4	FRRF DEEPEST
151028	550	28 19.122N	127 13.765E	992	D4	FRRF FINISHED
151028	551	28 19.158N	127 13.796E	992	D4	PRR STARTED
151028	556	28 19.316N	127 13.930E	991	D4	PRR DEEPEST
151028	601	28 19.444N	127 14.051E	990	D4	PRR FINISHED
151028	601	28 19.447N	127 14.055E	989	D4	PRR STARTED
151028	602	28 19.490N	127 14.104E	992	D4	PRR DEEPEST
151028	602	28 19.491N	127 14.105E	992	D4	PRR FINISHED
151028	611	28 19.739N	127 14.334E	1051	D4	CTD-CMS STARTED
151028	622	28 20.046N	127 14.540E	1034	D4	CTD-CMS DEEPEST
151028	630	28 20.265N	127 14.725E	1033	D4	CTD-CMS FINISHED
151028	638	28 20.449N	127 14.901E	1032	D4	TURBO MAP STARTED
151028	653	28 20.680N	127 15.352E	1037	D4	TURBO MAP DEEPEST
151028	702	28 20.839N	127 15.655E	1043	D4	TURBO MAP FINISHED
151028	703	28 20.852N	127 15.683E	1042	D4	TURBO MAP STARTED
151028	706	28 20.884N	127 15.752E	1044	D4	TURBO MAP DEEPEST
151028	708	28 20.919N	127 15.823E	1045	D4	TURBO MAP FINISHED
151028	708	28 20.919N	127 15.826E	1045	D4	TURBO MAP STARTED
151028	720	28 21.084N	127 16.167E	1052	D4	TURBO MAP DEEPEST
151028	731	28 21.253N	127 16.512E	1057	D4	TURBO MAP FINISHED
151028	737	28 21.369N	127 16.705E	1059	D4	NORPAC NET STARTED
151028	748	28 21.620N	127 16.998E	1059	D4	NORPAC NET FINISHED
151028	752	28 21.719N	127 17.089E	1058	D4	NORPAC NET STARTED
151028	807	28 22.169N	127 17.439E	1066	D4	NORPAC NET FINISHED
151028	818	28 22.324N	127 17.739E	1067		CHANGED ENGINE TO T/M
151028	823	28 22.267N	127 17.838E	1067		S/CO ON 130°
151028	850	28 17.904N	127 21.487E	1067		SUNSET & PUT ON REGULATION LIGHTS
151028	1030	27 57.962N	127 34.586E	1315		STOPPED ENGINE
151028	1032	27 57.969N	127 34.621E	1315	D5	CHANGED ENGINE TO E/M
151028	1037	27 57.956N	127 34.623E	1315	D5	CTD-CMS STARTED

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151028	1121	27 58.046N	127 34.507E	1315	D5	CTD-CMS DEEPEST
151028	1155	27 58.124N	127 34.564E	1315	D5	CTD-CMS FINISHED
151028	1206	27 58.088N	127 34.617E	1317	D5	TURBO MAP STARTED
151028	1218	27 57.997N	127 34.739E	1317	D5	TURBO MAP DEEPEST
151028	1229	27 57.905N	127 34.865E	1316	D5	TURBO MAP FINISHED
151028	1229	27 57.904N	127 34.866E	1316	D5	TURBO MAP STARTED
151028	1242	27 57.778N	127 34.992E	1315	D5	TURBO MAP DEEPEST
151028	1255	27 57.672N	127 35.103E	1310	D5	TURBO MAP FINISHED
151028	1318	27 57.659N	127 35.273E	1307	D5	CTD-CMS STARTED
151028	1332	27 57.677N	127 35.306E	1313	D5	CTD-CMS DEEPEST
151028	1342	27 57.688N	127 35.319E	1310	D5	CTD-CMS FINISHED
151028	1400	27 57.987N	127 35.835E	1320	D5	MULTIPLE CORER STARTED
151028	1440	27 58.028N	127 35.856E	1319	D5	MULTIPLE CORER HIT BOTTOM
151028	1443	27 58.026N	127 35.855E	1320	D5	MULTIPLE CORER LEFT BOTTOM
151028	1511	27 58.186N	127 35.865E	1316	D5	MULTIPLE CORER FINISHED
151028	1521	27 58.108N	127 35.914E	1316	D5	CHANGED ENGINE TO T/M
151028	1541	27 59.107N	127 38.735E	1310		S/CO ON 071°
151028	1543	27 59.291N	127 39.312E	1307		R/UP ENGINE
151028	2133	28 28.357N	129 12.316E	945		SUNRISE & PUT OFF REGULATION LIGHTS
151028	2319	28 37.645N	129 40.112E	267		A/CO TO 075°
151029	502	28 59.643N	131 13.397E	3811		S/B ENGINE
151029	512	29 00.020N	131 14.843E	3991		STOPPED ENGINE
151029	522	29 00.079N	131 14.910E	3997		CHANGED ENGINE TO E/M
151029	525	29 00.105N	131 14.927E	3999	I2	CTD-CMS STARTED
151029	648	29 00.699N	131 15.279E	3997	I2	CTD-CMS DEEPEST
151029	809	29 01.029N	131 15.712E	3975	I2	CTD-CMS FINISHED
151029	817	29 01.124N	131 15.793E	3961	I2	TURBO MAP STARTED
151029	832	29 01.132N	131 15.941E	3967	I2	TURBO MAP DEEPEST
151029	833	29 01.133N	131 15.952E	3976	I2	SUNSET & PUT ON REGULATION LIGHTS
151029	842	29 01.142N	131 16.053E	3969	I2	TURBO MAP FINISHED
151029	842	29 01.142N	131 16.055E	3969	I2	TURBO MAP STARTED
151029	854	29 01.160N	131 16.183E	3956	I2	TURBO MAP DEEPEST
151029	906	29 01.176N	131 16.298E	3957	I2	TURBO MAP FINISHED
151029	914	29 01.231N	131 16.409E	3952	I2	CTD-CMS STARTED
151029	939	29 01.437N	131 16.727E	3943	I2	CTD-CMS DEEPEST
151029	1011	29 01.753N	131 17.005E	4032	I2	CTD-CMS FINISHED
151029	1103	29 01.870N	131 17.040E	4026	I2	CTD-CMS STARTED
151029	1117	29 02.008N	131 17.244E	4027	I2	CTD-CMS DEEPEST
151029	1127	29 02.077N	131 17.354E	4040	I2	CTD-CMS FINISHED
151029	1241	29 02.889N	131 17.961E	3922	I2	CTD-CMS STARTED
151029	1344	29 03.400N	131 18.563E	3902	I2	CTD-CMS FINISHED
151029	1352	29 03.450N	131 18.674E	3904	I2	CHANGED ENGINE TO T/M
151029	1400	29 03.768N	131 18.410E	3894		S/CO ON 310°
151029	1410	29 04.831N	131 16.545E	3854		R/UP ENGINE
151029	1620	29 20.965N	130 46.221E	4393		S/B ENGINE
151029	1633	29 21.955N	130 45.032E	2983		STOPPED ENGINE
151029	1638	29 21.973N	130 45.092E	2984	I1	CHANGED ENGINE TO E/M
151029	1642	29 21.970N	130 45.165E	2987	I1	CTD-CMS STARTED
151029	1748	29 22.220N	130 46.364E	3060	I1	CTD-CMS DEEPEST
151029	1857	29 22.332N	130 47.175E	3073	I1	CTD-CMS FINISHED
151029	1928	29 21.944N	130 44.878E	2942	I1	CTD-CMS STARTED
151029	2036	29 22.139N	130 45.576E	3006	I1	CTD-CMS DEEPEST
151029	2128	29 22.227N	130 45.783E	3028	I1	SUNRISE & PUT OFF REGULATION LIGHTS
151029	2145	29 22.225N	130 46.025E	3050	I1	CTD-CMS FINISHED
151029	2153	29 22.207N	130 46.097E	3047	I1	NORPAC NET STARTED
151029	2202	29 22.178N	130 46.191E	3039	I1	NORPAC NET FINISHED
151029	2205	29 22.165N	130 46.233E	3037	I1	NORPAC NET STARTED
151029	2220	29 22.131N	130 46.438E	3042	I1	NORPAC NET FINISHED
151029	2228	29 22.108N	130 46.575E	3058	I1	TURBO MAP STARTED

Date (yymmdd)	TIME(GMT) hhmm	Latitude	Longitude	Depth(m)	Station	Ship Log
151029	2241	29 22.067N	130 46.751E	3037	I1	TURBO MAP DEEPEST
151029	2250	29 22.035N	130 46.811E	3033	I1	TURBO MAP FINISHED
151029	2251	29 22.032N	130 46.818E	3033	I1	TURBO MAP STARTED
151029	2306	29 22.013N	130 46.876E	3034	I1	TURBO MAP DEEPEST
151029	2317	29 22.041N	130 46.900E	3037	I1	TURBO MAP FINISHED
151029	2326	29 22.092N	130 46.939E	3042	I1	CTD-CMS STARTED
151029	2339	29 22.141N	130 47.009E	3053	I1	CTD-CMS DEEPEST
151029	2352	29 22.248N	130 47.076E	3068	I1	CTD-CMS FINISHED
151030	0	29 22.284N	130 47.114E	3070	I1	CHANGED ENGINE TO T/M
151030	5	29 22.520N	130 46.923E	3093	I1	S/CO ON 315°
151030	22	29 24.650N	130 44.351E	3471		R/UP ENGINE
151030	426	30 04.981N	129 54.899E	408		A/CO TO 301°
151030	643	30 21.087N	129 23.844E	507		S/B ENGINE
151030	650	30 21.614N	129 22.761E	535		STOPPED ENGINE
151030	653	30 21.637N	129 22.753E	540		CHANGED ENGINE TO E/M
151030	703	30 21.657N	129 22.899E	562	A2	CTD-CMS STARTED
151030	724	30 21.733N	129 23.274E	602	A2	CTD-CMS DEEPEST
151030	749	30 21.755N	129 23.682E	631	A2	CTD-CMS FINISHED
151030	757	30 21.715N	129 23.885E	629	A2	TURBO MAP STARTED
151030	811	30 21.432N	129 24.102E	640	A2	TURBO MAP DEEPEST
151030	821	30 21.222N	129 24.266E	615	A2	TURBO MAP FINISHED
151030	821	30 21.208N	129 24.277E	613	A2	TURBO MAP STARTED
151030	835	30 20.926N	129 24.515E	564	A2	TURBO MAP DEEPEST
151030	838	30 20.863N	129 24.564E	553	A2	SUNSET & PUT ON REGULATION LIGHTS
151030	849	30 20.587N	129 24.762E	517	A2	TURBO MAP FINISHED
151030	903	30 20.386N	129 25.053E	524	A2	CTD-CMS STARTED
151030	914	30 20.381N	129 25.363E	630	A2	CTD-CMS DEEPEST
151030	928	30 20.377N	129 25.510E	652	A2	CTD-CMS FINISHED
151030	941	30 20.141N	129 25.741E	648		CHANGED ENGINE TO T/M
151030	947	30 20.223N	129 25.909E	698		S/CO ON 322°
151030	1000	30 22.100N	129 24.213E	662		R/UP ENGINE
151030	1306	30 56.848N	128 51.069E	705	A1	S/B ENGINE
151030	1319	30 57.953N	128 49.945E	687	A1	STOPPED ENGINE
151030	1321	30 57.929N	128 49.921E	688	A1	CHANGED ENGINE TO E/M
151030	1343	30 57.985N	128 49.769E	686	A1	CTD-CMS STARTED
151030	1405	30 57.977N	128 49.634E	685	A1	CTD-CMS DEEPEST
151030	1432	30 57.952N	128 49.501E	684	A1	CTD-CMS FINISHED
151030	1441	30 57.917N	128 49.475E	684	A1	NORPAC NET STARTED
151030	1448	30 57.896N	128 49.426E	684	A1	NORPAC NET FINISHED
151030	1455	30 57.903N	128 49.372E	684	A1	NORPAC NET STARTED
151030	1512	30 57.912N	128 49.321E	683	A1	NORPAC NET FINISHED
151030	1519	30 57.838N	128 49.304E	683	A1	TURBO MAP STARTED
151030	1533	30 57.427N	128 49.297E	684	A1	TURBO MAP DEEPEST
151030	1545	30 57.070N	128 49.292E	686	A1	TURBO MAP FINISHED
151030	1547	30 57.010N	128 49.286E	686	A1	TURBO MAP STARTED
151030	1557	30 56.665N	128 49.281E	687	A1	TURBO MAP DEEPEST
151030	1616	30 56.097N	128 49.306E	690	A1	TURBO MAP FINISHED
151030	1629	30 55.823N	128 49.194E	690	A1	CTD-CMS STARTED
151030	1638	30 55.719N	128 49.178E	690	A1	CTD-CMS DEEPEST
151030	1648	30 55.716N	128 49.072E	689	A1	CTD-CMS FINISHED
151030	1733	30 57.997N	128 50.025E	685	A1	MULTIPLE CORER STARTED
151030	1759	30 57.969N	128 50.073E	689	A1	MULTIPLE CORER HIT BOTTOM
151030	1801	30 57.973N	128 50.063E	688	A1	MULTIPLE CORER LEFT BOTTOM
151030	1818	30 57.984N	128 50.075E	687	A1	MULTIPLE CORER FINISHED
151030	1829	30 57.735N	128 50.045E	687		CHANGED ENGINE TO T/M
151030	2009	31 01.780N	128 27.996E	318	K5	MULTIPLE CORER STARTED
151030	2026	31 01.750N	128 27.989E	317	K5	MULTIPLE CORER HIT BOTTOM
151030	2028	31 01.746N	128 27.990E	317	K5	MULTIPLE CORER LEFT BOTTOM
151030	2038	31 01.668N	128 28.048E	318	K5	MULTIPLE CORER FINISHED

Date (yymmdd)	TIME(GMT) hhmm	Latitude	Longitude	Depth(m)	Station	Ship Log
151030	2105	31 01.523N	128 28.203E	320		CHANGED ENGINE TO T/M
151030	2112	31 01.460N	128 27.433E	307		S/CO ON 260°
151030	2120	31 01.174N	128 25.410E	287		R/UP ENGINE
151030	2128	31 00.887N	128 23.288E	298		S/B ENGINE
151030	2141	31 02.015N	128 23.196E	324		SUNRISE & PUT OFF REGULATION LIGHTS
151030	2305	30 58.779N	128 03.063E	330		A/CO TO 311°
151031	711	31 54.377N	126 49.503E	106		STOPPED ENGINE
151031	716	31 54.339N	126 49.516E	107		CHANGED ENGINE TO E/M
151031	845	31 54.545N	126 48.665E	107		SUNSET & PUT ON REGULATION LIGHTS
151031	946	31 54.162N	126 48.053E	105	B3	CTD-CMS STARTED
151031	956	31 54.094N	126 48.116E	106	B3	CTD-CMS DEEPEST
151031	1011	31 54.047N	126 48.139E	107	B3	CTD-CMS FINISHED
151031	1018	31 53.981N	126 48.180E	107	B3	TURBO MAP STARTED
151031	1023	31 53.901N	126 48.175E	107	B3	TURBO MAP DEEPEST
151031	1025	31 53.855N	126 48.176E	106	B3	TURBO MAP FINISHED
151031	1026	31 53.839N	126 48.176E	106	B3	TURBO MAP STARTED
151031	1030	31 53.775N	126 48.175E	106	B3	TURBO MAP DEEPEST
151031	1036	31 53.671N	126 48.153E	106	B3	TURBO MAP FINISHED
151031	1043	31 53.548N	126 48.176E	106		CHANGED ENGINE TO T/M
151031	1048	31 53.308N	126 48.247E	105		S/CO ON 146°
151031	1107	31 50.607N	126 50.916E	108		R/UP ENGINE
151031	1316	31 25.279N	127 10.653E	106		S/B ENGINE
151031	1327	31 24.262N	127 11.664E	108	B4	STOPPED ENGINE
151031	1330	31 24.232N	127 11.702E	108	B4	CHANGED ENGINE TO E/M
151031	1335	31 24.202N	127 11.686E	108	B4	CTD-CMS STARTED
151031	1344	31 24.224N	127 11.665E	108	B4	CTD-CMS DEEPEST
151031	1357	31 24.299N	127 11.586E	108	B4	CTD-CMS FINISHED
151031	1406	31 24.294N	127 11.579E	108	B4	TURBO MAP STARTED
151031	1410	31 24.266N	127 11.563E	108	B4	TURBO MAP DEEPEST
151031	1413	31 24.246N	127 11.543E	108	B4	TURBO MAP FINISHED
151031	1414	31 24.243N	127 11.539E	108	B4	TURBO MAP STARTED
151031	1416	31 24.227N	127 11.524E	108	B4	TURBO MAP DEEPEST
151031	1421	31 24.187N	127 11.507E	108	B4	TURBO MAP FINISHED
151031	1433	31 24.096N	127 11.430E	107	B4	CHANGED ENGINE TO T/M
151031	1439	31 24.325N	127 11.445E	107	B4	S/CO ON 55°
151031	1515	31 28.845N	127 18.157E	113		R/UP ENGINE
151031	1943	32 05.965N	128 21.340E	156		A/CO TO 060°
151031	2140	32 19.742N	128 50.093E	193		SUNRISE & PUT OFF REGULATION LIGHTS
151031	2155	32 21.535N	128 53.876E	210		S/B ENGINE
151101	426	32 43.884N	129 40.276E	0		A/CO TO 090°
151101	457	32 43.952N	129 44.795E	0		CHANGED ENGINE TO S/M
151101	524	32 42.750N	129 48.600E	0		ENTERED PASSAGE
151101	542	32 42.466N	129 50.479E	0		CLEARED OUT PASSAGE
151101	600	32 42.340N	129 50.618E	0		SENT FIRST SHORE LINE
151101	611	32 42.336N	129 50.617E	0		F/W ENGINE

7. Explanatory notes
7.1. Research Vessel Hakuho-Maru

The Hakuho Maru (Japan Agency for Marine-Earth Science and Technology (JAMSTEC)) is equipped with the most up-to-date facilities for research 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 16 knot and precise maneuvering with use of bow and stern thrusters. Particulars of the Hakuho Maru are as follows:

Keel laid	9.May.88
Launching	28.Oct.88
Completion	1.May.89
Length (overall)	100.00 m
Length (p.p.)	90.00 m
Breadth (molded)	16.20 m
Depth (molded)	8.90 m
Gross tonnage (JG)	3,987 T
Propulsion system	diesel/electric-motor driven
Main engine	1,900 ps x 4 sets
Prop. Generator	1,085 kw x 2 sets
Twin propellers, twin rudders	
Main generator	715 KVA x 3 sets
Bow thruster	4.2 T x 2 sets
Stern thruster	6.8T x 1 set
Cruising speed	16.0 kn
Endurance	12,000 n.m.
Complement	89 (include. sci. 35)
Builder	
Shimonoseki Shipyard & Engine Works	
Mitsubishi Heavy Industries, Ltd.	

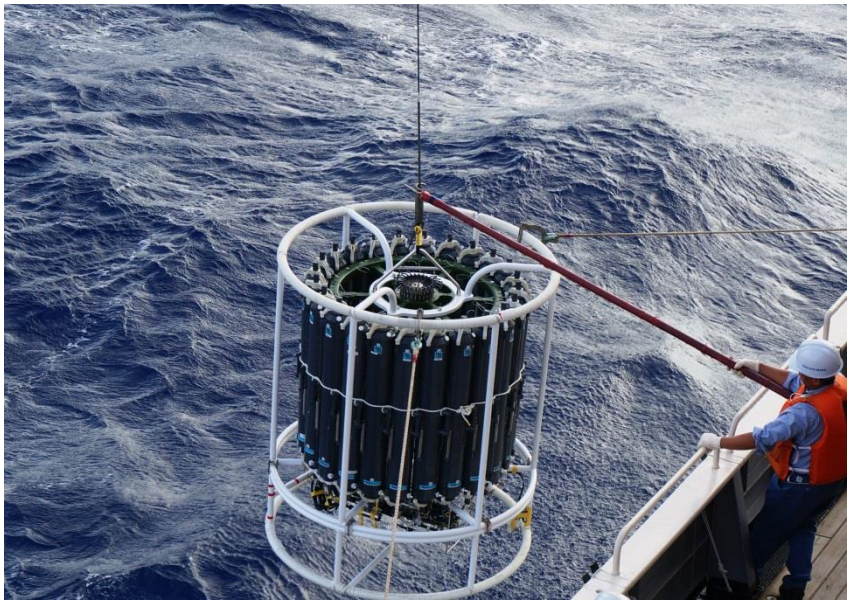
Research equipment
- 7 Winches (swell compensator for Nos. 1 & 2 Winches)
  - No.1 Winch: 14f x15,000 m
  - No.2 Winch: 8.15f x12,000 m (Titanium armoured)
  - No.3 Winch: 6.4f x12,000 m (Titanium)
  - No.4, 5, 7, 8 Winches
- 10 Laboratories
  - No.1 & 3: Dry lab., No.2: RI lab., No.7: Wet lab.
  - No.4: Clean room, No.5 & 6: Semi-dry lab.
  - No.10: Cold lab, etc.
- 11 ton gantry
- 11 ton bean crane & 3 ton deck crane
- Instruments
  - Seabeam, Subbottom profiler,
  - Oceanfloor imaging system,
  - Air gun compressor,
  - Marine meteorological observation system,
  - Acoustic biomass investigation system,
  - Meteorological satellite receiving system,
  - CTD/DO, Precise gyrocompass,
  - Data processing system, etc.

7.2. Water and particle sampling
7.2.1. CTD-Carousel sampling system (CTD-CMS)

The CTD-CMS (CTD-Carousel Multi Sampling System) used during the KH-15-3 cruise consists of the following instruments.

CTD fish (Seabird, Model SBE-9plus, 6800m) with a DO sensor (Seabird, SBE-43)
Carousel sampling system (Seabird, SBE-32)
24 or 36 Niskin-X bottles (General Oceanics, 12-liter type)
Turbidity meter (SeaPoint)
Fluorometer (SeaPoint)
Touch sensor (Seabird)
Altimeter (Benthos, Model PSA-916T)

The CTD-CMS system, attached at the end of the titanium armored cable (8mm o.d.) from the No.2 winch of R.V. Hakuho Maru, was controlled on board the ship by a CTD deck unit (Seabird, Model 11plus) connected with a WINDOWS desktop computer. The Carousel array frame has a capability to hold 24 or 36 Niskin bottles with a volume of 12 liters. A touch sensor and an altimeter were installed on the frame to monitor the distance above the sea bottom. During the hydrocasts, the ship stayed at a fixed position, and the system was lowered down to a depth of ~10 m 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.



7.2.2. Clean sampling

The CTD-CMS (CTD-Carousel Multi Sampling System), mentioned above, was also used for clean water during the KH-15-3. The CTD-CMS system was attached to Vectran Cable (14mm diameter, 7000m length, Cortland), which is the similar to US GEOTRACES system (Cutter and Bruland, 2013). By passing the cable was only through the plastic sheave, the sampling system was launched at the starboard side of the R. V. Hakuho-Maru. The Carousel array frame has a capability to hold 24 Niskin-X bottles with a volume of 12 liters.

In order to reduce the contamination level as low as possible, Niskin-X bottles were cleaned before the cruise, by filling the bottles with 1.5% 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 (120^{o}C, 3 hrs), 6M HCl (120^{o}C, 3 hrs), and Milli-Q water (100^{o}C, 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.

According to a GEOTRACES recommendation, sub-sampling for trace element analyses was done inside a clean space, called “BUBBLE”, in the seawater sampling room on board R/V Hakuho Maru. This space has a volume of about 2 m^3 (500 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)).

7.2.3. Large volume sampling

Wen-Hsuan Liao, Academia Sinica, Taiwan

Sampling of size-fractionated suspended particles was carried out in the East China Sea (ECS) and Kuroshio region, particularly focused on the euphotic zone, 0~200 m. I used a trace metal clean filtration device equipped with 150, 60, and 10 μm aperture changeable Nitex nets in sequence to gently collect the suspended particle samples with ~100 L seawater. The sampling procedures and the filtration device are described in details in previous paper (Ho et al. 2007). Meanwhile, ten liter of seawater filtered through the 10 μm net was also collected for the 0.2-10 μm fractions sampling. The filtered seawater was passed through 0.2 μm acid-washed polyethersulfone (PES) membranes with polypropylene filter holder under 15 KPa Hg vacuum condition in a class-100 clean room onboard. Right after the filtration, all the collected particles on filters were rinsed for three times with Milli-Q water to remove seawater residue to avoid analytical interference. The rinsed membranes were stored in acid-washed 7 mL Teflon vials, and they will be brought back to a land-based laboratory for further processing.

7.3. Plankton sampling

Jing Zhang (University of Toyama)
Hajime Obata (University of Tokyo)
Kohji Marumoto (National Institute for Minamata Disease)
Tomohiro Kodaira (University of Toyama)
Shota Kambayashi (University of Toyama)

Summary of sampling

A total of thirty-eight NORPAC-net (North pacific standard net, Motoda, 1957) casts in Northwestern Pacific and East China Sea were conducted from 15 October to 31 October (Table 1). A twin net with 100 μm and 335 μm was used in this cruise. Flow meters were equipped with the mouth of each net. The net was towed in twice from 50 m and 200 m, respectively, with a retrieval speed of 0.5 m/s.

Samples towed form 50 m depth were preserved in 50% ethanol solution, whereas samples towed from 200 m were refrigerated. In all, we sampled 71 lots of plankton.

Specifications of plankton nets Model: Home-made
Mouth diameter: 1 m
Mesh size: 100μm, 330 μm
Length: 2 m

7.4. Turbulence measurement

Turbulence in the ocean can be determined by measurement of micro-scale velocity shear. The vertical profiles of micro-scale velocity shear is measured with the microstructure profiler named TurboMAP-L (Fig. 7.4.1) manufactured by JFE Advantec. Two shear probes (Fig. 7.4.2) are equipped in the instruments to enhance the reliability of the shear data. Current velocity was measured with 512 Hz in about 0.6 m/s free falling descending speed. That means micro-scale velocity shear with the vertical resolution about 1 mm is detected. Turbulent dissipation rate ε is calculated from the current velocity shear, integrating the shear spectrum with wave number from about 1 cm to 1 m (Fig.7.4.1). Using the ε and the buoyancy frequency N^2, we can estimate the coefficient of vertical eddy diffusivity Kz, based on the dissipation method proposed by Osborn (1980), $Kz=\gamma\varepsilon/N^2$, where γ is the mixing ratio and to say less than 0.2.

Fig. 7.4.1 Microstructure profiler, TurboMAP-L

Fig. 7.4.2 Shear probe at the head of TurboMAP

The measurements with TurboMAP were carried out from the sea surface to the bottom, if the water depth is shallower than 500m. Fish of TurboMAP can hit the bottom protected by a guard, if the sea floor is expected not to be rock. Therefore, we can get the data to just above the bottom. At the station deeper than 600m, casting was termed when the fish approach 500m, then rewind the cable. However, since the fish is freely falling, it usually overshoots the depth, and actual measurement depth was from 520 to 570m depending on the loosing of the cable.

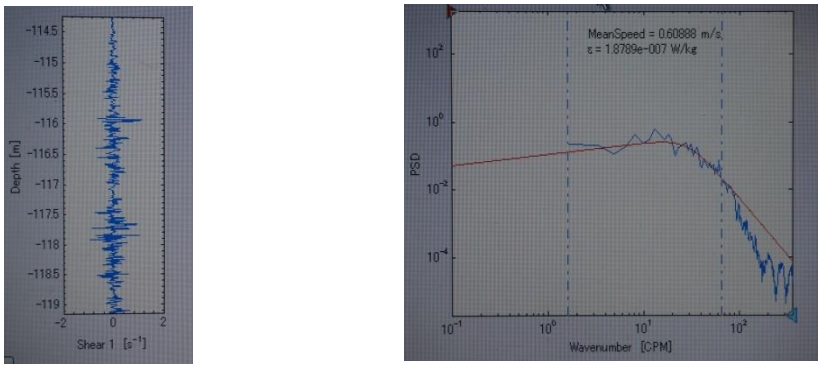


Fig.7.4.3 Example for (left) microscale current shear and (right) the shear spectrum with wave number.

7.5. Fast Repetition Rate fluorometry (FRRf) measurements

Z. Yhuali, J. Ishizaka, E.R. Maure and H. Naganuma (Nagoya University)

Active chlorophyll-*a* (Chl-*a*) fluorescence was measured semi-continuously using a FRR fluorometer (Diving Flash, Kimoto Electric) throughout the water column. Vertical speed was set to < 0.2 m s^{-1} to obtain fine vertical resolution data. This instrument is designed for measuring fluorescence simultaneously in both a "dark" chamber, which is fully shaded, and in "light" chamber equipped with a dichroic cyan filter to reduce the probable influence of red light effect. The FRRf uses a single-turnover protocol and was programmed to deliver sequences of 60 x 2 µs saturation flashes at 4 µs intervals followed by 20 x 2 µs relaxation flashes at 75 µs intervals. Blue LEDs are used for fluorescence excitation (445 - 495 nm and peak at around 470 nm as previously described (Fujiki et al., 2008). Inter-calibration of two chambers were done by comparing two chambers yield fluorescence of pre-dawn cast, and fluorescence parameters derived from both dark ($\boldsymbol{F_o}$, $\boldsymbol{F_m}$, $\boldsymbol{\sigma_{PSII}}$ and $\boldsymbol{F_v/F_m}$) and light (F', F_m', $\boldsymbol{\sigma_{PSII}}'$ and $\boldsymbol{F_q'/F_m'}$) chambers were provided with the instrument software (FRRCalc2, Kimoto) by the manufacturer whereby FRRf induction curves were fit to the KPF model (Kolber et al., 1998) to resolve physiological parameters.

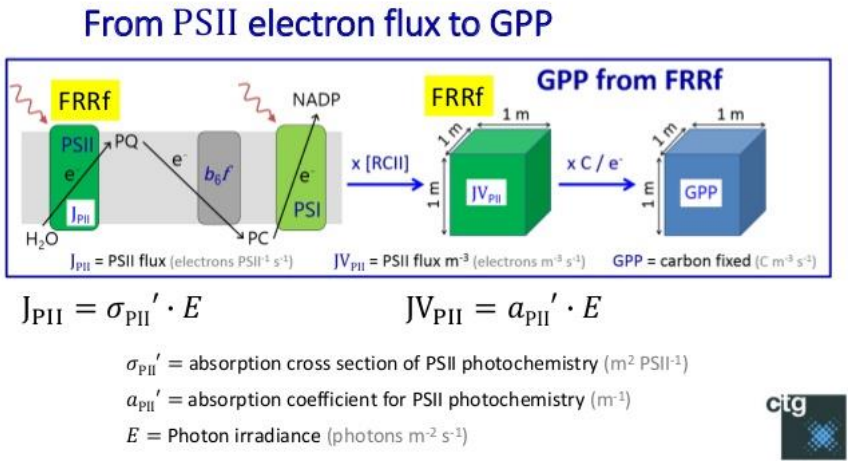


Fig.1. Schematic illustration of the FRRf principle (credits to the Chelsea Technologies Group, Ltd).

Then we calculate absolute electron transfer rate (ETR, mmol e^- (mg Chl-*a*)$^{-1}$ h^{-1}) by the following equation:

(1) $$\mathrm{ETR} = \mathrm{E} \times \sigma_{PSII}^{abs} \times n_{PSII} \times q_p \times 0.0243$$

where E is the irradiance (µmol quanta m^{-2} s^{-1}), σ_{PSII}^{abs} is the spectrally corrected effective absorption cross section of PSII (Å^2 quanta^{-1}), and n_{PSII} is the ratio of functional PSII reaction centres to Chl-*a* (mol RCII (mol Chl-a)$^{-1}$). q_p $(or\ F_q'/F_v')$ is the photochemical quenching coefficient under actinic light.

7.6. Profiling Reflectance Radiometer System (PRR-800)

E.R. Maure and H. Naganuma (Nagoya University)

The Profiling Reflectance Radiometer (PRR-800, Biospherical Instruments Inc.) is a free fall underwater optical instrument designed to measure vertically travelling light, downwelling irradiance ($E_{\mathrm{d}}(\lambda,\ z)$) and upwelling nadir radiance ($L_{\mathrm{u}}(\lambda,\ z)$) at 15 wavelengths between 380 and 694 nm, and Photosynthetically Available Radiation (PAR, between 400-700 nm). The instrument is deployed from a ship, supported by its own cable, and it should be floated away from the ship to avoid shadow effects. Tension in the cable during the free fall must be avoided to keep the vertical orientation of the instrument. Data acquisition is done through a computer interfaced to the PRR-800 deck box (Fig. 1). Simultaneously, a radiometrically identical deck sensor, above-water surface downwelling irradiance $E_{\mathrm{ds}}(\lambda,\ z)$, collects the incident irradiance at the sea surface (PRR-810, Fig. 1). This sensor should also be devoid of structural perturbations such as light reflected from the ship's superstructure. Calibration of the instrument is done on a yearly basis by K-engineering and field dark offsets are collected before deployment.

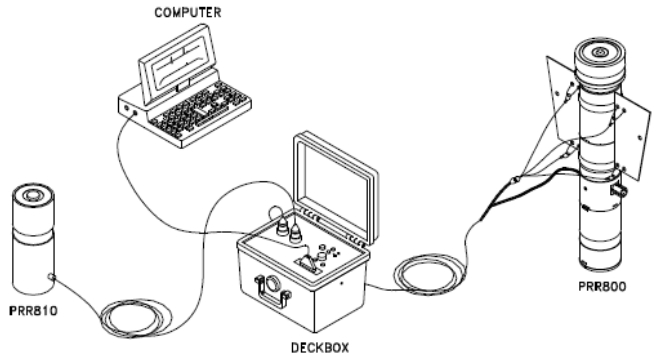


Fig.1. Schematic diagram showing the PRR-800/810 configuration used during deployment on R/V Hakuho-maru KH-15-3.

PRR-800 was deployed in the stations AND15/C3, AND16/C4, AND17/C5, AND26/D1, and AND31/D4. The PRR-800 casts collected in those stations will be used to calculate remote sensing reflectance, R_{rs} (Equation 1), and characterize the of water column light condition, e.g., euphotic depth (depth of 1% light level of incident PAR). For example, R_{rs} data are important for the validation of satellite derived values of the same parameter.

$$R_{rs}(\lambda) = \frac{L_w(\lambda)}{E_{ds}(\lambda)} \qquad (1)$$

where, L_w is the water leaving radiance, E_{ds} the incident irradiance at the sea surface.

7.7. Sediment sampling (Multiple corer)

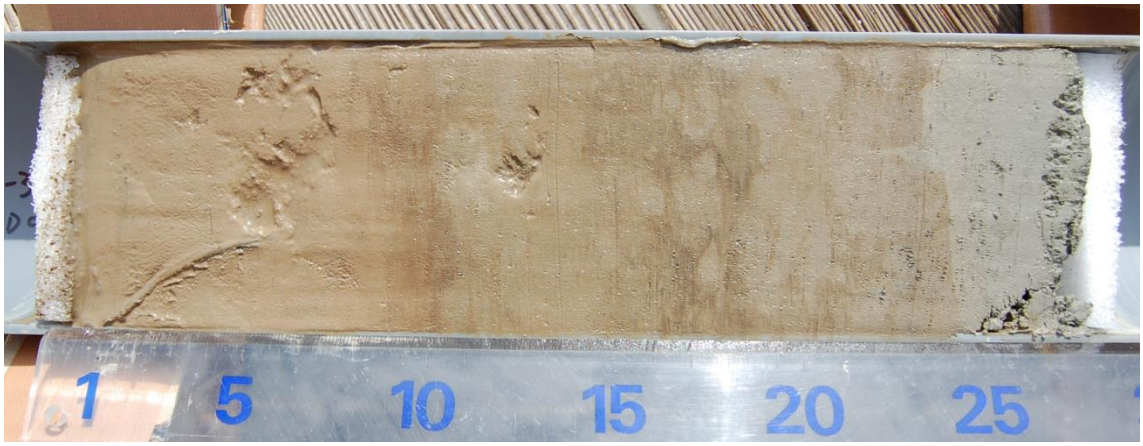
Keiji Horikawa (Graduate School of Science and Engineering for Research, University of Toyama)
Tomohiro Kodaira, Shyota Kambayashi, Ryosuke Kawanishi (Graduate School of Science and Engineering for Education, University of Toyama)
Kohji Marumoto (National Institute for Minamata Disease)
Corresponding researcher: KH (horikawa@sci.u-toyama.ac.jp)

During KH15-3 *R/V* Hakuho-maru cruise (called Andromeda Expedition), we used a multiple-corer (AORI, 450 kg weight) with eight 60 cm polycarbonate core tubes (9 cm diameter, Fig. 1) to obtain seafloor sediment. Surface sediments were obtained at 21 sites in the western North Pacific and in the East China Sea (Fig. 2 and Table.1).

Core samples were once reserved in a cold room (about 4°C) after recovery, and the sediment samples were sliced 1 cm thick (or 2 cm thick, dependent on research purpose) throughout the core within 24 hours, and kept in the cold room (4ºC) during the cruise. For one of the multiple cores taken at each site, we cut it into half and took a photograph onboard. Distribution list of requested sediments are also provided in Table 2.

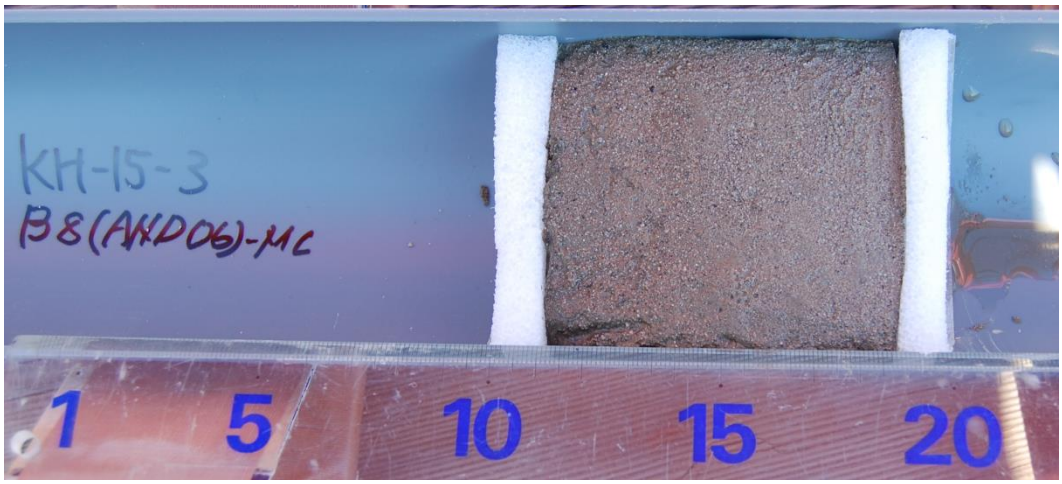
AND01

AND02

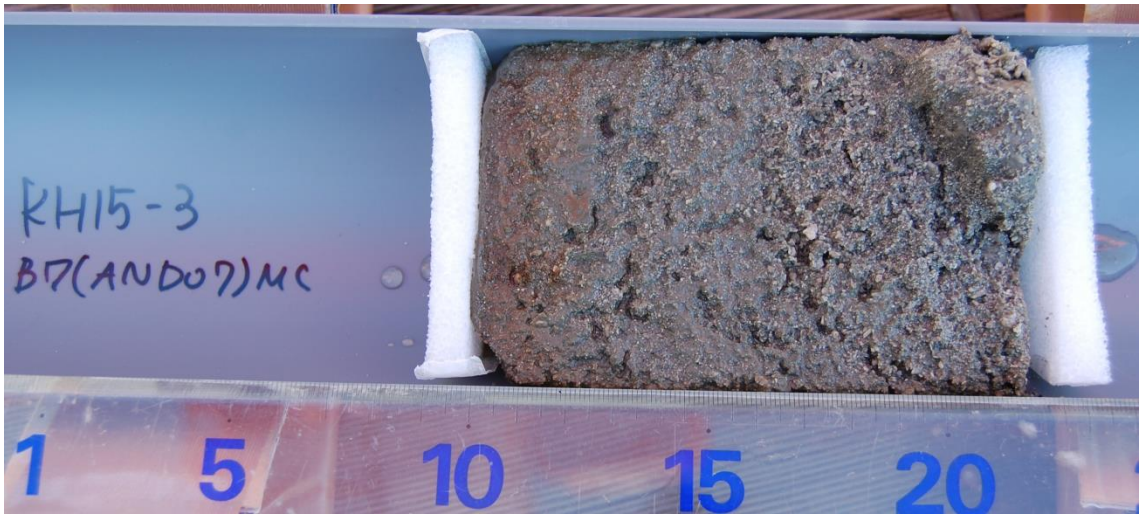


AND04

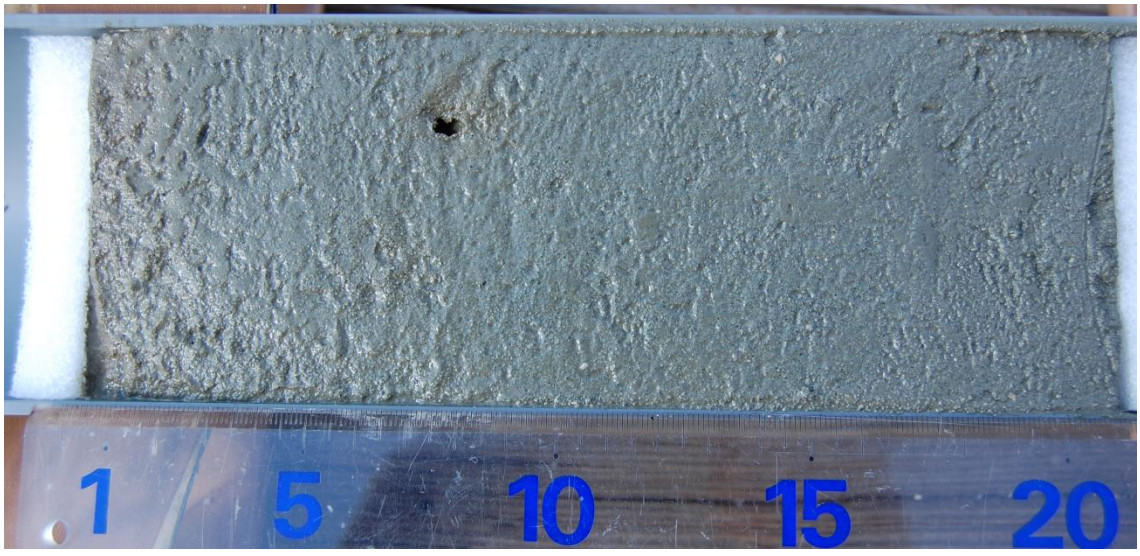
AND06



AND07



AND08



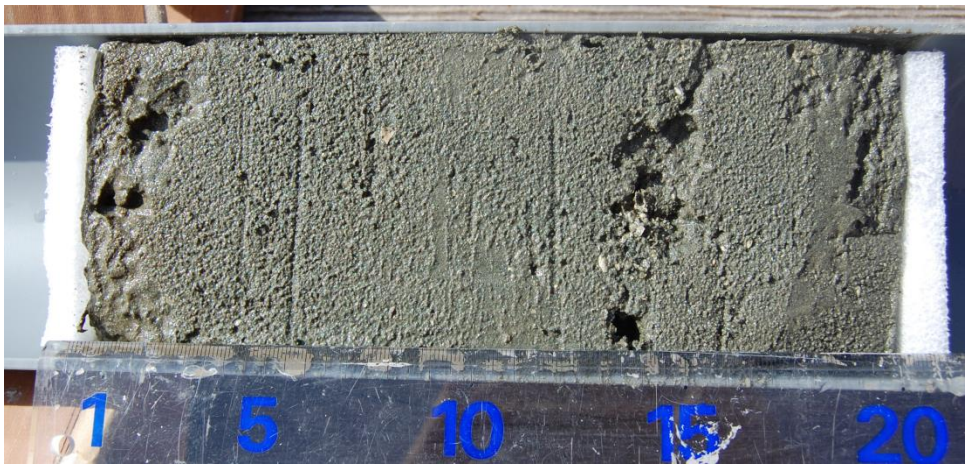
AND09

AND12

AND13

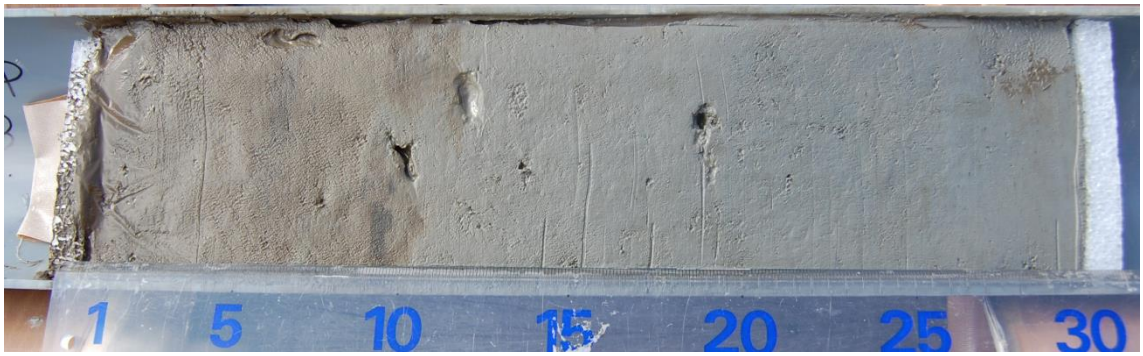
AND16

AND19

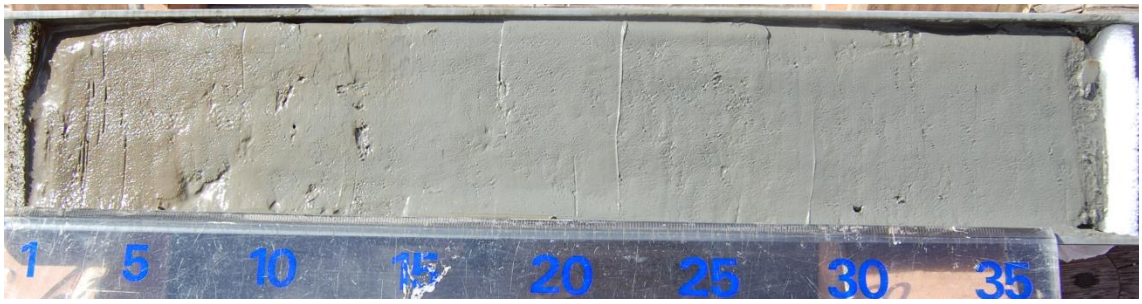


AND20

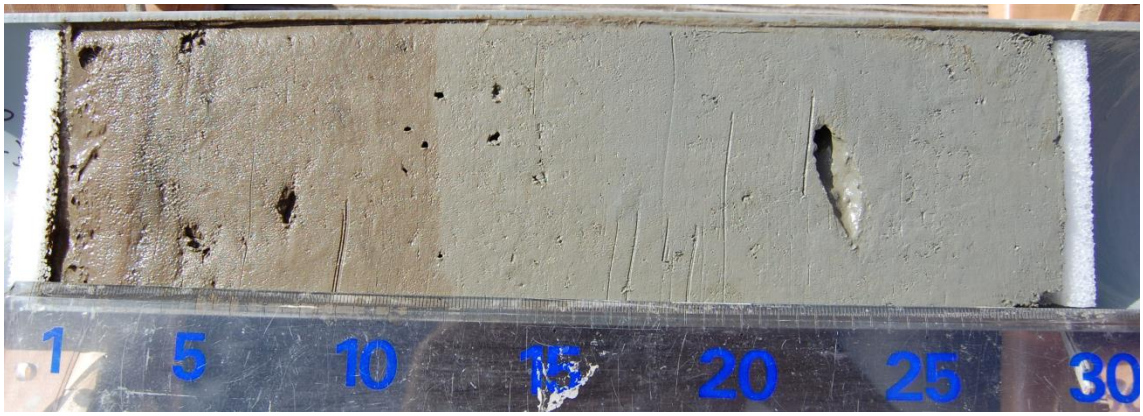
AND21



AND22



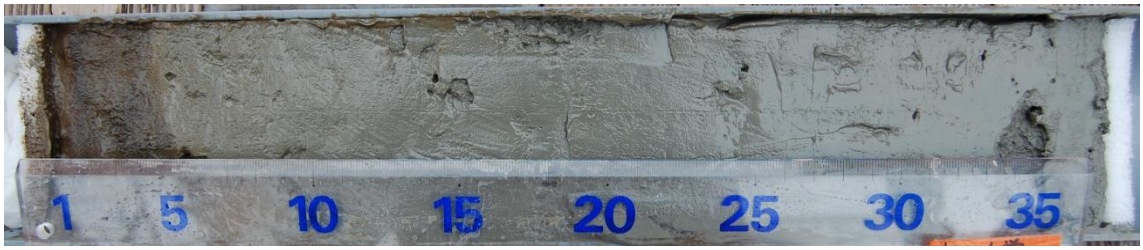
AND23



AND29

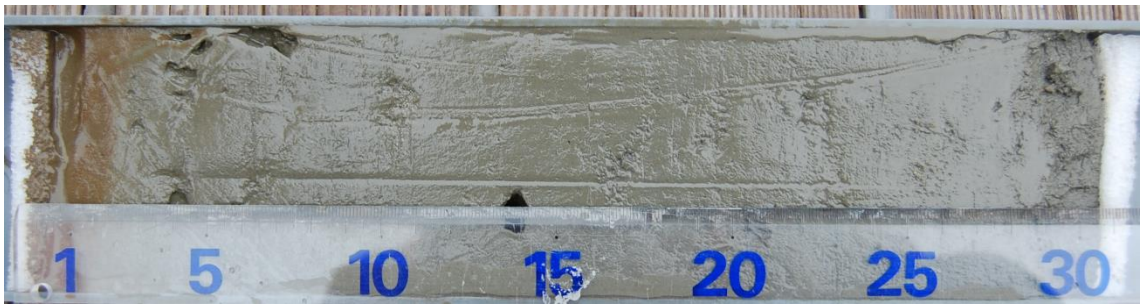
AND30

AND31



AND32

AND36



AND37

*left side is the top of the sediments

Table 1. Location of multiple cores obtained during the KH15-3 R/V Hakuho-maru cruise.

Date (JST)	Time (JST)	Station ID	Latitude	Longitude	Water depth (m)	Sedimentary Facies
2015/10/15	6:32	K1 (AND01)	32:40.982N	138:34.487E	3085	Foram-bearing calceous ooze
2015/10/15	15:49	K2 (AND02)	31:07.432N	138:41.252E	3279	Foram-bearing calceous ooze
2015/10/17	4:58	J1 (AND04)	31:36.976N	132:15.365E	1926	volcanic clastics,sandy silt with less foram
2015/10/17	22:34	A3 (AND05)	29:55.150N	129:44.671E	352	sediments were not obtained at this station
2015/10/18	8:36	B8 (AND06)	29:39.094N	129:06.140E	831	Foram-bearing sand
2015/10/18	12:59	B7 (AND07)	30:07.611N	128:34.093E	930	Foram-bearing sand
2015/10/18	19:40	B6 (AND08)	30:27.978N	128:05.152E	406	sand
2015/10/19	0:50	B5 (AND09)	30:55.034N	127:35.565E	126	sand
2015/10/19	16:29	B1 (AND12)	32:54.317N	125:59.953E	108	sandy silt
2015/10/19	23:26	C1 (AND13)	32:42.564N	124:50.153E	67	sandy silt
2015/10/20	13:57	C4 (AND16)	31:13.036N	126:00.046E	69	clayly silt
2015/10/21	3:06	C7 (AND19)	29:46.006N	127:17.341E	126	clayly silt
2015/10/21	11:52	C8 (AND20)	29:24.725N	127:50.404E	1026	Foram-bearing clay
2015/10/21	18:19	C9 (AND21)	28:59.272N	128:21.008E	1050	Foram-bearing clay
2015/10/25	21:56	F1 (AND22)	25:14.122N	122:59.787E	1660	Turbidite?, homogenized clay with woddy fragment and less foram
2015/10/26	16:20	E3 (AND23)	26:22.722N	125:42.239E	1888	Foram-bearing clay
2015/10/28	2:49	D2' (AND29)	28:35.143N	126:44.847E	175	sand
2015/10/28	4:25	D3 (AND30)	28:27.074N	126:49.298E	216	silty sand
2015/10/28	13:47	D4 (AND31)	28:17.467N	127:12.783E	1006	Foram-bearing clay
2015/10/28	23:40	D5 (AND32)	27:58.028N	127:35.856E	1319	Foram-bearing clay
2015/10/31	2:59	A1 (AND36)	30:57.969N	128:50.073E	689	Foram-bearing clay
2015/10/31	5:26	K5 (AND37)	31:01.750N	128:27.989E	317	sand

Lat/long position data were obtained from the bdirge log data (MC hits the bottom)
Water depth is PDR data when MC was in the surface (mainly based on our log note)

Table 2. Sample distributions of multiple cores in KH-15-3 cruise.

Core ID: K1(AND01)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	30	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
2	32	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
3	26	Honglian Ma	OUC	1cm thickness from top to bottom	Alkenone
4	21	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
5	27	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
6	26(25)	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
7	27	Keiji Horikawa	Univ. Toyama	Top 2 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
8	28	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

Core ID: K2(AND02)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	25	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
2	25	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
3	25	Honglian Ma	OUC	1cm thickness from top to bottom	Alkenone
4	21	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
5	24	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
6	24	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
7	25	Keiji Horikawa	Univ. Toyama	Top 2 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
8	28	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

Core ID: J1(AND04)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	28	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
2	28	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
3	28	Honglian Ma	OUC	1cm thickness from top to bottom	Alkenone
4	23	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
5	28.5	Keiji Horikawa	Univ. Toyama	Top 2 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
6	28	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
7	27.5	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

Core ID: A3(AND05)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1-8	-	Jing Zhang	Univ. Toyama	**NOT obtained at this site**	

Core ID: B8(AND06)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	7	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
2	9	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
3	6	Honglian Ma	OUC	1cm thickness from top to bottom	Alkenone
4	9	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
5	9	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
6	7.5	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

Core ID: B7(AND07)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	10	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
2	15	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
3	13	Honglian Ma	OUC	1cm thickness from top to bottom	Alkenone
4	11	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
5	5	Keiji Horikawa	Univ. Toyama	Top 2 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
6	10	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
7	12	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

Core ID: B6(AND08)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	11	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
2	21	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
3	19	Honglian Ma	OUC	1cm thickness from top to bottom	Alkenone
4	19	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
5	19	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
6	19	Keiji Horikawa	Univ. Toyama	Top 2 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
7	19	Keiji Horikawa	Univ. Toyama	Top 1 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
8	21	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

Core ID: B5(AND09)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	11	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
2	10	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
3	11	Honglian Ma	OUC	1cm thickness from top to bottom	Alkenone
4	11	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
5	12	Keiji Horikawa	Univ. Toyama	Top 2 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
6	9	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)

7	10.5	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

Core ID: B1(AND12)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	29	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
2	30	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
3	30	Honglian Ma	OUC	1cm thickness from top to bottom	Alkenone
4	25	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
5	30	Keiji Horikawa	Univ. Toyama	Top 2 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
6	17	Keiji Horikawa	Univ. Toyama	Top 10 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
7	30.5	Keiji Horikawa	Univ. Toyama	Top 10 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
8	32	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

Core ID: C1(AND13)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	34	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
2	33	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
3	34	Honglian Ma	OUC	1cm thickness from top to bottom	Alkenone
4	31	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
5	34	Keiji Horikawa	Univ. Toyama	Top 5 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
6	36	Keiji Horikawa	Univ. Toyama	Top 5 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
7	33.5	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

Core ID: C4(AND16)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	41	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
2	43	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
3	41	Honglian Ma	OUC	1cm thickness from top to bottom	Alkenone
4	33	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
5	41	Keiji Horikawa	Univ. Toyama	Top 5 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
6	41	Keiji Horikawa	Univ. Toyama	Top 5 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
7	41	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

Core ID: C7(AND19)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	17	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
2	17	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
3	17	Honglian Ma	OUC	1cm thickness from top to bottom	Alkenone
4	17	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
5	-			pipe supporter was broken and pipe was lost	
6	-			pipe supporter was broken and pipe was lost	
7	17	Keiji Horikawa	Univ. Toyama	Top 5 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
8	20	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

Core ID: C8(AND20)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	33	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
2	35	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
3	34	Honglian Ma	OUC	1cm thickness from top to bottom	Alkenone
4	31	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
5	34	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
6	34	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
7	32	Keiji Horikawa	Univ. Toyama	Top 5 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
8	32.5	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

Core ID: C9(AND21)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	33	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
2	33	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
3	31	Honglian Ma	OUC	1cm thickness from top to bottom	Alkenone
4	31	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
5	30	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
6	32	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
7	33	Keiji Horikawa	Univ. Toyama	Top 10 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
8	30.5	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

Core ID: F1(AND22)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	41	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
2	40	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
3	38	Honglian Ma	OUC	1cm thickness from top to bottom	Alkenone
4	37	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
5	39	Keiji Horikawa	Univ. Toyama	Top 10 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
6	40	Keiji Horikawa	Univ. Toyama	Top 10 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
7	38	Keiji Horikawa	Univ. Toyama	Top 10 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
8	40	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

Core ID: E3(AND23)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	28	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
2	27	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
3	27	Honglian Ma	OUC	1cm thickness from top to bottom	Alkenone
4	23	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
5	26	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
6	28	Keiji Horikawa	Univ. Toyama	Top 10 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
7	28	Keiji Horikawa	Univ. Toyama	Top 10 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
8	29	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

Core ID:D2'(AND29)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	14	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
2	19	Jing Zhang	Univ. Toyama	0.5cm thick (0-1cm), 1cm thick (1-4cm), 2cm thick below 4cm	Foram (Mg/Ca, Ba/Ca)
3	20	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
4	20	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

Core ID:D3(AND30)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	40	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
1		Honglian Ma	OUC		Foram (Mg/Ca, Ba/Ca)
2	35	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Alkenone
3	35	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
4	37.5	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

Core ID: D4(AND31)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	39	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
2	39	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
3	36	Honglian Ma	OUC	1cm thickness from top to bottom	Alkenone
4	36	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
5	39	Keiji Horikawa	Univ. Toyama	Top 10 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
6	39	Keiji Horikawa	Univ. Toyama	Top 10 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
7	39	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
8	38.5	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

Core ID: D5(AND32)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	27	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
2	27	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
3	28	Honglian Ma	OUC	1cm thickness from top to bottom	Alkenone
4	25	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
5	27	Keiji Horikawa	Univ. Toyama	Top 10 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
6	27	Keiji Horikawa	Univ. Toyama	Top 10 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
7	27	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
8	29	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

Core ID: A1(AND36)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	28	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
2	28	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
3	28	Honglian Ma	OUC	1cm thickness from top to bottom	Alkenone
4	28	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
5	27	Keiji Horikawa	Univ. Toyama	Top 10 cm (1 cm thick) was sampled	Foram (Mg/Ca, Ba/Ca)
6	30	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
7	30	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

Core ID: K5(AND37)-MC

Tube No.	Core length (cm)	Requester (onboard participant)	Affiliation	Sampling intervals	Objective
1	12	Jing Zhang	Univ. Toyama	1cm thickness from top to bottom	Trace metal
2	13	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
3	12	Honglian Ma	OUC	1cm thickness from top to bottom	Alkenone
4	12	Akinori Takeuchi	NIES	1cm thickness for the upper part of 5 cm. Below 5cm, 2cm thickness	T-Hg,MMHg
5	12	Keiji Horikawa	Univ. Toyama	top 1cm	Foram (Mg/Ca, Ba/Ca)
6	12	Keiji Horikawa	Univ. Toyama	top 1cm	Foram (Mg/Ca, Ba/Ca)
7	12	Keiji Horikawa	Univ. Toyama	1cm thickness from top to bottom	Foram (Mg/Ca, Ba/Ca)
8	12	Keiji Horikawa	Univ. Toyama	half cut	Core description/XRF core scanner

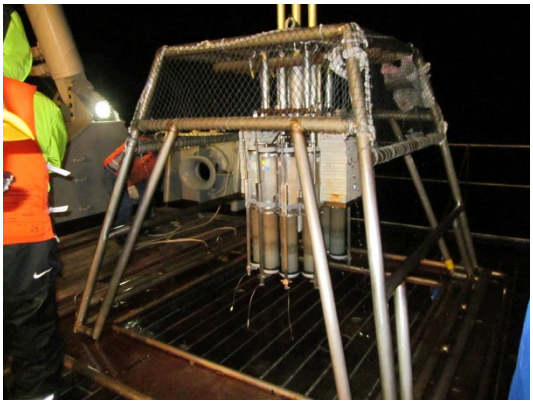


Fig. 1. Photo of the multiple-corer.

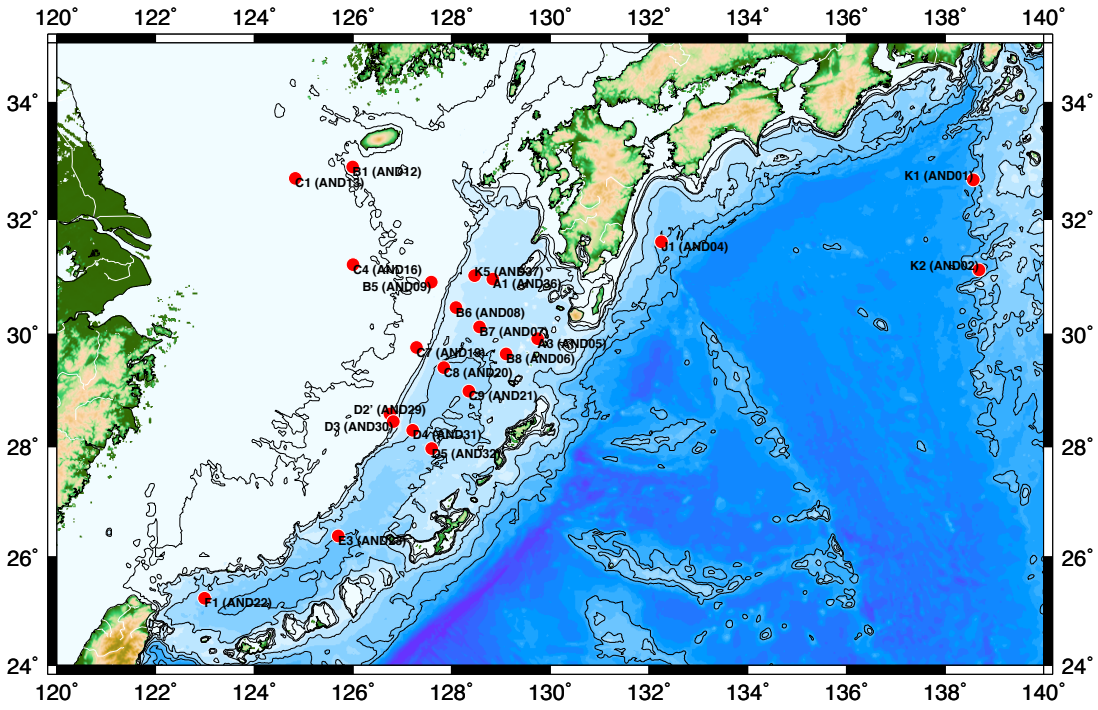


Fig. 2 Core site map

7.8. Routine analysis

7.8.1. Salinity

Salinity measurement group

Salinity was measured with the Autosal (Model 8400B, Guildline Instruments Ltd.) 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.

7.8.2. Dissolved oxygen

Keiji Horikawa, Tomohiro Kodaira, Shyota Kambayashi, Jiang Kai, Youhei Wakuta, Akito Ishida, Honglian Ma

Seawater samples for measurements of dissolved oxygen were collected in oxygen bottle with a volume of ~100 mL, avoiding the introduction of bubbles. Just after taking seawater samples, 1 mL of $MnCl_2$ solution and 1 mL of KI-NaOH solution were successively added to the bottles. This procedure fixes the dissolved oxygen in seawater as $MnO(OH)_2$ precipitate. After standstill for several hours for the precipitate to settling down the bottom of the bottle, ~1 mL of 10 N H_2SO_4 was added to the precipitation to release I_2. Then I_2 was titrated by 0.02 mol/L sodium thiosulfate ($Na_2S_2O_3$) standard solution, employing an automatic titrator (888 Titrando; Metrohm). Standardization of sodium thiosulfate titrant was calibrated by using 0.0100 N potassium iodate (KIO_3) solution.

7.8.3. Nutrients

Natsumi Oku, Yoshinori Ikeda, Yuzuru Nakaguchi

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

Nutrients are analyzed 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).

7.8.4. pH

pH measurement group

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 CTE42A (Yamato Scientific Co. Ltd.)) is circulated to hold the temperature of the inner seawater sample at 24.9±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 seawater sample bottle was placed in the temperature circulator water bath (25°C) for ~1 hour prior to the measurement. The pH measurement was therefore conducted in a completely closed environment with a constant temperature of 24.9±0.1°C.

Analysis time of each seawater sample is 15 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)), and AMP (Artificial Seawater (2-Aminopyridine)) were used for calibration of seawater pH scale (SWS). 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 the manual SOP6 (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.

7.8.5. Total alkalinity

TA-measurement group

1) Sampling

Seawater samples were collected with the Niskin bottle attached on the CTD system. Seawater for total alkalinity was transferred from the Niskin bottle to a 250 mL plastic sample bottle using a silicon tube. The seawater was overflowed by at least one bottle volume without rinsing.

2) Sample measurement

The total alkalinity will be measured onland after cruise using the high precision open-cell potentiometric titration method, described as SOP 3b of Dickson *et al.* (*Guide to best practices for ocean CO_2 measurements*; 2007), and also as ISO 22719:2008 "Water quality – Determination of total alkalinity in seawater using high precision potentiometric titration." The method is suitable for assaying oceanic levels of total alkalinity (2,000 µmol kg^{-1} to 2,500 µmol kg^{-1}) for normal seawater of practical salinity ranging from 30 to 40. In this cruise, we use two sets of the automatic total alkalinity titration equipment (ATT-05; KIMOTO ELECYRIC CO., LTD.). The bottles are put in a water bath kept at 25 °C before the titration. 100 ml of seawater is placed in a 125 ml tall beaker with calibrated Knudsen pipette, and titrated with 0.1 M HCl titrant in a two-stage titration. The sample of seawater is first acidified to a pH between 3.5 and 4.0. The solution is then stirred for 10 min. to allow for the escape of CO_2 that has evolved. The titration was continued until a pH of about 3.0 was been reached. The acid is made up in a solution of sodium chloride background (0.7M) to approximate the ionic strength of seawater to maintain approximately constant activity coefficients during the titration. The progress of the titration is monitored using a pH electrode.

3) Standardization and calculation

The concentration of HCl titrant is calibrated by a reference material for a dissolved inorganic carbon and alkalinity solution (The General Environmental Technos CO., LTD.). We also measure filtered surface seawater samples collected in the Yaizu coastal area as working standard to identify repeatability. To achieve the higher accuracy, the micro syringe pump and 100 ml of Knudsen pipette are calibrated by measuring the weight of pure water contained or delivered at standard temperature (20°C).

Total alkalinity of seawater is defined as the number of moles of hydrogen ion equivalent to the excess of proton acceptors in one kg of seawater sample. The mass of seawater samples is calculated by dividing the calibrated volume of Knudsen pipette by the density of seawater samples at the temperature of use. The total alkalinity is computed from the titrant volume and e.m.f measurements using a non-linear least-squares approach that corrects for the reactions with sulfate and fluoride ions.

7.8.6. Chlorophyll-*a*

E.R. Maure and H. Naganuma (Nagoya University)

Data sampling and filtration

Seawater samples for vertical profile of Chl-*a* were collected at discrete depths using Niskin bottles mounted on CTD. Samples for subsurface chlorophyll maximum (SCM) depths were determined from vertical profiles of fluorescence obtained from CTD. At each discrete depth, 100 mL of seawater was collected for Chl-*a* measurement. These samples were filtered onto 25 mm diameter Whatman GF/F glass fibre filters under low vacuum (< 0.02 MPa) and immediately soaked into 7 mL of N, N-dimethylformamide (DMF). The Chl-*a* pigment was extracted under dark condition for, at least, 24 hours at –20°C before the fluorescence measurement.

Fluorescence measurement and Chl-a concentration

Chl-*a* concentration was calculated using fluorometry. Turner Designs Model 10-AU fluorometer was used to read the fluorescence intensity of Chl-*a*. Blank correction was performed reading fluorescence intensity of DMF solution only in each sensitivity range (Low, Medium, and High) and the values respectively subtracted from the Chl-*a* fluorescence readings of each sample. The fluorometer was calibrated against known concentrations of purified Chl-*a* (Sigma) using spectrophotometer, and Chl-*a* concentration calculated according to the non-acidification method. The slopes of linear fits for three ranges (Low, 0.055-18.38 μg/L, Medium 30.64-183.84 μg/L, and High 306.40-1838.40 μg/L) were used accordingly as conversion coefficients from fluorescence to Chl-*a* concentration. Before fluorescence measurements, fluorometer was allowed to warm-up for about an hour and samples were brought to room temperature.

7.9. Particles (LISST)

Laser In-Situ Scattering and Transmissometry (LISST) can measure the distribution of particles with their amount for various sizes, determining the in-situ spectrum with particle size, based on principle of Laser reflection. Measurement components are distribution of particle size, VSF, transmissometry, pressure and temperature. The range of the particle concentration is 1~750 mg/l and resolution is less than 1 mg/l. The range of particle size is 1.25~250 μm and separated into 32 sizes. LISST was attached beside of CTD on the CTD frame (Photo.7.9.1) at the stations shallower than 200 m. Using LISST, we can see composition ratio of various particle sizes.

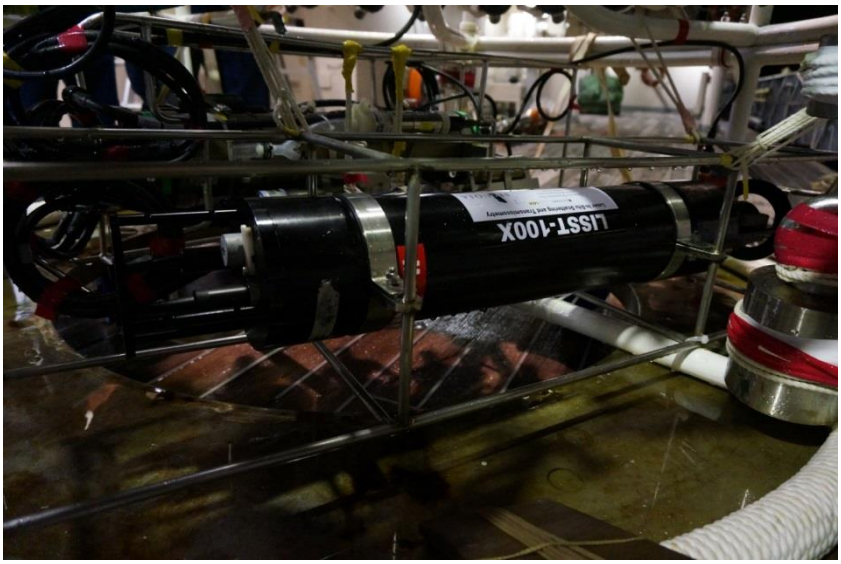


Photo 7.9.1 LISST attached beside of CTD on the CTD frame.

Table 1. Records for Norpac-net sampling

Net type	Station	Cast	Location		Depth	Time		Wire out	Mesh	Flow-meter	
			Lat.	Long.	(m)	Net in	Net out	(m)	size	No.	Revolution
Twin	K1 (AND01)	Cast-1	N32:41.01	E138:35.71	2991	2015/10/15 3:58	2015/10/15 4:10	51	XX13	3503	No data
		Cast-2	N32:41.00	E138:36.55		2015/10/15 4:13	2015/10/15 4:24	203	XX13	3503	No data
									NMG52	3433	No data
Twin	J3 (AND03)	Cast-1	N30:56.25	E133:11.71	4561	2015/10/16 16:17	2015/10/16 16:23	51	XX13	3503	648
		Cast-2	N30:56.86	E133:11.68		2015/10/16 16:47	2015/10/16 17:06	203	XX13	3503	2115
									NMG52	3433	2505
Twin	J1(AND04)	Cast-1	N31:32.92	E132:13.62	1958	2015/10/17 1:52	2015/10/17 2:00	51	XX13	3503	725
		Cast-2	N31:33.50	E132:13.84		2015/10/17 2:04	2015/10/17 2:17	203	XX13	3503	2205
									NMG52	3433	2571
Twin	A3 (AND05)	Cast-1	N29:55.18	E129:44.02	360	2015/10/17 20:27	2015/10/17 20:35	50	XX13	3503	580
		Cast-2	N29:55.11	E129:44.86		2015/10/17 20:40	2015/10/17 20:54	200	XX13	3503	2068
									NMG52	3433	2263
Twin	B8 (AND06)	Cast-1	N29:39.38	E129:08.21	836	2015/10/18 5:20	2015/10/18 5:27	50	XX13	3503	700
		Cast-2	N29:39.73	E129:08.63		2015/10/18 5:32	2015/10/18 5:45	200	XX13	3503	2210
									NMG52	3433	2300
Twin	B5 (AND09)	Cast-1	N30:54.65	E127:35.59	125	2015/10/18 23:37	2015/10/18 23:46	50	XX13	3503	405
									NMG52	3433	709
		Cast-2	N30:54.88	E127:35.64		2015/10/18 23:52	2015/10/19 0:00	100	XX13	3503	No data
									NMG52	3433	No data
Twin	B1 (AND12)	Cast-1	N32:55.41	E125:59.39	111	2015/10/19 14:56	2015/10/19 15:03	50	XX13	3503	553
									NMG52	3433	785
		Cast-2	N32:55.70	E125:59.21		2015/10/19 15:08	2015/10/19 15:15	50	XX13	3503	481
									NMG52	3433	579
Twin	C1 (AND13)	Cast-1	N32:43.11	E124:50.22	68	2015/10/19 21:57	2015/10/19 22:04	40	XX13	3503	482
									NMG52	3433	539
		Cast-2	N32:43.03	E124:50.28		2015/10/19 22:10	2015/10/19 22:16	40	XX13	3503	570
									NMG52	3433	659
Twin	C2 (AND14)	Cast-1	N32:13.94	E125:13.45	59	2015/10/20 3:06	2015/10/20 3:13	40	XX13	3503	565
									NMG52	3433	609
		Cast-2	N32:14.08	E125:13.37		2015/10/20 3:19	2015/10/20 3:25	40	XX13	3503	561
									NMG52	3433	533
Twin	C3 (AND15)	Cast-1	N31:42.91	E125:38.28	63	2015/10/20 7:51	2015/10/20 8:02	51	XX13	3503	740
									NMG52	3433	1098
		Cast-2	N31:42.76	E125:38.42		2015/10/20 8:08	2015/10/20 8:14	45	XX13	3503	540
									NMG52	3433	704
Twin	C4 (AND16)	Cast-1	N31:12.99	E126:01.23	71	2015/10/20 12:08	2015/10/20 12:13	50	XX13	3503	640
									NMG52	3433	710
		Cast-2	N31:12.93	E126:01.08		2015/10/20 12:20	2015/10/20 12:26	50	XX13	3503	550
									NMG52	3433	705
Twin	C7 (AND19)	Cast-1	N29:46.04	E127:17.57	125	2015/10/21 1:51	2015/10/21 1:59	50	XX13	3503	370
									NMG52	3433	No data
		Cast-2	N29:46.04	E127:17.60		2015/10/21 2:05	2015/10/21 2:13	100	XX13	3503	940
									NMG52	3433	1203
Twin	C8 (AND20)	Cast-1	N29:25.07	E127:50.28	1008	2015/10/21 7:06	2015/10/21 7:12	50	XX13	3503	646
									NMG52	3433	775
		Cast-2	N29:25.72	E127:50.53		2015/10/21 7:18	2015/10/21 7:34	200	XX13	3503	2275
									NMG52	3433	2448
Twin	F1 (AND22)	Cast-1	N25:10.65	E122:57.45	1669	2015/10/25 13:43	2015/10/25 13:52	50	XX13	3503	613
									NMG52	3433	720
		Cast-2	N25:11.13	E122:58.03		2015/10/25 13:58	2015/10/25 14:13	200	XX13	3503	2122
									NMG52	3433	2350
Twin	D1 (AND26)	Cast-1	N28:59.90	E126:10.05	105	2015/10/27 11:33	2015/10/27 11:42	50	XX13	3503	419
									NMG52	3433	620
		Cast-2	N28:59.84	E126:10.36		2015/10/27 11:48	2015/10/27 11:55	80	XX13	3503	869
									NMG52	3433	909
Twin	D2' (AND29)	Cast-1	N28:34.64	E126:46.40	197	2015/10/27 1:23	2015/10/27 1:28	50	XX13	3503	640
									NMG52	3433	700
		Cast-2	N28:34.58	E126:46.82		2015/10/27 1:35	2015/10/27 1:46	151	XX13	3503	1641
									NMG52	3433	1882
Twin	D4 (AND31)	Cast-1	N28:21.55	E127:16.93	1066	2015/10/28 16:40	2015/10/28 16:47	50	XX13	3503	652
									NMG52	3433	730
		Cast-2	N28:22.11	E127:17.34		2015/10/28 16:53	2015/10/28 17:06	200	XX13	3503	2011
									NMG52	3433	2295
Twin	I1 (AND34)	Cast-1	N29:22.18	E130:46.17	3039	2015/10/30 6:55	2015/10/30 7:00	50	XX13	3503	580
									NMG52	3433	602
		Cast-2	N29:22.13	E130:46.40		2015/10/30 7:07	2015/10/30 7:18	203	XX13	3503	2114
									NMG52	3433	2262
Twin	A1 (AND36)	Cast-1	N30:57.89	E128:49.42	683	2015/10/30 23:42	2015/10/30 23:49	50	XX13	3503	340
									NMG52	3433	615
		Cast-2	N30:57.90	E128:49.32		2015/10/30 23:56	2015/10/31 0:08	200	XX13	3503	1960
									NMG52	3433	2070

7.10. ADCP

E. Tsutsumi

Vertical structure of horizontal current such as Kuroshio Current, tidal currents, and so on is an important factor to understand vertical mixing processes. To obtain current profiles, a vessel-mounted 38kHz Acoustic Doppler Current Profiler (ADCP) is used. The ADCP is set to measure current velocity from 38.4 (1st layer) to 1296.4 meters depth (80th layer) where each layer has 16 meters thickness. It is also set to measure nearly every 7 seconds. Fig.1, 2 and 3 show 10-min average current velocity along the ship's track at 1st (32.4 m below the sea surface), 5th (96.4m) and 18th layer (304.4m), respectively.

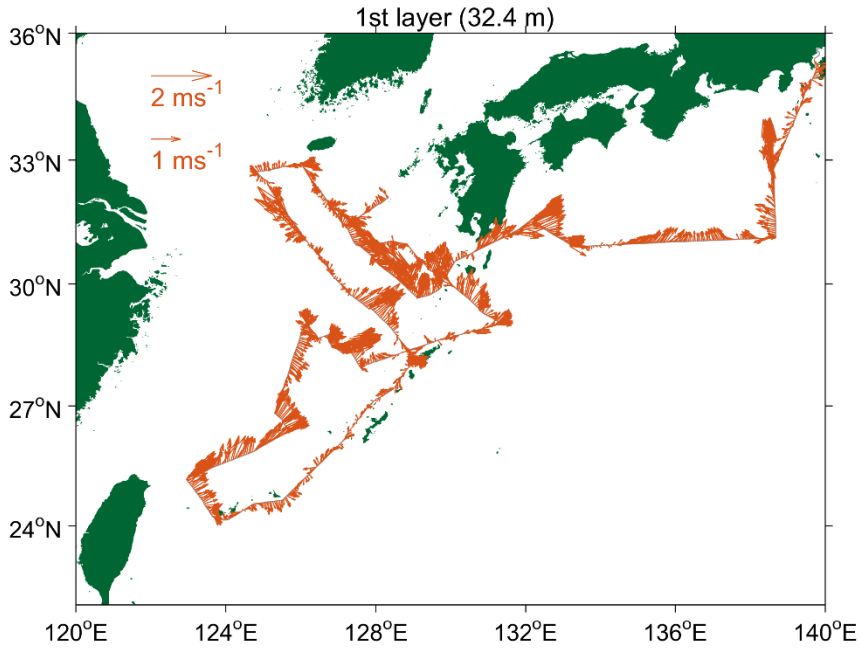


Fig.1 Absolute current velocity vector at the 1st layer (32.4 m depth) along the ship's track. Velocity reference is derived from the navigation system of the ship.

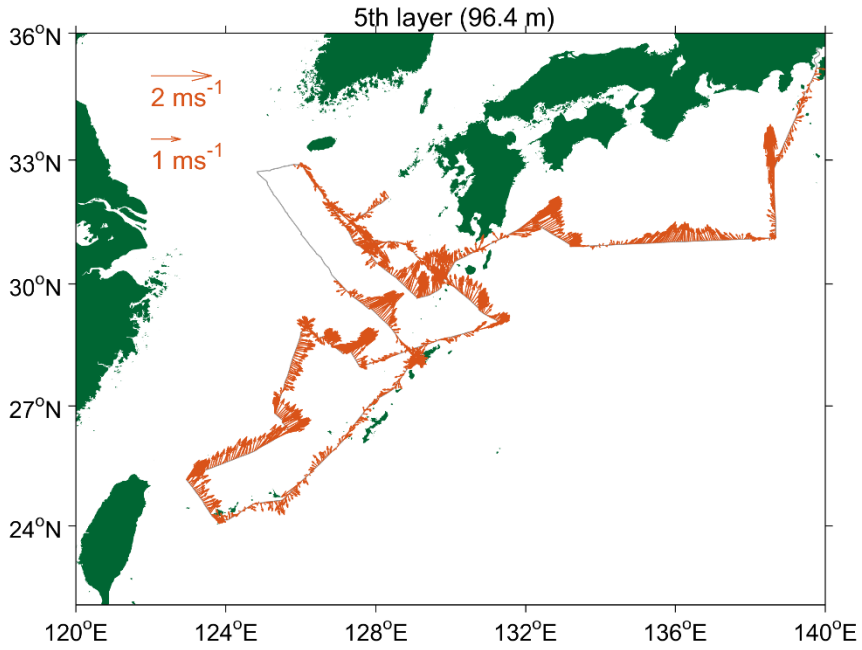


Fig.2 Same as Fig.1 but for 5th layer (96.4m depth).

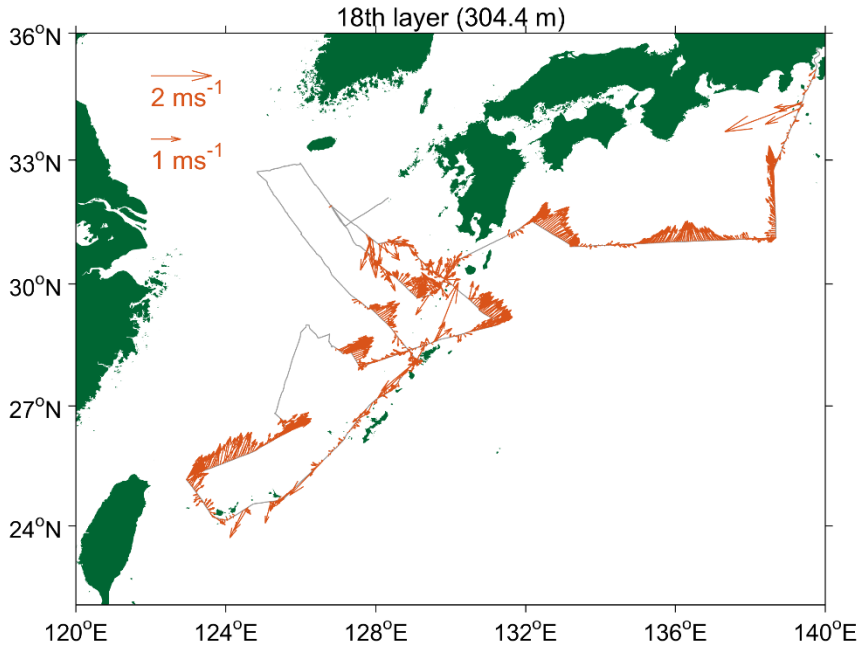


Fig.3 Same as Fig.1 but for 18th layer (304.4m depth).

9. Hydrographic background

T. Matsuno and the figures are drawn by K.J. Lee

Hydrographic background can be easily found with vertical sections of temperature, salinity, density and dissolved oxygen obtained by CTD and oxygen sensors along B, C, E, D and A sections which are sequence of observation date. CTD cast was carried out from 5~10 m below the sea surface to 5~10 m above the sea bottom, depending on the sea condition and water depth. The first section obtained in this cruise was along the section B, where B4 and B7 were skipped for saving time. Vertical sections of temperature, salinity, density and dissolved oxygen are shown in Fig.9-1.

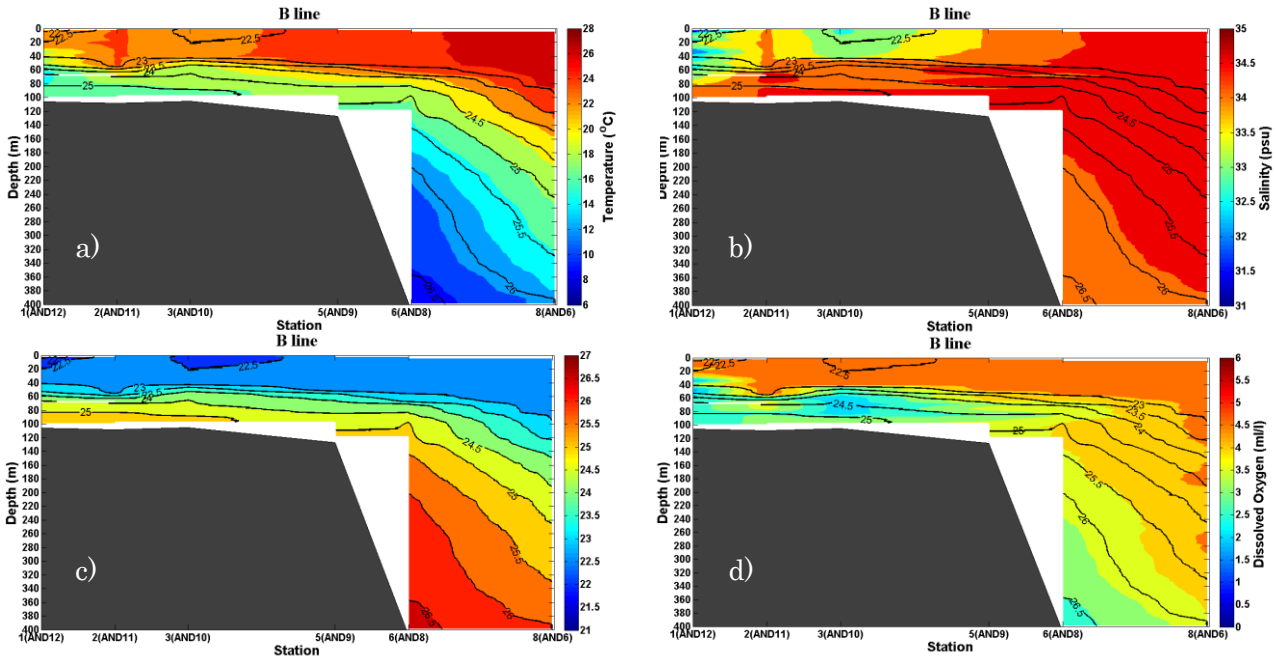


Fig.9-1 Vertical sections of a) temperature, b) salinity, c) density and d) dissolved oxygen obtained by CTD along the section B on 19 Oct, 2015. Contours in each panel indicate isopycnals. Vertical range is limited to 400 m to see the structure on the shelf easily, while the observations were carried out to just above the bottom.

We can see the Kuroshio in the slope region with inclined isotherms and isopycnals. In the shelf region, we ca see low dissolved oxygen water less than 3ml/l in the bottom layer.

Vertical section of temperature, salinity, density and dissolved oxygen along the section C are shown in Fig.9-2. Clear inclination of the isopycnals due o the Kuroshio are found in the slope reion similarly to the section B. Less saline water compared with along the secton B was found in the shelf region. Dissolved oxygen in the bottom layer on the shelf was lower than that along the section B, and less than 2 ml/l.

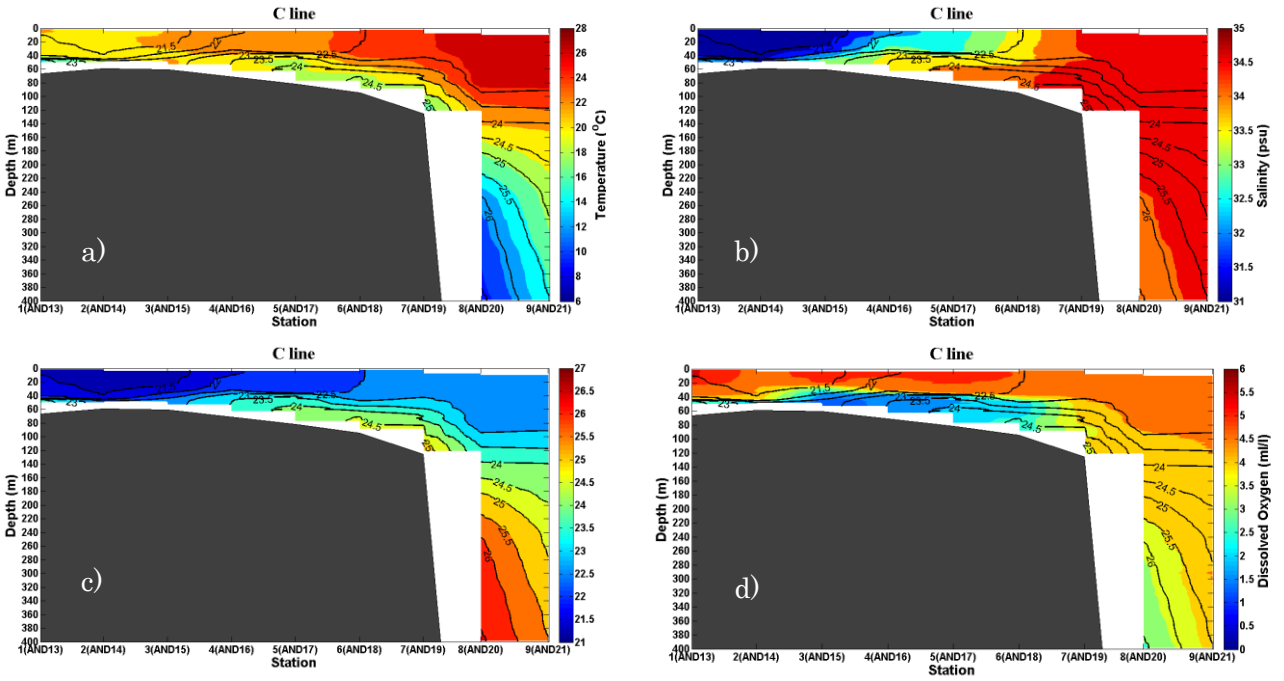


Fig.9-2 Vertical sections of a) temperature, b) salinity, c) density and d) dissolved oxygen obtained by CTD along the section C on 19, 20 and 21 Oct, 2015. Contours in each panel indicate isopycnals. Vertical range is the same as Fig.9-1.

Vertical section of temperature, salinity, density and dissolved oxygen along the section E are shown in Fig.9-3. The section E consists of three stations.

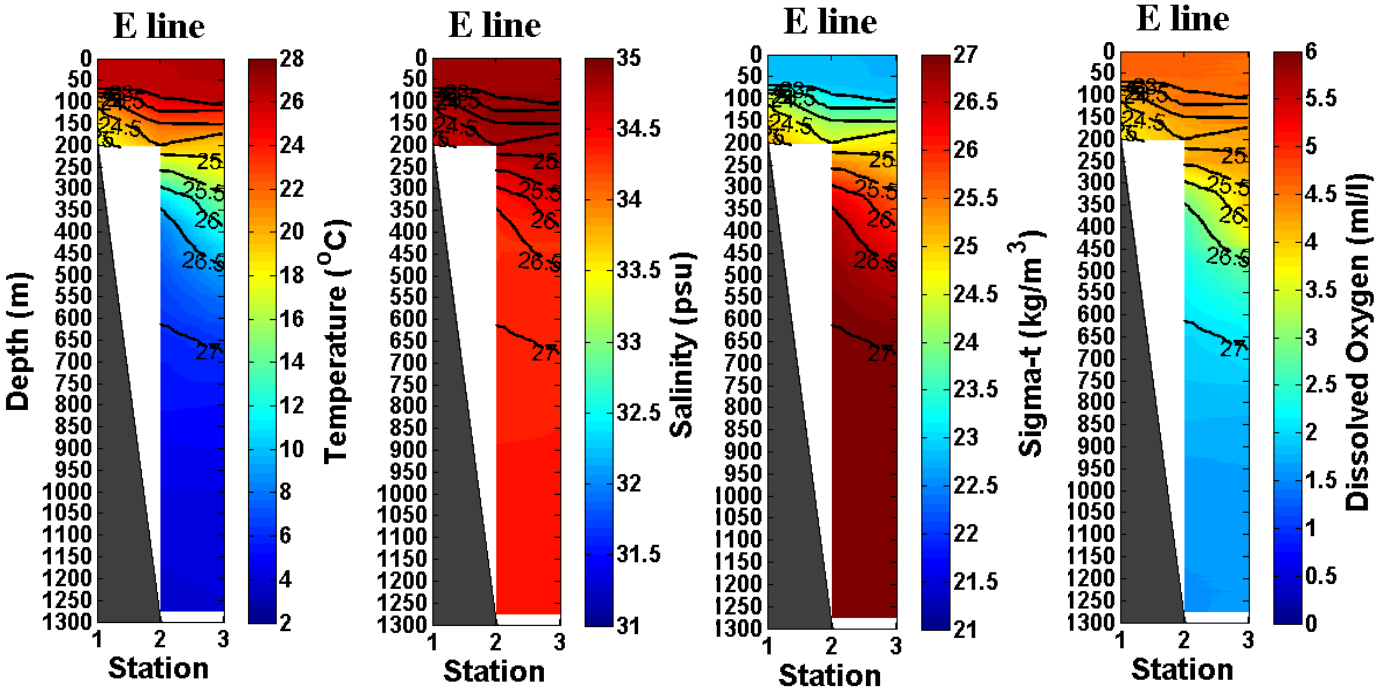


Fig.9-3 Vertical sections of (left to right) temperature, salinity, density and dissolved oxygen obtained by CTD along the section E on 26 Oct, 2015. Contours in each panel indicate isopycnals.

Vertical section of temperature, salinity, density and dissolved oxygen along the section D are shown in Fig.9-4. The section D corresponds to a part of the PN-section, which is a traditional section regularly obsered by Japan Meteorology Agency for long term. Each structure around the shelf break and slope region shows typical structure of the Kuroshio.

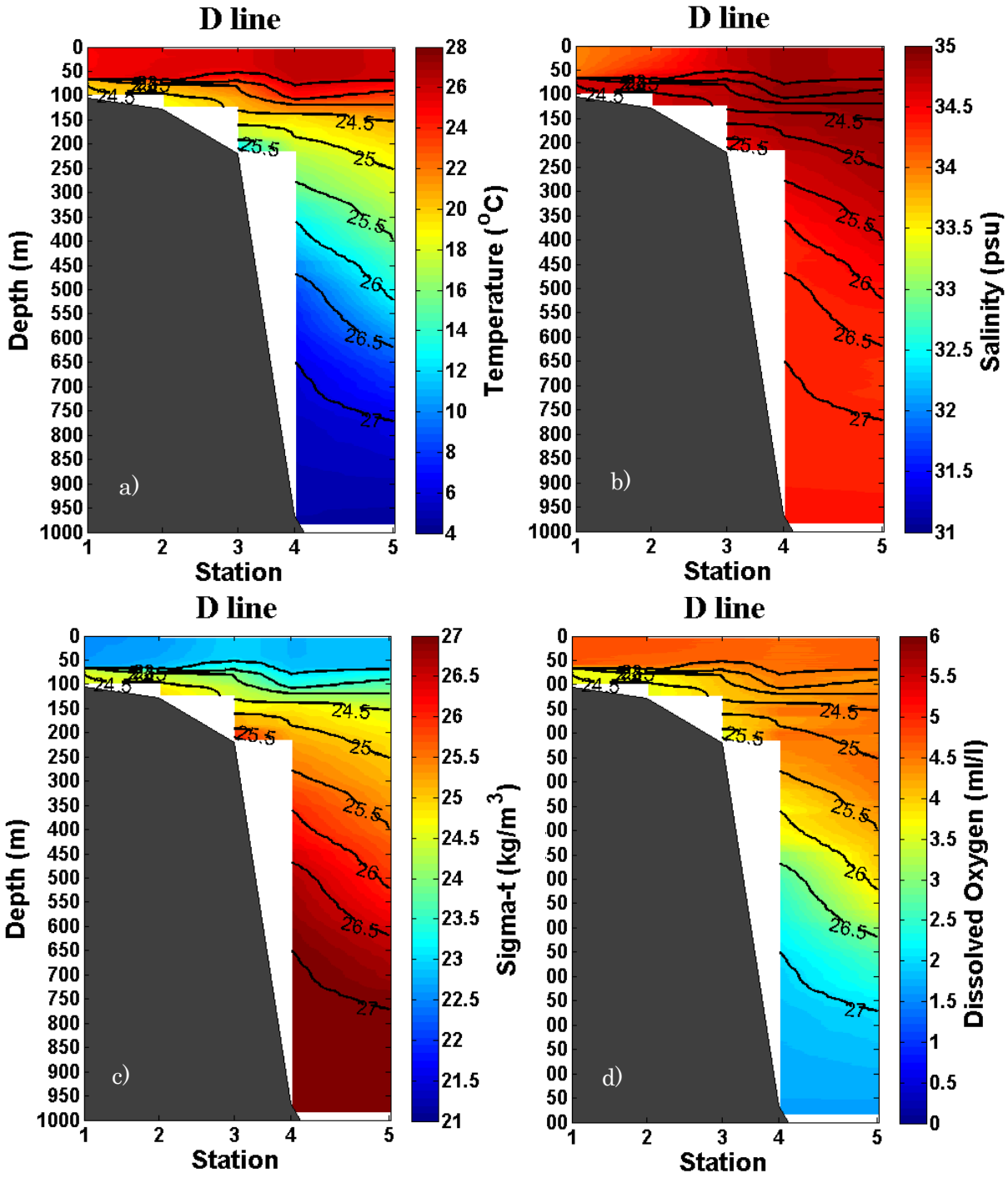


Fig.9-4 Vertical sections of a) temperature, b) salinity, c) density and d) dissolved oxygen obtained by CTD along the section D on 27 and 28 Oct, 2015. Contours in each panel indicate isopycnals.

Vertical section of temperature, salinity, density and dissolved oxygen along the section I and A are shown in Fig.9-5. The sections I and A are located around Tokara Strait, where the Kuroshio passes through from the East China Seaa to the Pacific Ocean, and there are many islands and sea mountains. While the observations at Stn.A3 was carried out on 17 Oct, about 2 weeks before the other observations in this section. It is found that the Kuroshio was located between A2 and I1.

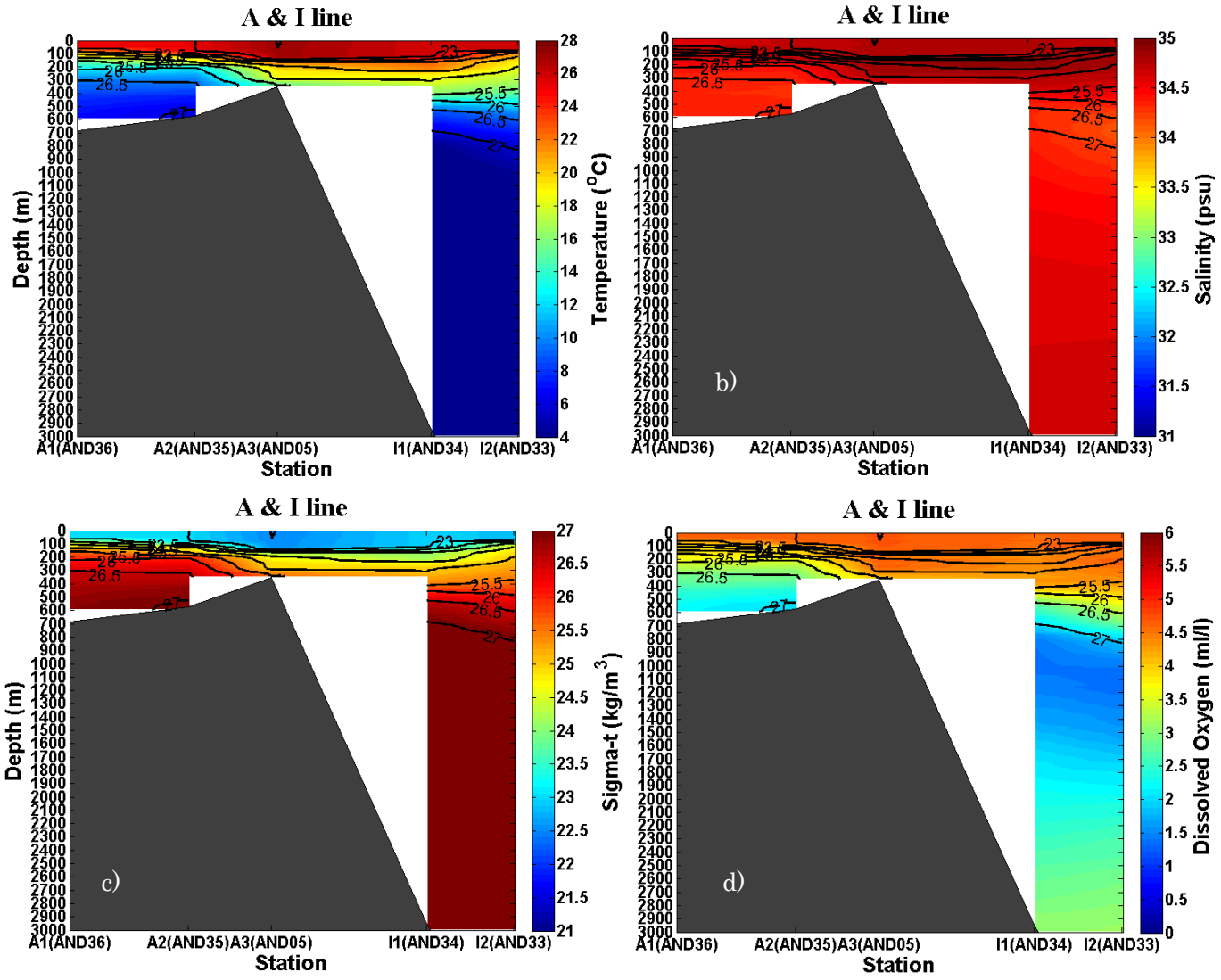


Fig.9-5 Vertical sections of a) temperature, b) salinity, c) density and d) dissolved oxygen obtained by CTD along the section A and I observed on 17, 29,30 and 31 Oct, 2015. Contours in each panel indicate isopycnals.

10.1. Distributions and their speciation of trace metals in the East China Sea and Kuroshio Water

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1) Distributions of trace metals in the East China Sea and Kuroshio Water

1-1) Objective

Trace metals, such as Fe, Mn, Zn and Cu are now thought to be essential for phytoplankton growth in the open oceans. However, distributions of trace metals have not been investigated intensively in the marginal seas, like the East China Sea. To understand the marine biogeochemical cycles of trace metal, we need to investigate the detailed distributions of trace metals in the marginal seas. In this study, we will study the distributions of dissolved trace metals (Fe, Mn, Zn, Cu, Cd, Ag and Pb etc.) in the East China Sea, as the international GEOTRACES project.

1-2) 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.

CTD sampling

Station: AND- 06 (B8), 22 (F1), 26 (D1), 31 (D4) and 34 (I1)

Depth (m): 10, 20, 30, 50, 100, 150, 200, 250, 300, 400, 500, 600, 800, 1000, 1200, 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. 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.

2) Trace metal speciation in the East China Sea and Kuroshio Water

2-1) Introduction

Trace metals, such as Fe, Cu and Zn, 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 seawaters of the marginal seas. In this study, we will investigate trace metal speciation in the East China Sea by using cathodic stripping voltammetry (CSV).

2-2) 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^{o}C and stored.

CTD sampling

Station: AND- 06 (B8), 22 (F1), 26 (D1), 31 (D4) and 34 (I1)

Depth (m): 10, 30, 50, 100, 150, 200, 300, 400, 600, 800, 1000, 1500, 2000, 3000, 4000, 5000, Bottom

2-3) Methods

On the land-based laboratory, ligand concentrations and conditional stability constants for Zn, Cu and Fe 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).

10.2. Distribution of trace metals (Al, Mn, Fe, Co, Ni, Cu, Zn, Cd, Pb, and Au) and their isotopes (δ^{66}Ni, δ^{65}Cu, δ^{66}Zn, δ^{98}Mo, and δ^{186}W) in the East China Sea and Kuroshio water

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(Institute for Chemical Research, Kyoto University)

Objectives

In the modern ocean, the distributions of trace metals are important, since they can be a limiting factor of biological production and a potential toxicant to organisms at a high concentration. Our laboratory have developed a method for simultaneously preconcentrating the multi-elements by using chelating resin NOBIAS CHELATE-PA1 (Hitachi High-Technologies)[1]. In this study, we will clarify the sectional distribution of bioactive trace metals (Al, Mn, Fe, Co, Ni, Cu, Zn, Cd, and Pb) and Au at clean stations in the East China Sea and Kuroshio water (AND6, AND22, AND26, AND31, AND34). And we will also clarify the isotopic compositions of Ni (δ^{60}Ni), Cu (δ^{65}Cu), Zn (δ^{66}Zn), Mo (δ^{98}Mo), and W (δ^{186}W).

Sampling method

Seawater samples were collected using the clean CTD sampling system. Seawater samples were passed through an AcroPak cartridge filter and distributed to each bottle in a clean bubble. Unfiltered seawater were also sampled for bioactive trace metals. All the samples were acidified in a clean room (No.4 Lab) with HCl. A kind of sample bottles and the grade of HCl for acidification were summarized in a table below.

Elements	Sample bottles	Grade of HCl
Bioactive trace metals	250 mL LDPE bottle (Nalgene)	Optima (Thermo)
Au	4 L LDPE bottle (Nalgene)	Ultrapur-100 (Kanto Chemicals)
Ni (δ^{60}Ni), Cu (δ^{65}Cu), Zn (δ^{66}Zn)	1 L LDPE bottle (Nalgene)	Ultrapur-100 (Kanto Chemicals)
Mo (δ^{98}Mo), W (δ^{186}W)	5 L LDPE bag (AS ONE)	Reagent grade (Wako)

Land-based experiments

Trace metals will be pre-concentrated from seawater by chelating resin columns. The concentrations of bioactive trace metals and Au will be determined by HR-ICP-MS following pre-concentration. Ni, Cu, Zn, Mo, and W in pre-concentrated samples will be purified by ion exchanging for the isotopic measurement. Isotope ratios will be measured by multi-collector ICP-MS.

Reference:

Sohrin, Y. *et al.* Multielemental determination of GEOTRACES key trace metals in seawater by ICPMS after preconcentration using an ethylenediaminetriacetic acid chelating resin. *Anal. Chem.* **80**, 6267-6273 (2008).

10.3. Chemical speciation of selenium in the East China Sea

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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 East China Sea are still not well known. The purpose of this research cruise is making of the cross-sectional distribution of three selenium species in the East China Sea.

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.

10.4. Mercury (Hg) distribution in the East China Sea

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Kohji Marumoto (National Institute for Minamata Disease)
Hitoshi Kodamatani (on-land, Kagoshima University)

Introduction and objectives

Mercury (Hg) becomes a global pollutant. East and Southeast Asia contributes approximately 50% of the global total anthropogenic mercury emissions. It can be transported and deposited to East China Sea. Hg also can be transformed to methylated form (MMHg) in aquatic environment, which is more toxic than inorganic Hg (Hg^{2+}) to human and wildlife health. MMHg tends to be accumulated in biota, and it has been concerned about its concentrations in fishes. With regard to the Hg pollution, present-day concentrations of Hg in East China Sea must be determined. Thus, seawater, sediments, atmospheric Hg, and planktons were sampled in this cruise.

Inventory information for the sampling

Seawater

Approximately 1.5L of the seawater samples were filtered by 0.45 μm membrane within 24 hours after their samplings. Containers are all pre-cleaned Teflon bottles, and labwares used for filtration were all glasswares. The filtered seawater samples were divided into two aliquots. Approximately 800 mL of the samples were collected for MMHg analysis. 4 mL of high purity H_2SO_4 was added to each sample, and they were stored in a cool room. Approximately 200 mL of the filtered samples were preserved for total Hg analysis. 1 mL of high purity HCl was added to each bottle, and they were stored in a cool room too. In addition, surface seawater samples were collected by a custom-made Teflon sampler. They were treated as the same as other seawater samples. The following tables indicate the samples collected during the KH15-3 cruise.

Table 1.1 Surface seawater sample list for Hg analysis

	AND 03	AND 04	AND 05	AND 06	AND 09	AND 10	AND 12	AND 13	AND 15
S0	○	○	○	○	○	○	○	○	○

	AND 16	AND 18	AND 19	AND 21	AND 22	AND 23	AND 25	AND 26	AND 30
S0	○	○	○	○	○	○	○	○	○

	AND 31	AND 33	AND 34	AND 35	AND 36				
S0	○	○	○	○	○				

Table 1.2 Subsurface seawater sample list for Hg analysis

	AND 06		AND 22		AND 26	AND 29	AND 31		AND 34
Depth (m)	Clean	Normal	Clean	Normal	Clean	Clean	Clean	Normal	Clean
10	○		○		○		○		○
20	○		○	○	○		○	○	○
30	○		○		○		○		○
40	○				○				
50	○	○	○		○		○		○
75	○		○	○	○		○		
100	○	○	○				○	○	○
125	○			○					
150	○		○				○		○
200	○	○	○	○			○		○
250			○				○		○
300	○		○				○		○
400	○	○	○	○			○		○
500	○		○					○	○
600	○	○	○	○			○		
700	○								
800			○	○			○		
1,000			○						○
1,200			○						
1,250				○					
1,500			○						○
2,000									○
2,500									○
Bottom	○	○	○	○	○	○	○		○

Sediments

Sediment cores were collected by a multiple core sampler. Length of the collected cores range from 15 to 40 cm. Some of them were composed of greenish gray silty sand to clay, and the others were consisted of brownish and greenish gray silty clay to clay. 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. The following table indicates the collected sediment samples (Table 2).

Table 2. Sample list of sediments for Hg analysis

Depth (cm)	AND 01	AND 02	AND 03	AND 04	AND 06	AND 07	AND 08	AND 09	AND 12	AND 13
0 – 1	○	○	○	○	○	○	○	○	○	○
1 – 2	○	○	○	○	○	○	○	○	○	○
2 – 3	○	○	○	○	○	○	○	○	○	○
3 – 4	○	○	○	○	○	○	○	○	○	○
4 – 5	○	○	○	○	○	○	○	○	○	○
5 – 7	○	○	○	○	○	○	○	○	○	○
7 – 9	○	○	○	○	○	○	○	○	○	○
9 – 11	○	○	○	○			○	○	○	○
11 – 13	○	○	○	○			○		○	○
13 – 15	○	○	○	○			○		○	○
15 – 17	○	○	○	○			○		○	○
17 – 19	○	○	○	○					○	○
19 – 21	○	○	○	○					○	○
21 – 23									○	○
23 – 25									○	○
25 – 27										○
27 – 29										○
29 – 31										○

Depth (cm)	AND 16	AND 19	AND 20	AND 21	AND 22	AND 23	AND 29	AND 30	AND 31	AND 32
0 – 1	○	○	○	○	○	○	○	○	○	○
1 – 2	○	○	○	○	○	○	○	○	○	○
2 – 3	○	○	○	○	○	○	○	○	○	○
3 – 4	○	○	○	○	○	○	○	○	○	○
4 – 5	○	○	○	○	○	○	○	○	○	○
5 – 7	○	○	○	○	○	○	○	○	○	○
7 – 9	○	○	○	○	○	○	○	○	○	○
9 – 11	○	○	○	○	○	○	○	○	○	○
11 – 13	○	○	○	○	○	○	○	○	○	○

13 – 15	○	○	○	○	○	○	○	○	○	○
15 – 17	○	○	○	○	○	○	○	○	○	○
17 – 19	○		○	○	○	○	○	○	○	○
19 – 21	○		○	○	○	○		○	○	○
21 – 23	○		○	○	○	○		○	○	○
23 – 25	○		○	○	○			○	○	○
25 – 27	○		○	○	○			○	○	
27 – 29	○		○		○			○	○	
29 – 31	○		○		○			○	○	
31 – 33	○				○			○		
33 – 35					○			○		
35 – 37					○					

Depth (cm)	AND 36	AND 37
0 – 1	○	○
1 – 2	○	○
2 – 3	○	○
3 – 4	○	○
4 – 5	○	○
5 – 7	○	○
7 – 9	○	○
9 – 11	○	○
11 – 13	○	
13 – 15	○	
15 – 17	○	
17 – 19	○	
19 – 21	○	
21 – 23	○	
23 – 25	○	

Atmospheric (Gaseous) Hg

Atmospheric Hg and dissolved gaseous Hg (DGM) in seawater were collected during the cruise. The gaseous Hg in air were sampled in gold traps at 0.5 L/min for 20 to 40 minutes. The dissolved gaseous Hg in seawater were also sampled in gold traps by N_2 gas bubbling from 800 mL of seawater for 30 minutes. The following table indicates the collected gaseous Hg during the cruise (Table 3).

Table 3 Sample list of atmospheric Hg and DGM

	AND 01	AND 02	AND 03	AND 04	AND 05	AND 06	AND 07	AND 08	AND 09
Atmospheric Hg	○	○	○	○	○	○	○	○	○
DGM	○	○	○	○	○	○	○	○	○

	AND 10	AND 11	AND 12	AND 13	AND 14	AND 15	AND 16	AND 17	AND 18
Atmospheric Hg	○		○	○		○	○		○
DGM	○		○	○		○	○		○

	AND 19	AND 20	AND 21	AND 22	AND 23	AND 24	AND 25	AND 26	AND 27
Atmospheric Hg	○		○	○	○	○	○	○	
DGM	○		○	○	○	○	○	○	

	AND 28	AND 29	AND 30	AND 31	AND 32	AND 33	AND 34	AND 35	AND 36
Atmospheric Hg	○		○	○		○	○	○	○
DGM	○		○	○		○	○	○	○

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 MMHg will be determined. Table 4 indicates a list of the collected plankton samples in this cruise.

Table 4 List of the plankton samples

	AND 01	AND 02	AND 03	AND 04	AND 05	AND 06	AND 07	AND 08	AND 09
Planktons	○			○	○	○			○

	AND 10	AND 11	AND 12	AND 13	AND 14	AND 15	AND 16	AND 17	AND 18
Planktons	○		○	○	○	○	○		

	AND 19	AND 20	AND 21	AND 22	AND 23	AND 24	AND 25	AND 26	AND 27

Planktons	○	○		○				○	

	AND 28	AND 29	AND 30	AND 31	AND 32	AND 33	AND 34	AND 35	AND 36
Planktons		○		○			○		○

Materials and analytical method

Sample bottles and other materials were prepared based upon US EPA Method 1630 and 1631. Approximately 300 pre-washed teflon bottles by nitric and hydrochloric acid were prepared. Approximately 60 pre-baked Hg gold traps were on-board. An atomic florescence spectroscopy (AFS: NIPPON Instruments RF-3) was set in order to determination of Hg concentrations using cold-vapor or thermal desorption atomic florescence spectroscopy (CV or TD-AFS) on board.

Two analytical trials and an experiment were performed during the cruise in order to make high sensitivity Hg analysis because this was our first cruise to perform Hg analysis using the Hakuho-maru. First, in-room air samples were collected to make sure low Hg content in lab air. The air samples were collected on Hg gold traps with moisture traps using a mini-pump. Second, several Hg standards were measured using the TD-AFS to check their instrumental performance. Research vessels are typically swung and make vibration during their cruise. Finally, seawater samples were collected at the same depth between normal and clean samplings. Both seawater samples were filtered by 0.45 μm membrane in the same way.

Although some of the collected atmospheric Hg and DGM were measured during the cruise, the analytical instrument was slightly unstable compared with its performance in a daily lab environment. Therefore, the collected samples will be determined when they are back to the lab. All of the collected samples will be analyzed based upon the modified US EPA method 1630 for total Hg concentration and 1631 for MMHg concentration.

Anticipated results and work plan

This will be the first Hg data in East China Sea. According to the number of studies about Hg concentrations in the other oceanic environment, it is expected that the collected clayish sediments contain more Hg than sandy sediments. It is also expected that the deeper seawater samples likely contain more Hg than shallow water. Nevertheless, the expected level of Hg concentrations of the collected samples is uncertain.

10.5. Water mass structure analysis in the East China Sea and Kuroshio water using rare earth elements and Nd isotope

Jing Zhang and Qian Liu (University of Toyama)
Hongliang Ma (Ocean University of China) and Jing Zhang (University of Toyama)

Introduction and objectives

The East China Sea (ECS) is one of the largest marginal seas in the world, and it has shown high primary production (Hama et al., 1996). Its enhanced primary productivity is sustained by rich nutrients from terrestrial and marine sources (Walsh, 1991; Wollast, 1993). Purcell et al. (2001) reported that the blooms of jellyfish in the ECS are related to increases in nutrients. However, primary production in the ECS has decreased due to changes in the nutrient balance (Gong et al., 2006). Therefore, there is an urgent need to clarify how nutrients have changed in the ECS, in particular nutrients provided by relevant water masses. To understand the changes in nutrients, the water masses' structure within the ECS first needs to be understood. The ECS has four water sources: the Kuroshio water, the Changjiang (Yangtze) River, the Yellow Sea Coastal Current (YSCC), and the Taiwan Strait Current (TSC). These four sources of water supply nutrients to the shelf of the ECS (Gong et al., 1996). Although the nutrients from Changjiang significantly affect the area surrounding the Changjiang estuary, their effect on the shelf region is limited (Liu et al., 2003; Tian et al., 2000; Wang et al., 2002). Chen and Wang (1999) suggested that the nutrient flux from the Kuroshio to the shelf is greater than that from the river. Rare earth elements (REE) show unique and chemically coherent behavior in geologic systems. As a result of the systematic decrease in ionic radius with atomic number within the suite of lanthanides, there are predictable chemical differences from lanthanum (La) through lutetium (Lu), which can be regarded as subtle geochemical processes in natural systems (Taylor and McLenan, 1988). In addition, Nd isotopic composition ($^{143}Nd/^{144}Nd$) is useful isotopic tracers in geochemistry, is frequently utilized in chemical oceanography because water masses show characteristic values reflecting the geology of Nd source areas. Therefore, the objective of this cruise is to describe the horizontal and vertical distributions of nutrients over the shelf of the ECS using multi-tracers, e.g. REES and Nd isotopes etc. With a simple mixing model, we calculate the mixing ratios of KIW and then use these ratios to illustrate the extent to which KIW nutrients contribute to the shelf's primary productivity.

Sampling and analysis

In this cruise, we collected samples around the Kuroshio area and the shelf's edge to study the extent of the Kuroshio in the ECS, Seawater samples of REES and Nd isotopes from surface to bottom were taken by 24L Niskin bottles mounted on a Rosette sampler

equipped with a calibrated Conductivity-Temperature-Depth (CTD) recorder. Upon sampling, REES samples (~500 mL) and Nd isotopes samples (~5 L) were filtered with 0.2 μm cellulous acetate membrane filter, and 0.45 μm teflon membrane filter, respectively within 24 hours, and then the filtrate was immediately acidified to pH < 1.6 with ultrapure HCl (TAMAPURE AA-100, Tama Chemicals) in the clean room on board. The filtrate of REES was pre-concentrated and then analyzed with an inductively coupled plasma mass spectrometer (ICP-MS, ELEMENT Ⅱ) in the laboratory of the University of Toyama. Pre-concentration of Nd will be analyzed by adsorption onto C18 SeaPak cartridges. Then they will be measured with MC-ICP-MS (Inductively-Coupled Plasma Mass Spectrometer) in the laboratory on land.

Inventory information for the sampling

REES sampling stations: AND03, AND04, AND06, AND08, AND09, AND10, AND11, AND12, AND13, AND14, AND15, AND16, AND17, AND18, AND19, AND20, AND21, AND22, AND23, AND24, AND25, AND26, AND27, AND28, AND29, AND30, AND31, AND32, AND33, AND34, AND35, AND36, AND38, and AND39.

$^{143}Nd/^{144}Nd$ sampling stations: AND03, AND06, AND10, AND11, AND13, AND15, AND17, AND19, AND23, AND26, AND28, AND29, AND31, and AND34.

Anticipated results and work plan

Sample measurement is expected to be finished in the end of July, 2016. Manuscript will be submitted by July 2017.

Data Archive

All of the raw and processed data from the KH-15-3 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

10.6. Calibration of foraminifera Ba/Ca-salinity proxy: Ba/Ca ratios of seawater, living and fossil planktonic foraminifera in the East China Sea

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Introduction and objectives

Salinity is the principal oceanographic information as well as seawater temperature. Therefore, evaluating amplitude of past climate changes requires quantitative and accurate estimates of seawater temperature and salinity: however, an accurate estimate of salinity of the past ocean has been challenged. Previous studies have pointed out that Ba/Ca ratio in sedimentary foraminifera test provides past salinity information in marginal seas because the seawater Ba concentration in estuaries and coastal waters shows inverse correlation with salinity due to higher supplies of riverine-derived Ba to the coastal waters. In fact, the Ba/Ca ratio of planktonic foraminifer shells has been used as a proxy for river run-off (salinity) at marginal seas near large rivers (Weldeab et al., 2007; Sprovieri et al., 2008).

In this research cruise, we collected seawater, living planktonic foraminifera (plankton net samples), and fossil plankton foraminifera samples (sediment cores) from the East China Sea (ECS), and will measure the seawater Ba/Ca ratio and foraminiferal Ba/Ca ratio. Using this data set, we will evaluate whether the Ba/Ca ratio of planktonic foraminifer shells has been used as a proxy for paleo-salinity in the ECS.

Inventory information for the sampling

The collected seawater samples are listed as an appendix. For plankton net and sediment core samples, samples list can be seen in Chapter 8, respectively.

Analysis and method

The Ba concentration will be measured by isotope dilution method by using a ICP-MS (HP4500). Ba/Ca ratios of chemical cleaned sedimentary foraminifera test will be measured by using a ICP-MS (Element II, Thermo). We also obtained 0.5 L seawater from some stations for Ba isotopes. This will be measured by a TIMS, after chemical separation of Ba and other interference elements.

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) and KS15-6 (July) 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 a possibility 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 try to reinforce our preliminary data by adding the data from this KH15-3 cruise.

Further, as a future study, we will measure Ba isotopes of seawater, living planktonic foraminifera, and fossil foraminifera. We hope Ba isotopes can be used as a water mass tracer in the ECS.

Data Archive

All of the raw and processed data from the KH-15-3 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

Appendix

	AND03-D/J3 *Normal*			AND04-D/J1 *Normal*			AND05/A3 *Normal*			AND06-C/B8 *Clean*			AND06-D/B8 *Normal*			AND08-D/B6 *Normal*			AND09/B5 *Normal*			AND10/B3 *Normal*			AN *N*
Bottle No.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)
S0	0	○		0	○		0	○		-			0	○		0	○		0	○		0	○		0
1	4530			69			99			826			20	○	○	20	○	○	-			-			-
2	3934	○	○	69			141			695			51	○	○	50	○	○	9			21	○	○	21
3	2958	○	○	69			20	○		595			100	○	○	99	○	○	30			50	○	○	50
4	2468			69			49	○		496			198	○	○	149			39			74			74
5	1976	○	○	2298			343			397			298			198	○	○	49	○	○	96	○	○	100
6	1484	○	○	1978			343			298			396	○	○	298			55			28			34
7	1238			1485			299			299			496			45			69			43			99
8	991	○	○	1239			201	○		198			595	○	○	403	○	○	85			20			20
9	792	○	○	992			248			198			693			20			99			50			50
10	694			794			248			149			90			50			99	○	○	75			74
11	594	○	○	694			299			125			786	○		100			38			96			99
12	496			596			201			100			149			150			39			29			35
13	396	○	○	496			99	○		100			787			198			118			43			99
14	297			398			140			76			595			299			71			88			59
15	197	○	○	298			20			50			397			45			70			28			59
16	148			199	○		50			50			199			404			119			20			77
17	124			147	○		149			41			125			80			9			51			78
18	98			124			149	○		30			100			80			75			75			30
19	87			101	○		124			30			75			133			9			96			10
20	88	○	○	75			124			21			51			125			75			95			29
21	73			48	○		75			10			20			75			10	○	○	10			10
22	50	○	○	19	○		74			10			10			10			39			28			35
23	20	○	○	12	○		10			91			90			46			39			28			34
24	10			6			10			827			91			45			-			-			-
		13	12		7	0		6	0		0	0		8	6		6	5		4	3		4	3	

D11/B2 *ormal*		AND12/B1 *Normal*			AND13/C1 *Normal*			AND14/C2 *Normal*			AND15/C3 *Normal*			AND16/C4 *Normal*			AND17/C5 *Normal*			AND18/C6 *Normal*			AND19/C7 *Normal*			AND *No*
Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)
○		0	○		0	○		0	○		0	○		0	○		0	○		0	○		0	○		0
		-			-			-			-			-			-			-			-			90
		19			10	○	○	10	○		10			19			20			20			20			89
○		50			20			19			20	○	○	50			49			50			83			997
		75			30	○	○	29	○		31			15			75			74			74			100
○		50			40			40			41			36	○		40			53			100			51
		15			17			5			5	○	○	15			15			13			50			793
		100	○	○	60	○	○	50	○		53	○	○	63			77	○	○	90			120			398
		19			10			10			10			20			20			20			21			299
		50			20			20			20			49			50			50	○		83	○		150
		75			29			30			30			16			74			74			74			991
		50			40			39			40			36			40			53			99	○		793
		15			17			5			4			16			15			13			50			694
		99			59			50			53			63			76			89	○		120			596
		35			46			50			-			16			15			13			50			497
		35			46			49			-			16			15			13			50			398
		39			21			45			28			16			30			13			51			300
		40			30			45			27	○	○	30			10			50			51			200
		75	○	○	40			5			44			10			76			30			30			151
		50	○	○	49			5			45			50	○		50	○	○	11			10			125
○		29	○	○	60			50			50			30	○		30	○	○	31	○		31	○		99
○		10	○	○	49	○	○	50			50			10	○		10	○	○	11	○		9	○		76
		15			16			5			4			16			14			13			50			49
		15			17			6			4			16			14			13			50			19
		-			-			-			-			-			-			-			-			9
5	0		6	5		5	4		4	0		5	4		5	0		5	4		5	0		5	0	

20-D/C8 *ormal*		AND21/C9 *Normal*			AND22-CD/F1 *Clean, Cast-1 (deep)*			AND22-CD/F1 *Clean, Cast-2 (shallow)*			AND22-D/F1 *Normal*			AND23-D/E3 *Normal*			AND24-D/E2 *Normal*			AND25/E1 *Normal*			AND26-C/D1 *Clean*			AND *No*
Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)
○		0	○		-			-			0	○		0	○		0	○		0	○		-			0
		90			1665	○	○	197			87			105			95			20			100			-
		90			1665			151			87			105			95			49			101			21
○	○	1044			1666			125			1657			1880	○	○	1266			99			75			50
		793			1486			98	○	○	397			1881			73			150			74			75
		496			1486			99			19			397			99			73			50			99
		298			1485			99			1657	○	○	99			125			204			50			45
		99			1189			75			1485	○		1485			95			20			50			100
		49			1189			49			1238			1238	○	○	1238			50			40			20
		50			1189			49			991	○	○	991	○	○	991			100			40			65
		991			990	○	○	49			793	○		793			793			150			30			75
○	○	793			990			30			694			694			694			73			30			65
		694			990			29			596	○		595			595			203			30			45
○	○	595			793			20			496			496	○	○	496			72			20			100
		496			794			20			397	○		397			397			72			20			45
○	○	397			795			21			297			298			298			124			20			45
		298			695			21			199	○		198	○	○	198			73			11			45
○	○	198			595			11	○	○	148			149			150			30			11			45
		150			497			9			125			124			125			10			11			45
		124			497			9			99	○	○	100	○	○	99			124			11			45
○	○	99			398			10			74			75			74			75			11			30
		73			297			9			51	○		49	○	○	50			30			45			10
○	○	20			247			80			30			29			30			10			44			45
○	○	20			199			81			20			20	○	○	20			73			40			45
		10			199			78			10	○	○	10			10			73			66			-
9	8		1	0		2	2		2	2		11	4		9	8		1	0		1	0		0	0	

26-N/D1 *ormal*		AND27/D2 *Normal*			AND28/DU *Normal*			AND29/D2' *Normal*			AND30/D3 *Normal*			AND31-C/D4 *Clean*			AND31-D/D4 *Normal*			AND32-D/D5 *Normal*			AND33-D/I2 *Normal,Cast-1 (deep)*			AND *Normal,Ca*
Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)
○		0	○		0			0	○		0			-			0	○		0	○		-			0
		-			-			-			20			949			75			71			4038			103
		20			20			172			50			948			76			71			3447			102
		50			49			171			99			793			976			1312			2959			694
		75			100			171	○	○	148			695			694			71			2469			397
		99			138			171			201			596			396			99			1978			150
		59			63			172			60			498			50			76			1487			74
		123			138			172			214			398			20			50			1239			50
		76			20			20	○		20			299			9			1239			991			30
		20			50			49	○		50			249			794			991			794			20
		50			100			99	○		99			198			694			794			4039			10
		76			139			149			148			149			595			695			3446			795
		98			64			64			200			125			498			595			2959			695
		124			139			74			60			100			398			497			2469			594
		59			86			169			213			100			298			397			1978			496
		59			87			168			60			74			247			299			1487			397
		59			64			167			61			50			197			199			1240			298
		59			64			170			60			50			149			150			992			199
		59			63			167			123			30			124			125			794			150
		59			64			167			73			29			99			100			4039			124
		29			63			167			30			21			76			75			2960			99
		9			64			167			10			10			49			50			1980			74
		59			64			65			60			11			29			31			1488			50
		59			63			64			60			83			20			20			991			20
		-			-			-			61			55			9			11			1149			10
1	0		1	0		0	0		5	1		0	0		0	0		1	0		1	0		0	0	

)33-S1/I2 ***ast-2 (shallow)***		AND34-C/I1 ***Clean***			AND34-D/I1 ***Normal***			AND35-D/A2 ***Normal***			AND36-D/A1 ***Normal***			AND38/B3-2 ***Normal***			AND39/B4 ***Normal***			
Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	Depth (m)	Ba conc.	Ba iso.	
○		-			0	○		0			0	○		0			0	○		
		3041			56			66			9			40			10			
		1978			57			66			9			79			10			
		1484			2997			590			677	○	○	79			10			
		1189			2997			66			397			65			10			
		991			802			397			298			65			10			
		794			2468			200			199			46			90			
		595			1978			100			100			46			90			
		496			1486			50			50			98			64			
		397			1239			10			10			98			64			
		298			991			590			30			40			10			
		249			794			30			30			98			100			
		198			695			30			678			75			75			
		150			596			30			596	○		51			50			
		100			497			497			497			31			30			
		100			398			398			397	○		20			20			
		50			298			298			298			10			10			
		50			199			200			199	○		40			10			
		30			150			150			150			98			100	○		
		20			125			125			124			75			75			
		10			100			100			100	○		51			50	○		
		10			75			75			75			30			30			
		41			50			50			50	○		21			20	○		
		2467			20			20			20	○	○	10			10			Total Ba conc. Sample
		93			10			11			10			40			10			152
1	0		0	0		1	0		0	0		8	2		0	0		4	0	Total Ba iso. Sample 73

10.8. Pb and Pb isotopes in the East China Sea and Kuroshio water

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Introduction and objectives for Pb and Pb isotope

Pb in the present-day ocean is dominated by anthropogenic sources such as leaded petrol, coal and high-temperature industrial activities [Duce et al., 1991; Flegal, 1986; Schaule and Patterson, 1981; Settle and Patterson, 1982]. Since sources and fluxes of anthropogenic Pb have been constantly changing, Pb in the oceans follows a temporal and spatial dependent pattern that reflects the regional historical evolution of anthropogenic Pb emissions [Alleman et al., 1999; Weiss et al., 2003]. The temporal and spatial variation of Pb in the ocean is important for various purposes, including the interpreting the recent distribution of Pb within a historical context; assessing the relative contribution of different Pb sources; and understanding the movement mechanism of Pb through the marine environment.

The East China Sea and western Pacific are important sites characterizing the injection of anthropogenic Pb into the ocean from emerging Asian economies that experienced intensive development over the last few decades. East China Sea is adjacent to China, the world's largest Pb producer since late 1990s [Flegal et al., 2013; International Lead and Zinc Study Group, 1999; Keating, 1997]; and western Pacific could be an important ocean basin characterizing the transport of the Asian Pb into the Pacific Ocean and other continents.

Pb has four stable isotopes: ^{204}Pb, ^{206}Pb, ^{207}Pb and ^{208}Pb. Among the stable Pb isotopes, ^{204}Pb is the only non-radiogenic isotope, while ^{206}Pb, ^{207}Pb and ^{208}Pb are radiogenic with an evolving abundance [Brown, 1962]. The abundance of radiogenic Pb isotopes follow the uranium and thorium decay chain as:

$^{238}U \rightarrow {}^{234}U \rightarrow {}^{206}Pb$ via a chain of alpha and beta decays; $t_{1/2}$= 4.47 G.y.
$^{235}U \rightarrow {}^{207}Pb$ via a chain of alpha and beta decays; $t_{1/2}$ = 0.704 G.y.
$^{232}Th \rightarrow {}^{208}Pb$ via a chain of alpha and beta decays; $t_{1/2}$ = 14.0 G.y.

With the radiogenic growth of ^{206}Pb, ^{207}Pb and ^{208}Pb, the relative abundance of Pb isotopes is dependent on the initial U/Th/Pb composition in the reservoir where Pb ore was extracted, and the age of the reservoir from which the Pb is extracted [Cumming and Richards, 1975]. As little isotope fractionation occurs during environmental processes (compared to its source variability), Pb isotopes can be utilized as a fingerprint tracing the source and pathways of anthropogenic Pb to the environment [Cheng and Hu, 2010; Komárek et al., 2008]

Analysis and method

The samples are filtered (0.4μm) and eventually acidified to pH~2 with ultrapure 6N HCl. The filtered samples are analyzed for both Pb concentration and Pb isotope. The Pb concentrations are measured using isotope dilution after single batch nitrilotriacetate (NTA) resin extraction [Lee et al., 2011]. In brief, 1.3mL of seawater samples are spiked with a known amount of ^{204}Pb enriched spike (Oak Ridge National Laboratories) and then adjusted to pH=5.3 by adding an ammonium acetate buffer. ~2400 NTA superflow resin beads are added to each sample. After 4 days on a shaker table to allow the resin beads to bind Pb, the sample and resins are rinsed several times with ultrapure water and then elute using 0.1M high purity nitric acid. The eluted samples are then analyzed on a Quadruple ICP-MS (VG PlasmaQuad 2+). All samples are run in triplicate and accepted only if at least two out of three replicates agreed.

The Pb isotope in the seawater are measured using an IsoProbe multi-collector ICP-MS after $Mg(OH)_2$ co-precipitation and HCl-HBr ion exchange chromatography as described in Boyle et al. [2012] and Reuer et al. [2003]. Each seawater sample is spiked with a minimum dose of ammonia solution to induce $Mg(OH)_2$ precipitation, which scavenges the Pb from the seawater. The precipitates are re-dissolved by a minimum amount of high purity HCl and the $Mg(OH)_2$ precipitation repeated for a second time to further concentrate and separate the Pb from the Mg. The final precipitates are redissolved in 200µL of ultrapure 1.1M HBr and loaded onto an Eichrom AG-1X8 (chloride form, 200 – 400 mesh) anion exchange resin column to separate the Pb from the sample matrices. After ion exchange, the samples are dried in a class 100 clean environment and then redissolved in ultrapure 0.2M HNO_3 for ICP-MS analysis. Standardization and corrections are handled as discussed in Boyle et al [2012]. Although the expected precision and accuracy of the measurement depends on the concentration of the sample (limited by Johnson resistor noise), in general, this 206Pb/207Pb data should be good to at least ± 0.001 (2SD).

Inventory information for the Pb and Pb isotope samples:

Station	Cast	Pb No.	Pb V (L)*	Pb iso. No.	Iso.V (L)*
B8	1	16	0.25		
F1	1	8	0.25	8	0.5
	2	8	0.25	8	0.5
D1	1	8	0.25	8	0.5
D4	1	13	0.25	13	0.5
I1	1	13	0.25	13	0.5
Total:		66		50	

*****The sample volume means the volume for each sample.
During the cruise, 66 Pb concentration samples and 50 isotope samples (total 116) were collected as shown in the Table.

Anticipated results and work plan
Several lines of results are expected to get after the cruise:

(1) Pb concentration levels and it isotopic ratios in the East China Sea;
(2) The depth-related and spatial variation of Pb and its isotopes;
(3) The proportional contributions of different Pb sources will be achieved, especially from the Chinese Pb which is triggered by the economic jump of China.

Work plan:
November-December, 2015: Sample acidification and stabilization;
December, 2015-March, 2016: Measurement for Pb concentration;
March-September, 2016: Measurement for Pb isotopes;

Data Archive
All of the raw and processed data from the KH-15-3 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

10.9. Total dissolved inorganic carbon and carbon isotopes ($\Delta^{14}C$ and $\delta^{13}C$) in the Kuroshio water

Jing Zhang (University of Toyama)
Xuchen Wang (on-land, Ocean University of China)

Introduction and objectives

Radiocarbon study of dissolved inorganic carbon (DIC) in the East China Sea: Using $D^{14}C$-DIC as a tracer to investigate the water influence of the Kuroshio on the slope and shelf ranges in the ECS, and to determine the material exchange between ECS and the Kuroshio current.

Inventory information for the sampling

Sampling stations: AND23, AND26, AND29, AND31, AND33, and AND34.

Analysis and method

Concentrations of DIC, $\Delta^{14}C$-DIC and $\delta^{13}C$-DIC will be measured. Concentration of DIC will be measured using a Shimadzu TOC-L analyzer equipped with an ASI-V auto-sampler. The instrument blank and DIC concentrations will be checked against DIC reference seawater (CRMs, Scripps Institute of Oceanography, University of California San Diego) to ensure accuracy of the data. For $\Delta^{14}C$-DIC and $\delta^{13}C$-DIC measurement, DIC will be extracted as CO_2 first based on standard method. Purified CO_2 gas will be send to the National Ocean Sciences Accelerator Mass Spectrometry (NOSAMS) facility at Woods Hole Oceanographic Institution (WHOI) for ^{13}C and ^{14}C analysis. A small split fraction of CO_2 will be measured for $\delta^{13}C$ using a VG Isotope Ratio Mass Spectrometer (IRMS) and the rest of the CO_2 will be graphitized for $\Delta^{14}C$ analysis using AMS.

Anticipated results and work plan

Concentrations of DIC will be measured within 2-3 months and $\Delta^{14}C$-DIC and $\delta^{13}C$-DIC will be measured within 6-8 months after the cruise.

Data Archive

All of the raw and processed data from the KH-15-3 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

10.10. Submarine groundwater discharge and its influence on coastal primary productivity in the East China Sea using ^{226}Ra and $\delta^{18}O$

Qian Liu and Jing Zhang (University of Toyama)

Introduction and objectives

Submarine groundwater discharge (SGD) has been emerging as an important component of the land-ocean interactions spanning from hydrology to biogeochemistry. SGD is often characterized by high concentrations of nutrients, trace metals and carbon as compared with surface water. Inputs of these materials can have a profound impact on the biogeochemistry and ecosystem functioning of coastal systems (Moore, 2010). In particular, SGD has been shown to be an important nutrient source to estuaries, salt marshes, oceanic islands, and coral reefs (Charette, 2007; Santos et al., 2008; Burnett et al., 2009; Kim et al., 2011). As a consequence, studies have suggested a linkage between SGD and coastal eutrophication and harmful algae bloom outbreaks (Hu et al., 2006; Lee and Kim, 2007; Lee et al., 2010). East China Sea (ECS) is one of the largest marginal sea in the world with extremely wide shelf region. However, SGD study on the shelf of ECS is very limited, and its influence on the nutrient cycling and related ecosystem response is completely unknown. Sediment in the ECS is mostly composed by permeable sand, which provides excellent SGD flow conduit. Based on our previous study, we observed low dissolved oxygen (DO) and low salinity water near Jeju Island, whose characteristics are inconsistent with Changjiang diluted water. We hypothesize these low DO waters source from lateral transport of SGD, potential organic matter degradation occurred in the low DO waters might produce nutrients to the offshore seawater and might enhance the primary production. Radium isotopes have proved to be useful tracers of SGD in many environments on both small and large scales from salt marshes (e.g., Rama and Moore 1996) to the continental shelf (Moore 1996). Being orders of magnitude more enriched in groundwater relative to seawater, Ra is useful for evaluating sources and rates of SGD, as well as nutrients carried by this process. In this study, we will determine SGD water flux using Ra and oxygen isotope ($\delta^{18}O$) and its related nutrient fluxes, and examine their contribution to the nutrient budget in the shelf of ECS. Further, we will test hypothesis above of low DO water source and assess the SGD effect on hypoxia in the outer shelf of ECS.

Sampling and analysis

Seawater samples of Ra and $\delta^{18}O$ from surface to bottom were taken by 12 L Niskin bottles mounted on a Rosette sampler equipped with a calibrated Conductivity-Temperature-Depth (CTD) recorder. Upon sampling, Ra samples (~500 mL) were filtered with 0.45 μm cellulous acetate membrane filter within 24 hours, and then the filtrate was immediately acidified to pH < 1.6 with ultrapure HCl (TAMAPURE AA-100, Tama Chemicals) in the clean room on board. All the Ra samples analysis work will be conducted using SF-ICP-MS (Sector Field Inductively-Coupled Plasma Mass Spectrometer, Thermo Fisher Scientific, KK) in laboratory of the University of Toyama. $\delta^{18}O$ samples will be analyzed for oxygen isotopes by IR-MS (Isotope Ratio Mass Spectrometry).

Inventory information for the sampling

Ra sampling stations: AND03, AND06, AND08, AND09, AND10, AND11, AND12, AND13, AND14, AND15, AND16, AND17, AND18, AND19, AND20, AND22, AND23, AND24, AND25, AND26, AND27, AND28, AND29, AND31, AND32, AND33, AND34, AND35, AND36, AND38, and AND39.

$\delta^{18}O$ sampling stations: AND03, AND04, AND05, AND06, AND08, AND09, AND10, AND11, AND12, AND13, AND14, AND15, AND16, AND17, AND18, AND19, AND20, AND21, AND22, AND23, AND24, AND25, AND26, AND27, AND28, AND29, AND30, AND31, AND32, AND33, AND34, AND35, AND36.

Anticipated results and work plan

After the measurement of Ra and $\delta^{18}O$, we will construct the Ra and $\delta^{18}O$ budget to quantify SGD flux and SGD-associated nutrient fluxes to the ECS shelf, and further assess the potential ecosystem effect.

Sample measurement is expected to be finished in the end of April, 2016. Manuscript will be submitted by March 2017.

Data Archive

All of the raw and processed data from the KH-15-3 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

10.11. The relationship of elemental composition (especially Nitrogen, Phosphorus and Silicate) in Particulate Organic Matter and nutrient in the East China Sea and Kuroshio region

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Introduction and objectives

The stable nitrogen and oxygen isotope in nitrate

Nitrate is the predominant DIN (dissolved inorganic nitrogen) in East China Sea (ECS), and new nitrogen is supplied many river, intrusions from around water mass, remineralization of organic matter, and deposition from atmosphere. Although there are many nitrate sources in the ECS, and source were vary with the horizontal, vertical and seasons, it is not clear which source nitrate is actually stimulate phytoplankton growth. The stable nitrogen and oxygen isotopes of NO_3^- ($\delta^{15}N$ and $\delta^{18}O$) have been effectively used to understand nitrate dynamics. To investigate nutrients dynamics, especially nitrogen cycle in the ECS and Kuroshio region, water samples were collected at some station, and vertical profiles of $\delta^{15}N$ and $\delta^{18}O$ in nitrate.

Elemental composition (especially Nitrogen, Phosphorus and Silicate) of size-fractionated POM (Particulate Organic Matter)

Nutrient concentration and composition is important to the strategy for phytoplankton under nutrient limited conditions. Some phytoplankton species can change elemental composition in those body to adapt nutrient limited conditions. Recent studies suggest that N/P ratio of nutrient in Changjiang river water, and atmospheric nitrogen deposition were increased, it have an effect on not only phytoplankton community but also body composition (N/P/Si ratio) of phytoplankton. To investigate the strategy for phytoplankton under nutrient limited conditions, water samples for the analysis of N/P/Si ratio of POM were collected in the surface and chlorophyll maximum layer water at some stations. Further, water samples were preserved with formalin to check phytoplankton species, and paraformaldehyde to check picophytoplankton species in the both layer.

Inventory information for the sampling

Table 1 show locations and sampling depth

Station name (AND)	Station name	Sampling Depth	
		(Nitrate samples, m)	(POM, Pleserved samples, m)
AND03	J3	75, 88, 100, 200, 600, 1000, 2000, 4000, 4530	Surface(0m), Chl Max (88m)
AND04	J1	50, 70, 75, 100, 200, 500, 2000, 2298	Surface(0m), Chl Max (70m)
AND06	B8	50, 91, 100, 200, 400, 600, 786	Surface(0m), Chl Max (70m)
AND08	B6	20, 45, 50, 100, 200, 300, 403	Surface(0m), Chl Max (45m)
AND10	B3	20, 28, 50, 75, 96	Surface(0m), Chl Max (28m)
AND12	B1	15, 20, 35, 50, 75, 100	Surface(0m), Chl Max (15m)
AND13	C1	10, 16, 20, 30, 40, 60	Surface(0m), Chl Max (16m)
AND15	C3	5, 10, 20, 30, 40, 53	Surface(0m), Chl Max (5m)
AND17	C5	0, 10, 15, 20, 30, 40, 77	Surface(0m), Chl Max (15m)
AND19	C7	20, 50, 84, 100, 120	Surface(0m), Chl Max (50m)
AND21	C9	75, 91, 100, 200, 400, 600, 800, 1044	Surface(0m), Chl Max (91m)
AND22	F1	75, 87, 100, 200, 400, 1000,1500, 1657	
AND24	E2	75, 96, 100, 125, 200, 400,600, 1000, 1266	
AND26	D1	20, 45, 50, 75, 100	Surface(0m), Chl Max (63m)
AND28	DU	20, 50, 63, 75, 100, 139	Surface(0m), Chl Max (64m)
AND29	D2'	50, 64, 100, 150, 167, 168, 172	Surface(0m), Chl Max (75m)
AND31	D4	20, 50, 75, 100, 200, 400, 600, 976	Surface(0m), Chl Max (71m)
AND32	D5	50, 71, 75, 100, 200, 400, 600, 1000, 1312	
AND33	I2	100, 103, 200, 400, 600, 1000, 2000, 3000, 4039	Surface(0m), Chl Max (103m)
AND34	I1	50, 57, 75, 100, 200, 600, 1000, 2997	Surface(0m), Chl Max (57m)
AND35	A2	20, 50, 66, 75, 100, 125, 200, 400, 590	Surface(0m), Chl Max (66m)
AND36	A1	9, 10,50, 100, 200, 400, 600, 677	

Analysis and method

The stable nitrogen and oxygen isotope in nitrate

Water samples were filtrated by 0.2μm disc filter, and kept frozen at -20℃ before analysis. For water samples with more than about 1.5μM- NO_3^-, the stable nitrogen and oxygen isotope ratios (i.e., $\delta^{15}N$ and $\delta^{18}O$) in NO_3^- +NO_2 were determined using the denitrifier methods of Sigman et al. (2001) and Casciotti et al. (2002). In brief, nitrate was converted into nitrous oxide. The nitrous oxide was purified using cryogenic trapping, separated chromatographically, and analyzed using mass spectrometry.

Size-fractionated POM

N/P/Si ratio in POM will be determined for three different size-fractions (i.e., 200-20 μm, 20-2 μm and 2-0.2 μm), each of which is categorized as microplankton, nanoplankton and picoplankton. Samples of size fractioned PON and POP treated with alkaline persulfate oxidation method, and persulfate oxidation method. Samples of size fractioned BSi(Biogenic Silica) in POM samples were determined using the NaOH digestion method. After degradation treatment, samples will be measured calorimetrically using an autoanalyzer (AACS 4; BLTEC, Japan).

Fixed Phytoplankton

Water samples were preserved with formalin to check phytoplankton species in the both layer. In addition, water samples were fixed with paraformaldehyde and frozen in liquid nitrogen to count picoplankton (i.e., *Synechococcus*, *Prochlorococcus* and pico-eukaryotes) by flow cytometer.

Anticipated results and work plan

We will investigate the mechanisms that control $\delta^{15}N$ and $\delta^{18}O$ value in NO_3^- in ECS. The investigation will explore combine with temperature, salinity, chl.a concentration, dissolved oxygen and $\delta^{15}N$ and $\delta^{18}O$ in NO_3^- data.

Data Archive

All of the raw and processed data from the KH-15-3 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy

10.12. Biogeochemical dynamics of macro- and micro- nutrients (nitrate, trace metals and B vitamins) in the East China Sea and adjacent Kuroshio region

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Introduction

Recent findings on the role of trace metals as a factor controlling primary productivity and biogeochemical processes in the oceanic waters emphasized the need for better understandings of interaction between macro- and micronutrients as well as chemical speciation of trace metals in seawater. The East China Sea is one of the largest marginal seas in the world ocean with high productivity and biological diversity. In the East China Sea, there are several sources of macro- and micro-nutrients such as atmospheric transport of mineral dust and aerosols, sedimentary input, freshwater input from the Changjiang River. Furthermore, the input of Kuroshio water from south also influences the distributions of these micro- and macro-nutrients. During *RV/Hakuho-maru* KH-15-3 cruise, distributions of nitrate, trace metals and B vitamins, atmospheric deposition, nifH gene are investigated to understand biogeochemical dynamics of macro- and micro-nutrients in the East China Sea and adjacent Kuroshio region.

Methods & Future works

Distributions of dissolved trace metals and Fe speciation upper 400 m depths

Seawater samples were collected using acid-cleaned Teflon-coated 12-liter Niskin-X bottles on a CTD-Carousel system. Seawater was obtained from 10, 50, 100, 200 and 400 m depths and subsurface chlorophyll maximum layer at Stns. AND06, AND22, AND26, AND31 and AND34. After the recovery, Niskin-X bottles were placed in a clean-air booth and the sample seawater was filtered through an AcroPak 200 Capsule filter unit having 0.2 μm 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 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 or 250-ml LDPE bottles with PE cap for Al samples 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 C-DOM.

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

Atmospheric deposition of macro- and micro-nutrients and monitoring of surface water temperature, salinity and chlorophyll *a* concentration

Atmospheric aerosol samples were (ca. 1-2 day interval) collected using a high-volume virtual dichotomous air sampler (Model AS-9, Kimoto Electric, Co., Ltd.) that was mounted on the compass deck of the ship. The sampler was controlled by an automated wind-sector control system. The virtual impactor separated coarse (diameter, d>2.5 μm) and fine (d<2.5 μm) particles, wherein both the fractions were collected on a single 90 mm diameter Teflon filter (PF040, Advantec). These filters were stored at 4˚C for onshore analysis of nutrients (inorganic/organic N) and major ions.

For the analysis of soluble aerosol Fe, aerosol samples were also collected on three replicate 47 mm, 0.4 μm filters (one prewashed Nuclepore polycarbonate filter and two Osmonics polypropylene filters) at a flow rate of 4-6 L/min and as much as 35 m^3 of air was filtered through each filter during a 3-4 days period. Sample filters were stored frozen during the cruise. Soluble aerosol Fe concentrations will be measured in an onshore laboratory by extracting one of the polypropylene filters with 100 mL of 0.2 μm filtered surface seawater or ultrapure deionized water as described by Buck et al. (2010). The Nuclepore polycarbonate filters will be used for the analysis of total aerosol Fe.

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 aerosol and 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-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.

During the cruise, underway discrete sampling was performed using the surface water surface water pumped up from the ship bottom. Temperature, salinity and chlorophyll *a* concentration were monitored using a SWEMA-DAT system (AORI).

B vitamins in the surface water and subsurface chlorophyll maximum

B vitamins such as cobalamin (B_{12}), thiamin (B_1) and biotin (B_7) play important role in cell metabolism. Despite the biogeochemical importance of B vitamins in the ocean, the distribution of B vitamins in the ocean and the processes controlling their ambient concentrations are still not well understood. During this cruise, filtered seawater samples and filter samples are obtained to elucidate the distribution of dissolved and particulate B vitamins (B_1, B_7 and B_{12}) in the East China Sea and Kuroshio region.

Filtered seawater samples (pore size: 0.4 μm) obtained at Stns. AND03, AND06, AND16, AND22, AND26, AND31 and AND34 were stored frozen in high-density polyethylene dark bottles. Size-fractionated filtration was carried for the analyses of particulate B vitamins using 10 μm, 2 μm and 0.4 μm membrane filters. Dissolved and particulate B vitamins will be measured by solid-phase extraction – liquid chromatography/tandem mass spectrometry (LC-MS-MS) (Sañudo-Wilhelmy et al., 2012).

Macro-nutrient dynamics near the subsurface chlorophyll maximum layers

Fine structures of nitrate profile (nitracline) near the subsurface chlorophyll maximum (SCM) were obtained for estimation of nutrient supply fluxes by vertical diffusion along transects of Line B, C and D (Stns. AND08, AND09, AND10, AND11, AND12, AND13,

AND14, AND15, AND16, AND17, AND18, AND19, AND20, AND26, AND27, AND28 and AND29). Vertical distributions of nitrate and chlorophyll *a* were observed within the euphotic layers (upper 200 m depth) using an in situ nitrate sensor (ISUS, Satlantic) and chlorophyll fluorometer equipped on the CTD-rosette system during the down-casts at 0.16 m/sec.

The observed profiles of nitrate will be compared with those of chlorophyll *a*, temperature, salinity and other nutrients to understand the relationship between the vertical nutrient flux and the development/decline of SCM.

DNA analyses in the surface water and subsurface chlorophyll maximum

Nitrogen fixation provides a significant source of new nitrogen in the oligotrophic ocean and supports the ecosystem. Evaluation of nitrogen fixation has been focused on large diazotrophs such as *Trichodesmium* and *Richelia intracelluaris*. However, unicellular diazotrophs were newly discovered by molecular techniques and they have been considered as important to marine nitrogen fixation as the large diazotrophs (Zehr et al. 2001; Montoya et al., 2004). The large diazotrophs were also of particular interest in nitrogen fixation in the Kuroshio and its adjacent waters (Chen et al., 2008; Tuo et al., 2014), and unicellular diazotrophs have not been studied well. The present study examined spatial variation of diazotroph community in this region by using molecular techniques including qPCR and clone library analyses.

Water samples for DNA analysis were collected in 2-L polycarbonate bottles from surface water and subsurface chlorophyll maximum layer. The samples were filtered onto Sterivex-GP pressure filter units with a 0.22 μm pore size (Millipore) using a peristaltic pump. The filters were subsequently stored in freezer (-20^{o}C) for on-shore analysis. Total DNA will be extracted using a ChargeSwitch Forensic DNA Purification Kit (Invitrogen, Carlsbad, CA, USA) on land. qPCR analysis will be targeted on the *nifH* phylotypes of *Trichodesmium*, *Richelia intracelluaris*, UCYN-A, UCYN-B, UCYN-C, and γ-proteobacteria γ-24774A11. The clone library analysis will be performed according to Shiozaki et al. (2014).

10.13. Nutrient flux via sediment-bottom seawater interface in the northern central shelf region, East China Sea

Kai Jiang, Shota Kambayashi, and Jing Zhang (University of Toyama)

Introduction and objectives

Pore water is a major interface between the bottom seawater and marine sediment. The high productivity in the East China Sea and its shallow water depth leads to the lots of biogenic materials accumulated in the sediments, and these materials feed back to the water column in return. During this cruise, it aims to clarify the benthic nutrient fluxes to bottom water and up layer in the East China Sea. Nutrients in pore water, overlying water and seawater were analyzed on board and potential diffusion fluxes will be calculated from the corresponding concentration gradients, eventually evaluating the contribution of nutrients in the pore water to the primary productivity. To quantify the influence of suspended particle, which controlled by horizontal advection/transportation, a measurement of multi-size particulate characterizing contour (LISST) was carried out together with CTD casts. The detailed sampling information is listed in Table 1.

Table1. Inventory information for the LISST observation

Stn. name (AND)	Stn.name	Latitude			Longitude			Depth (m)	Area	Note
AND08	B6	30	27.98	N	128	5.19	E	407	East China Sea	Only shallow cast (< 200m)
AND09	B5	30	54.28	N	127	35.59	E	127	East China Sea	
AND10	B3	31	54.28	N	126	47.80	E	105	East China Sea	
AND11	B2	32	24.29	N	126	23.89	E	108	East China Sea	
AND12	B1	32	54.28	N	126	0.00	E	106	East China Sea	
AND13	C1	32	43.43	N	124	49.98	E	67	East China Sea	
AND14	C2	32	13.43	N	125	13.92	E	59	East China Sea	
AND15	C3	31	43.43	N	125	37.81	E	61	East China Sea	
AND16	C4	31	13.43	N	126	1.71	E	71	East China Sea	
AND17	C5	30	43.43	N	126	25.61	E	82	East China Sea	
AND18	C6	30	13.43	N	126	49.50	E	95	East China Sea	
AND19	C7	29	46.20	N	127	17.47	E	126	East China Sea	
AND20	C8	29	23.00	N	127	49.50	E	1038	East China Sea	Only shallow cast (< 200m)
AND25	E1	26	49.00	N	125	18.00	E	191	East China Sea	
AND26	D1	28	57.00	N	126	4.60	E	105	East China Sea	
AND27	D2	28	42.00	N	126	26.90	E	127	East China Sea	
AND28	DU	28	46.07	N	126	46.07	E	147	East China Sea	
AND29	D2'	28	35.10	N	126	44.77	E	178	East China Sea	
AND30	D3	28	28.22	N	126	50.02	E	219	East China Sea	
AND38	B3	31	54.13	N	126	48.10	E	105	East China Sea	
AND39	B4	31	24.19	N	126	11.68	E	107	East China Sea	

Analysis and method

During the cruise, pore water samples were taken from multiple cores from 4 stations (Table 2.), Sediment samples were continuously sliced at every 0.5 cm from the top to 5.0 cm, 1.0 cm from 5.0 cm to 15.0 cm and 2.0 cm deeper than 15.0 cm in thickness throughout the cores on board. Porewater were squeezed on board ship, and the squeezing process for multiple cores was carried out by pressure filtration through 0.45μm Millipore filter for nutrients, using a stainless steel clamp at 4 deg C.

Table 2. Inventory information for the pore water sampling

Stn. name (AND)	Stn.name	Latitude			Longitude			Depth (m)	Area	Note
AND12	B1	32	54.28	N	126	0.00	E	106	East China Sea	
AND13	C1	32	43.43	N	124	49.98	E	67	East China Sea	
AND16	C4	31	13.43	N	126	1.71	E	71	East China Sea	
AND29	D2'	28	35.10	N	126	44.77	E	178	East China Sea	Mud volcano site

Nutrients are analyzed by an auto analyzer AACSII (BLAN+LUBBE) on board (by Kinki University group). All analytical data (nitrate, nitrite, phosphate and silicate) were corrected by using seawater reference material of nutrients (KANSO).

Anticipated results and work plan

All the analysis work has been finished on board, the next step is trying to make a box model to calculate the amount of nutrients in pore water fluxes to water column, and combining the LISST data to reduce the affection from advection. Paper will be written within a year.

Data Archive

All of the raw and processed data from the KH-15-3 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

10.14. Size-fractionated particulate trace elements and its isotopes (TEIs) distribution in the surface water of the East China Sea and Kuroshio region

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Tung-Yuan Ho (on-land, Research Center for Environmental Changes, Academia Sinica, Taiwan)

Introduction and objectives:

Kuroshio, the most important western boundary current in the North Pacific Ocean, also passes through the Western Philippine Sea (WPS) and plays an important role in regulating water mass exchange in the East China Sea (ECS) and WPS. Kuroshio region receives the input of different materials, including lithogenic and anthropogenic materials. The anthropogenic materials derived from the East Asia seriously influence this region and account for a significant portion. However, the relative contributions of lithogenic and anthropogenic materials should vary spatially along the trajectory of Kuroshio. The plankton community structure also varies a lot in this region. To identify the relative contribution of biogenic, lithogenic and anthropogenic sources, I propose to analyze dissolved and particulate trace element samples collected from the euphotic zone (0 ~ 200 m) of Kuroshio region. In this region, lithogenic and anthropogenic trace metal inputs from river and aerosols will be relative significant, and bottom sediment resuspension also might be a source in some shallow sampling stations. Among several different sources, aerosol input could be the dominant source of trace metal. The other objective of my study is to investigate the interaction between size-fractionated suspended particles and dissolved phases by studying their Zn isotopes compositions. After the analysis of trace metal concentration, I will use Zn isotopic composition as a proxy to further study Zn sources and internal cycling processes in Kuroshio region.

Inventory information for the sampling:

The samples I collected in this cruise are listed in Table 1.

Analysis and method:

Large volume sampling:

I collected dissolved (only for samples collected at Chl-*a* max) and particulate trace element samples, including four size-fractionated particulate fractions (0.2~10, 10~60, 60~150, >150 μm). The filtration apparatus I plan to use in the cruise is a gravitational gentle filtration device (Fig. 2). This trace metal clean filtration device equipped with 150, 60, and 10 μm aperture changeable Nitex nets in sequence to gently collect the suspended particle samples with diverse sizes (Ho et al. 2007). The sampling procedures and the filtration device are described in details in previous paper (Ho et al. 2007). Roughly one hundred liters of seawater were used to pass through the filtration device. Subsequently, ten liters of seawater filtered through the 10 μm net was also collected for the 0.2-10 μm fraction. The filtrate/dissolved phase passed through these membranes should be clean and can be used for analyses of dissolved constituents.

Analytical methods:

After sampling, the membranes with the particles will be leached/digested with 5 mL 8 N HNO3-2.9 N HF in 15 mL 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 with a 2 mL sample loop (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 plankton analysis were described by Ho et al. (2003) and Ho et al. (2007). Double spike technique will be used in this study to obtain Zn isotopic composition. Isotopic analysis of Zn will be performed on a Thermo Finnigan Neptune MC-ICPMS at low mass resolution. More details for isotopic analysis were described by Conway et al. (2013).

Anticipated results and work plan:

In this cruise, I collected the size-fractionated particle samples basically along the trajectory of Kuroshio. I will use their elemental ratio, for example, M/Al and M/P ratios, to identify their trace metal sources. Combined with the data I obtained in the previous cruise to Green Island, I will have the size-fractionated particulate trace metal concentration distribution along the trajectory of Kuroshio, in other words, from southern Taiwan to southern Kyushu (Fig. 1). Along the trajectory, there are several factors which might influence the particle composition and further influence the particulate trace metal concentration. From the southern part, there is an island wake behind Green island. The island wake might cause the upwelling transporting materials form the deeper ocean to surface ocean. In the northeastern Taiwan, there is also an eddy which is generated by Kuroshio passing through the ECS slope change. This Eddy also might pump up the materials from the deep ocean to influence the particle composition in the surface ocean. In the ECS, the input of Changjiang also plays a significant role providing a lot of lithogenic and anthropogenic into the ECS and further influenced Kuroshio. A Cold seep is also being found in between D2 and D4 station. This seep might provide lithogenic materials from the bottom of the ocean to the surface ocean. Thus, I hypothesize that the particulate trace metal composition could have different characteristics after Kuroshio passing by D-transect. After passing D-transect, Kuroshio will flow into a “turning point” around southern Kyushu. Besides, the community structures are also different along the trajectory. All the above factors will influence the particulate trace metal distribution. Talking about size, I will also obtain the particulate trace metal concentration of four different size fractions (0.2~10, 10~60, 60~150, >150 μm). The smallest 0.2~10 μm portion should be the dominant one which has highest trace metal concentration, but the distribution pattern of trace metal concentration might be different at different sampling station along the trajectory. I anticipate that this study can elucidate the sources of particulate trace metals along the trajectory of Kuroshio.

Tentative work plan:

After cruise to Jan. 2016: Particulate trace metal concentration analysis.
Jan. 2016 to Feb. 2016: Dissolved trace metal concentration analysis.
Feb. 2016 to Aug. 2016: Particulate and dissolved Zn isotopic composition analysis.

Data Archive:

All of the raw and processed data from the KH-15-3 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

Table 1 The sampling information of particulate and dissolved samples during KH15-3

KH15-3				Large volume particle filtration				
				Filtration volume (L)				
Sampling station	Long.	Lat.	Depth (m)	0.2~10 (μm)	10~60 (μm)	60~150 (μm)	>150 (μm)	Dissolved
J3	133.19	30.91	10	8		96		no
			80	10		96		500ml*2
			150	8		96		no
J1	132.21	31.50	10	6		84		no
			70	8		96		500ml*2
			150	6		96		no
B8	129.10	29.65	50	7		84		no
			105	6		96		500ml*2
			200	8		96		no
C8	127.83	29.38	50	7		84		no
			100	8		96		500ml*2
			200	8		84		no
F1	123.37	25.25	50	8		84		no
			100	8		72		500ml*2
			200	7		72		no
E3	126.08	25.92	50	8		96		no
			88	7		96		500ml*2
			200	7		96		no
E2	125.70	26.37	50	8		96		no
			104	9		96		500ml*2
			200	5		72		no
D1	126.08	28.95	45	4.5		72		500ml*2
D2	126.45	28.70	60	6		72		500ml*2
D4	127.20	28.21	50	6		96		no
			85	8		96		500ml*2
			200	8		96		no
D5	127.58	27.97	50	8		72		no
			94	7		72		500ml*2
			200	5		72		no
I2	131.86	29.05	50	6		84		no
			90	8		72		500ml*2
			200	5		72		no
I1	130.75	29.37	26	7		72		no
			50	8		72		500ml*2
			200	8		72		no
A2	129.39	30.36	12	8		72		no
			60	8		72		500ml*2
			150	8		72		no
A1	129.00	30.86	30	9		72		no
			66	7		72		500ml*2
			150	5		72		no
				0.2~10	10~60	60~150	>150	Dissolved
Total amount of samples				41	41	41	41	15

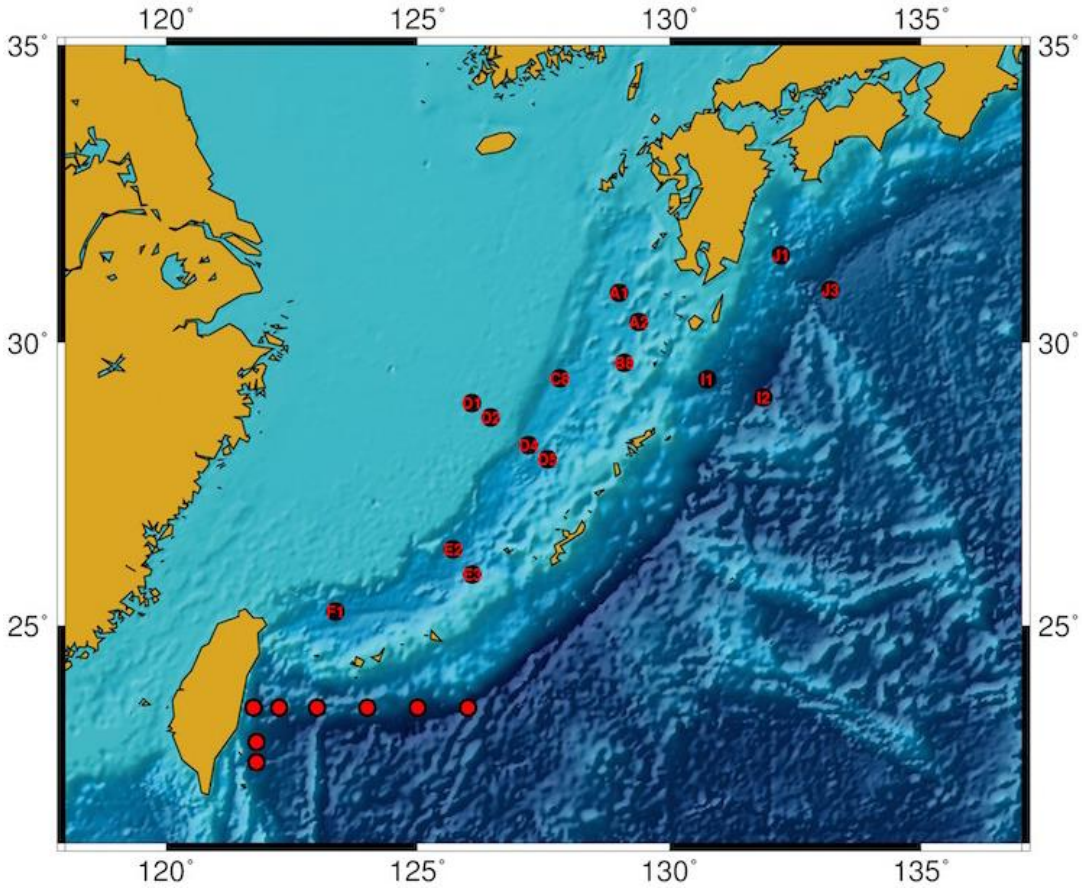

Figure 1. The sampling locations during KH15-3 with the sampling location in two Taiwanese GEOTRACES cruises and another cruise to Green island.

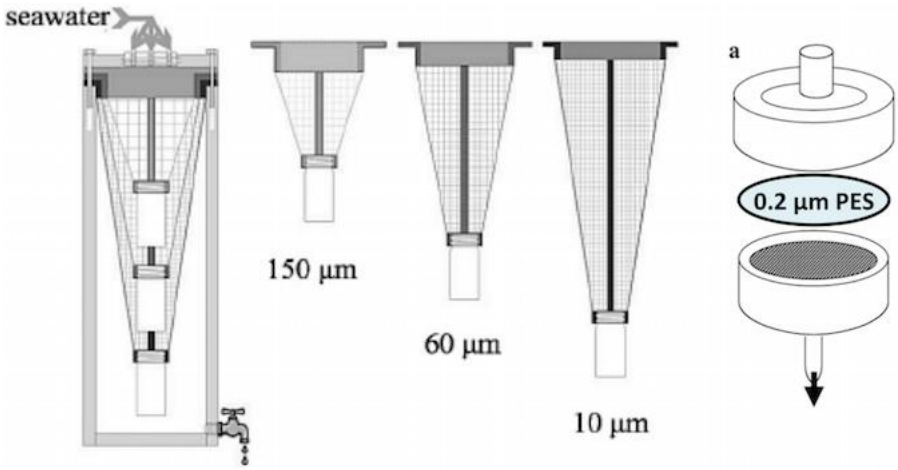

Figure 2. The gravitational sampling apparatus connecting with a filter holder was used in this cruise.

10.15. Determination of bioactive trace metals in the atmospheric aerosol

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Introduction and objectives

Trace elements such as Al, Mn, Fe, Co, Ni, Cu, Zn, Cd and Pb are called “bioactive trace metal”. 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-15-3 cruise. The chemical composition and the origin of atmospheric aerosols are investigated by individual particle analysis with SEM-EDX and ICP-MS.

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-15-3 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

10.16. Aerosol chemistry and nutrient depositions into the East China Sean and western North Pacific

Hongliang Ma (Ocean University of China)
Jing Zhang (University of Toyama)

Introduction and objectives

The East China Sea is an important area with a high primary productivity resulting from nutrient transported from the land. The dust aerosol from the Asian continent is considered one key origin transporting and supplying the major nutrients (nitrite, nitrate, phosphate, and silicate) and microelement nutrients (Fe) to the East China Sea and western North Pacific, since nitrate and iron become available for uptake by the phytoplankton while the aerosol settles on the ocean surface. Chemical composition together with S-isotope of the aerosol sample were collected in this cruise, to investigate the atmospheric influence to the surface ocean in the ECS.

Analysis and method

The aerosol samples were collected by using a high-volume air sampler on the compass deck during this cruise, and a wind-sector controller was used to avoid contamination from the ship (MR05-04, 9/15/2005 to 10/24/2005). All the samples were collected on Teflon filter membrane, and classify as >7.0μm 3.3～7.0μm 2.0～3.3μm 1.1～2.0μm by classifier. The samples were collected along 8 sections of the cruise track. The detail is shown in Table 1.

Sample No	Start time	Finish time	Latitude	Longitude	Total account (m^3)
1	10/14 21:50	10/17 12:20	34:04.66	139:14.50	698.5
2	10/17 12:20	10/19 16:00	30:56.97	130:59.98	1536.4
3	10/19 16:00	10/24 12:00	32:56.05	125:58.81	3038.5
4	10/24 12:00	10/26 15:30	25:06.13	125:59.76	1535.4
5	10/26 15:30	10/28 14:00	28:17.70	127:12.76	1167.3
6	10/28 14:00	11/01 12:00	32:39.74	129:30.88	2966.0

Anticipated results and work plan

The filter will be divided into four parts, one for nutrient analysis (extracted by the artificial seawater, see Fig.1, one for water-soluble major ions, and the rest for S-isotope analysis. All these will be conducted at the laboratory on land afterwards. The ionic components were analyzed by means of ion chromatograph, and S isotope will be measured by mass spectrometer.

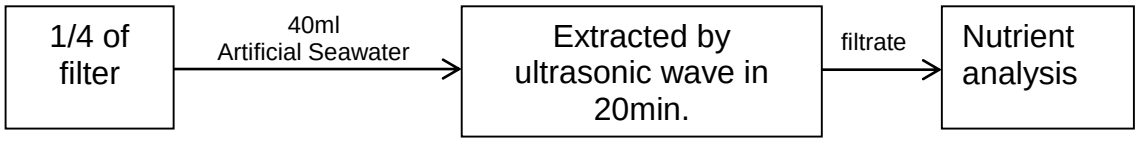

Fig.1. The experiment procedure of nutrients

We expect to finish the aerosol study with 12 months.

Data Archive

All of the raw and processed data from the KH-15-3 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

10.17. Spatial patterns of archaea and phytoplankton biomarkers in the East China Sea and Kuroshio water

Meixun Zhao (on-land, Ocean University of China)
Jing Zhang, Keiji Horikawa (University of Toyama)

Introduction and objectives

We have two objectives.

The first focuses on the sources and transport pathways of organic carbon (OC) in the Okinawa Trough by comparing OC molecular and isotope composition between particulates (through filtering) with surface and core sediment samples.

The second focuses on calibrating proxies to study the influence of the Kuroshio on Okinawa salinity and subsurface temperature, using surface sediments of several transects from the south to north Okinawa Trough. The TEX86 proxy will be used to obtain surface temperature results; while the hydrogen isotopes of selected biomarkers (alkenones and brassicasterol) will be tested for salinity reconstruction.

Inventory information for the sampling

Sample No	Station	Core length (cm)	Sampling intervals
1	K1(AND01)-MC	26	1cm thickness from top to bottom
2	K2(AND02)-MC	25	1cm thickness from top to bottom
3	J1(AND04)-MC	28	1cm thickness from top to bottom
4	A3(AND05)-MC	6	1cm thickness from top to bottom
5	B7(AND07)-MC	13	1cm thickness from top to bottom
6	B6(AND08)-MC	19	1cm thickness from top to bottom
7	B5(AND09)-MC	11	1cm thickness from top to bottom
8	B1(AND12)-MC	30	1cm thickness from top to bottom
9	C1(AND13)-MC	34	1cm thickness from top to bottom
10	C4(AND16)-MC	41	1cm thickness from top to bottom
11	C7(AND19)-MC	17	1cm thickness from top to bottom
12	C8(AND20)-MC	34	1cm thickness from top to bottom
13	C9(AND21)-MC	31	1cm thickness from top to bottom
14	E3(AND23)-MC	27	1cm thickness from top to bottom
15	D4(AND31)-MC	36	1cm thickness from top to bottom
16	D5(AND32)-MC	28	1cm thickness from top to bottom
17	A1(AND36)-MC	28	1cm thickness from top to bottom
18	K5(AND37)-MC	12	1cm thickness from top to bottom

Analysis and method

Biomarker content analysis

Freeze–dried filters were extracted with an Automated Solvent Extractor (ASE-200, Dionex, CA, USA). Each sample was extracted with a mixture of dichloromethane (DCM) and methanol (MeOH) (9:1 v/v) at 1500 psi and 100°C for three five-minute static phases. The extracts were first hydrolyzed with 1 N KOH in MeOH for 12 hours at 60°C and then extracted with hexane. The saponified extracts were subsequently separated into hydrocarbon, ketone/ester, alcohol, and polar fractions using 5% deactivated silica gel chromatography. The alcohol fraction (containing alkanols, sterols and phytol) was eluted with 8 mL ethyl acetate/hexane (1:4). Before GC analysis, the alcohol fraction was dried

under a gentle N_2 stream and derivatized using N, O-bis(trimethylsily)-trifluoroacetamide (BSTFA) at 60°C for one hour. The remaining solution was acidified with 4N HCl until pH=1 to yield acidic fraction. Fatty acids were extracted with hexane and then methylated with anhydrous methanol of known isotopic composition and acetyl chloride at 55-65°C overnight (12-24h). Subsequently, fatty acid methyl esters (FAMEs) were extracted with hexane.

Biomarker identification and structure verification were performed on an Agilent 6890N GC with an Agilent 5975 quadrupole mass selective detector and an Agilent DB-5ms capillary column (60 m ×0.32 mm×0.25 μm). All samples were run in full scan mode (m/z 50–700). Oven temperature programming for GCMS was 60°C to 150°C at 15°C /min, 150°C to 320°C at 6 °C /min, and holding at 320°C for 28 minutes. Biomarker quantification was performed on an Agilent 6890N GC with a FID detector, using an Agilent DB-5mscapillary column (60 m ×0.32 mm×0.25 μm) and He as the carrier gas. Oven temperature programming was 60°C to 150°C at 15°C /min, 150°C to 320°C at 6°C/min, and holding at 320°C for 28 minutes. Quantification of FAMEs was performed by comparing their integrated peak areas to that of a 5a-cholestane quantification standard of known concentration that was added to each sample prior to GC analysis.

Analysis of GDGTs for TEX86 temperature

Samples were freeze-dried, powdered and homogenized with a solvent rinsed agate mortar and pestle. After addition of an internal standard containing a C_{46} GDGT (Huguet et al., 2006) sediments were ultrasonically extracted 2x in MeOH, 2x in 1:1 (v/v) dichloromethane (DCM) in MeOH, and 2x in DCM. The combined extracts were dried over anhydrous Na_2SO_4. After dissolution in 2 ml hexane/DCM (9:1, v/v), each total lipid extract (TLE) was separated into a non-polar and polar fraction using Al_2O_3 gel chromatography (100-200 mesh, Shanghai Ludu corporation, China) by sequential elution with 8 ml hexane/ DCM (9:1, v/v) followed by 12 ml DCM/MeOH (1:1, v/v; Schouten et al., 2007).

The GDGT-containing polar fraction was dried under a stream of N_2 before being redissolved in hexane/isopropanol (95:5, v/v) and filtered through a PTFE filter (0.45μm; Pt. No. 6783-0404, Whatman Corporation, UK) before analysis using high performance liquid chromatography-mass spectrometry (HPLC-MS) and procedures adapted from Schouten et al. (2007). An Agilent 1200 HPLC instrument was coupled to a triple quadrupole mass spectrometer (Waters-Quattro Ultima mass) equipped with an atmospheric pressure chemical ionization (APCI) source. GDGTs were separated on a Prevail Cyano column (150 mm ×2.1mm diam.) with 0.2 ml/min hexane/isopropanol (99:1; v/v) for the first 5 min, then with a linear gradient to 1.8% isopropanol over 45 min. The MS instrument was operated with nebulizer 60 psi, vaporizer 400 °C, N_2 600 l/h, cone gas 80 l/h, APCI source 95 °C and APCI probe 550 °C. The mass spectrometer was operated in single ion monitoring (SIM) mode with the $[M + H]^+$ ions of the 6 GDGTs (Supplementary Fig.) scanned. The relative abundances of GDGTs were obtained by comparing the respective $[M + H]^+$ peak areas that of the C_{46} GDGT internal standard. The precision of GDGT concentration determination relative to the internal standard was better than 10%, as determined from the mean standard deviation of 6 injections of one sample. TEX_{86} values were calculated from the ratio of GDGTs defined by Schouten et al. (2002) and TEX^H_{86} and TEX^L_{86} were calculated from the ratio of GDGTs defined by Kim et al. (2010).

Hydrogen isotope analysis of biomarkers

δD values of akenones and sterolsare done by GCIRMS on a Thermo DELTA V PLUS system (Thermo Scientific, Waltham, MA, USA). The gas chromatograph (Trace Ultra, Thermo) was equipped with a split-splitless injector operated in splitless mode at 300℃, a TRIPLUS autosampler (Thermo Scientific), and an Agilent DB-5 ms capillary

column (60 m ×0.32 mm×0.25 μm). The GC was held at 120 °C for 10 minutes, then at 20°C /min to 180°C, 180°C to 325°C at 3°C /min, and holding at 325°C for 20 minutes. Helium was used as the carrier gas at a constant flow of 1.3 ml/min. Compounds were pyrolyzed in a ceramic reactor at 1400°C. The H^+_3 factor was determined each day using pulses of a reference gas of varying heights and ranged between 1.72 and 1.76. A 1μl sample was injected along with 0.5 μl of *n*-C_{32} of known isotopic composition. A mixture of three standards (C_{21}, C_{26}, and C_{34} *n*-alkanes) whose δD values had previously been established using TC–EA–IRMS was injected every three injections in order to monitor instrument performance. Thermo ISODAT software V.2.5 was used to control instrumentation and calculate δD values. The δD value of the methanol used to methylate the PA and SA samples was determined by using phthalic acid of known isotopic composition. The δD value of the methanol calculated by a mass balance calculation was then used to correct the measured δD values of methylated PA and SA samples for the δD value of the added hydrogen. Each sample was measured in triplicate and the average standard deviation of triplicate analyses was 2.8‰ and 3.3‰ for PA and SA, respectively. Hydrogen isotope ratios are reported using delta notation：$\delta D=[(D/H)_{sample}/(D/H)_{standard}-1]\times100\%$

Fractionation factors between individual fatty acids samples and water were calculated from the relationship: $\alpha_{FA\text{-}water} = (1000+\delta D_{FA})/(1000+\delta D_{water})$.

Anticipated results and work plan

We expect to publish two papers based on the analysis of samples from this cruise.

The first will be on the sources and transport pathways of OC in Okinawa sediment, with analysis finished by June 30, 2016 and manuscript submitted by Sept. 30, 2016.

The second will be on the validation of TEX86 and hydrogen isotope as proxies for Kuroshio water influences, with analysis finished by Dec. 31, 2016 and manuscript submitted by Mar. 31, 2017.

Data Archive

All of the raw and processed data from the KH-15-3 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

10.18. Development of Mg/Ca-temperature equations for multispecies of planktonic foraminifera in the East China Sea

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Introduction and objectives

At this point, Mg/Ca-derived temperature calibration has not been developed in the ECS, and therefore Mg/Ca-derived temperature estimates of planktonic foraminifera have a large error for SST reconstruction in the ECS. In this situation, we try to develop Mg/Ca-temperature calibration equations for multispecies planktonic foraminifera in the ECS using the core-top sediments in the ECS.

Inventory information for the sampling

The sediment core samples used in our study are the ECS sediments. The MC sediment list can be seen in Chapter 7.

Analysis and method

Trace metal of sedimentary foraminifera test will be measured by using a ICP-MS (Element II, Thermo) after chemical cleaning. The chemical cleaning follows Boyle and Keigwin (1985). In brief, samples undergo a multistep process consisting of initial rinses in ultrapure water and methanol, followed by treatments with hot reducing and oxidizing solutions, transferred into new acid-leached micro-centrifuge tubes (1.5 mL), and finally leached with a dilute ultrapure nitric acid solution (0.001 M HNO3, TAMAPURE-AA-100 from Tama Chemicals, Ltd.).

Anticipated results and work plan

We have collected sediment cores at the water depths ranging from ~100 m to 1800 m. Using these sediment cores, we expect to develop robust Mg/Ca-temperature calibration equations for multispecies planktonic foraminifera in the ECS. We plan to publish a paper regarding Mg/Ca-temperature calibrations for multispecies planktonic foraminifera by the end of 2016.

Data Archive

All of the raw and processed data from the KH-15-3 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

10.19. REEs, Sr and Nd isotope patterns of the core-top sediments in the ECS: Sediment provenance and transport information for reconstruction of paleo-Kuroshio Current

Keiji Horikawa and Yukiko Kozaka
Graduate School of Science and Engineering for Research, University of Toyama
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Introduction and objectives

To understand Kuroshio-related sediment dispersal patterns of fine-grained sediments in the ECS, we will investigate REE, Sr and Nd isotopes of fine-grained fraction (< 63 μm) from the core-top sediments. This knowledge on sediment provenance/transport will provide principle information to reconstruct the flow regime of the Kuroshio Current in the past.

Inventory information for the sampling

The sediment core samples used in our study are the ECS sediments. The MC sediment list can be seen in Chapter 7.

Analysis and method

We focus on the fine-grained (< 63 μm) sediments, which are easily transported by currents with long distance, for analyses of the sediment provenance and transport. The fine-grained sediments will be dissolved by the concentrated HNO_3 acid and HF, and the aliquot will be separated into Sr, REE, and Nd by using cation ion exchange column and Rn lesin column, respectively. REEs will be measured by a ICP-MS (Element II, Thermo). Sr and Nd isotopes will be measured by using a TIMS.

Anticipated results and work plan

We have collected sediment cores from the southern to northern Okinawa Trough and the shelf regions at the water depths ranging from ~100 m to 1800 m. These sediments cover wide areas in the ECS, and are ideal for understanding how fine-sediments are distributed in the ECS under the influence of the Kuroshio Current. We will make a sediment distribution map regarding REE, Sr and Nd isotopes, and summarize it as a sediment provenance map. We will try to discuss the relationship between the Kuroshio Current and sediment provenance, and expect to publish a paper by the end of 2016.

Data Archive

All of the raw and processed data from the KH-15-3 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

10.20. Estimation of net primary production using Fast Repetition Rate fluorometry

Zhu Yhuali and Joji Ishizaka (On land, Nagoya University)

Introduction and objectives

Fast Repetition Rate fluorometry (FRRf) potentially provides the means to examine marine primary productivity free from limitations associated with carbon uptake (C-uptake) measurements. However, FRRf-based productivity estimates require knowledge of the electron requirement of C-uptake ($\Phi_{e,C}$) to fully scale electron transfer rate (ETR) to CO_2 uptake rates and recently $\Phi_{e,C}$ was also considered to be the key for directly converting FRRf results to Net primary production (NPP). Once the NPP can be estimated fairly well, directly from FRRf, it will allow getting abundant in situ data for further satellite NPP algorithm calibrating and/or improving.

Inventory information for the sampling

The following table shows the locations and date of FRRf deployment.

Station name	Date
AND13/C1	2015.10.19
AND14/C2	2015.10.20
AND16/C4	
AND26/D1	2015.10.27
AND27/D2	
AND30/D3	2015.10.28
AND31/D5	

Analysis and method

A FRR fluorometer (Diving Flash, Kimoto Electric) integrated with a photosynthetically active radiation (PAR, 400–700 nm) radiometer and a pressure sensor were deployed after CTD casts with both light and dark chambers to a final depth of ca. 100 m with fast descent speed upward speed of about 0.1 m s^{-1}. Night cast of FRRf were obtained for getting phytoplankton physiological information. Daytime FRRf casts should be deployed on the sunward side to avoid the shadow from the ship.

Anticipated results and work plan

Based on the FRRf-NPP algorithm we developed, the primary productivity from FRRf will be compared with those from satellite NPP algorithm (e.g. vertically generalized production model (VGPM, Behrenfeld and Falkowski, 1997) or Kameda and Ishizaka model (KI, Kameda and Ishizaka, 2005). We anticipate both results are strongly co-related and it will prove that our FRRf-NPP method can be applied in East China Sea. Based on FRRf night casts, we also anticipate phytoplankton physiological status is different with previous results we observed at same area but in different season.

Data Archive

All of the raw and processed data from the KH-15-3 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

10.21. Boundary mixing and microstructure in the East China Sea and the Kuroshio

Takeshi Matsuno[1], Eisuke Tsutsumi[1], Keun Jong Lee[1], Chang Su Hong[2], Gyu Nam Baek[2]
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Vertical profiles of the turbulent dissipation rate were obtained with the microstructure profiler, TurboMAP-L (TM), at most of the observation stations during this cruise. In general two casts were carried out at each station except for a few stations for saving ship time. Time table of the TM casts is shown in Table 10.21.1.

Table 10.21.1 Details of the microstructure measurements.
Station name is included in the filename.

Date	Cast #	Water depth	Start time	End time	End depth	Filename	Memo
10/16	1	4530	17 : 34	17 : 48	530	tm-J3-01	falling speed ~ 0.6m/s shear probe1 #1342, shear probe2 #1343, FPO #187
10/17	2	2300	02 : 36	02 : 48	518	tm-J1-01	
	3	370	21 : 11	21 : 21	350	tm-A3-01	29° 55.11′N, 129° 44.90′E 2nd cast file is divided to two
	4	353	21 : 29	21 : 40	345	tm-A3-02	29° 55.11′N, 129° 45.05′E
10/18	5	837	06 : 02	06 : 14	543	tm-B8-01	29° 39.84′N, 129° 08.96′E
	6	417	17 : 04	17 : 16	422	tm-B6-01	30° 28.47′N, 128° 04.63′E
	7	422	17 : 28	17 : 41	427	tm-B6-02	30° 28.50′N, 128° 04.28′E
10/19	8	125	00 : 15	00 : 19	128	tm-B5-01	30° 54.97′N, 127° 35.60E
	9	125	00 : 22	00 : 26	128	tm-B5-02	30° 54.99′N, 127° 35.58′E
	10	110	07 : 17	07 : 21	107.8	tm-B3-01	
	11	110	07 : 23	07 : 26	107.5	tm-B3-02	
	12	108	11 : 15	11 : 18	108.2	tm-B2-01	32° 24.34′N, 126° 23.15′E

	13	108	11 : 22	11 : 25	109.7	tm-B2-02	
	14	112	15 : 26	15 : 29	112.1	tm-B1-01	32° 55.99′N, 125° 59.04′E
	15	111	15 : 33	15 : 36	110.8	tm-B1-02	
	16	68	22 : 55	22 : 57	67.5	tm-C1-01	32° 42.74′N, 124° 50.36′E
	17	68	23 : 00	23 : 02	67.5	tm-C1-02	lots of strange shear spectrum
10/20	18	59	03 : 57	04 : 00	58.8	tm-C2-01	32° 14.37′N, 125° 13.02′E
	19	59	04 : 02	04 : 05	58.9	tm-C2-02	
	20	62	08 : 29	08 : 31	61.9	tm-C3-01	31° 42.49′N, 125° 38.36′E
	21	62	08 : 34	08 : 36	62.0	tm-C3-02	
	22	70	13 : 18	13 : 20	70.0	tm-C4-01	31° 13.05′N, 126° 00.51′E
	23	69	13 : 24	13 : 26	70.1	tm-C4-02	
	24	84	17 : 51	17 : 59	84.4	tm-C5-01	30° 43.84′N, 126° 25.61′E
	25	84	17 : 57	17 : 59	84.3	tm-C5-02	
	26	97	21 : 48	21 : 51	96.0	tm-C6-01	30° 13.54′N, 126° 49.38′E
	27	97	21 : 53	21 : 56	97.6	tm-C6-02	
10/21	28	125	02 : 28	02 : 32	128.2	tm-C7-01	29° 46.03′N, 127° 17.53′E
	29	125	02 : 35	02 : 38	128.5	tm-C7-02	
	30	1019	07 : 47	07 : 58	438	tm-C8-01	29° 26.08′N, 127° 50.64′E stopped due to the strained cable by strong wind
	31	1055	16 : 51	17 : 05	546	tm-C9-01	28° 59.64′N, 128° 20.67′E
10/2	32	1645	12 :	12 : 54	524	tm-F1-01	25° 09.77′N, 122° 56.83′E

5			41				
	33	1648	13 : 09	13 : 21	512	tm-F1-02	25° 10.02′N, 122° 56.98′E strange data below 400m
	34	1657	18 : 44	18 : 58	493	tm-F1-03	25° 13.93′N, 123° 00.25′E
	35	1658	19 : 11	19 : 23	510	tm-F1-04	25° 14.15′N, 123° 59.81′E
10/26	36	1806	13 : 15	13 : 28	590	tm-E3-01	26° 23.60′N, 125° 42.69′E stopped data recording at 535m
	37	1799	13 : 39	13 : 54	574	tm-E3-02	26° 23.90′N, 125° 42.81′E substituted to FPO #247
10/26	38	1252	20 : 11	20 : 25	547	tm-E2-01	26° 36.72′N, 125° 30.61′E
	39	1236	20 : 42	20 : 54	515	tm-E2-02	26° 37.07′N, 125° 30.72′E
10/27	40	186	00 : 07	00 : 12	191	tm-E1-01	26° 49.13′N, 125° 18.94′E
	41	192	00 : 17	00 : 22	195	tm-E1-02	26° 49.06′N, 125° 19.12′E
	42	107	12 : 58	13 : 01	109	tm-D1-01	28° 59.46′N, 126° 12.36′E
	43	107	13 : 05	13 : 08	109	tm-D1-02	28° 59.47′N, 126° 12.64′E
	44	127	16 : 27	16 : 31	125	tm-D2-01	28° 41.24′N, 126° 27.20′E
	45	128	16 : 35	16 : 39	131	tm-D2-02	28° 40.92′N, 126° 27.35′E
	46	146	19 : 16	19 : 20	149	tm-DU-01	28° 46.58′N, 126° 45.79′E
	47	146	19 : 26	19 : 30	149	tm-DU-02	28° 46.55′N, 126° 45.88′E
10/28	48	181	00 : 49	00 : 54	185	tm-D21-01 (D2′)	28° 35.07′N, 126° 45.26′E
	49	182	00 : 59	01 : 04	187	tm-D21-02 (D2′)	28° 34.93′N, 126° 45.57′E
	50	216	04 : 47	04 : 53	221	tm-D3-01	28° 27.07′N, 126° 49.38′E
	51	217	04 : 58	05 : 05	215	tm-D3-02	28° 27.15′N, 126° 49.55′E
	52	1032	15 :	15 : 54	545	tm-D4-01	28° 20.46′N, 127° 14.94′E

			41				
	53	1042	16 : 05	-	32	tm-D4-02	28° 20.85′N, 127° 15.69′E signal stopped around 32m
	54	1045	16 : 08	16 : 21	540	tm-D4-03	28° 20.92′N, 127° 15.83′E
	55	1315	21 : 06	21 : 19	565	tm-D5-01	27° 58.09′N, 127° 34.61′E
	56	1315	21 : 30	21 : 43	562	tm-D5-02	27° 57.90′N, 127° 34.87′E
10/29	57	3959	17 : 19	17 : 34	573	tm-I2-01	29° 01.12′N, 131° 15.80′E
	58	3968	17 : 43	17 : 57	572	tm-I2-02	29° 01.14′N, 131° 16.05′E
10/30	59	3058	07 : 30	07 : 43	545	tm-I1-01	29° 22.10′N, 130° 46.59′E
	60	3033	07 : 52	08 : 04	539	tm-I1-02	29° 22.02′N, 130° 46.84′E
	61	628	16 : 58	17 : 11	504	tm-A2-01	30° 21.68′N, 129° 23.90′E
	62	610	17 : 23	17 : 35	473	tm-A2-02	30° 21.18′N, 129° 24.29′E
10/31	63	683	00 : 21	00 : 33	485	tm-A1-01	30° 57.78′N, 128° 49.30′E
	64	685	00 : 46	00 : 58	434	tm-A1-02	30° 57.06′N, 128° 49.29′E
	65	106	19 : 20	19 : 23	109	tm-B3-03	31° 53.96′N, 126° 48.17′E
	66	106	19 : 27	19 : 30	108	tm-B3-04	31° 53.83′N, 126° 48.17′E
	67	107	23 : 07	23 : 10	109	tm-B4-01	31° 24.31′N, 127° 11.58′E
	68	106	23 : 14	23 : 17	109	tm-B4-02	31° 24.24′N, 127° 11.53′E

The range of the turbulent dissipation rate ε was from O (10^{-10} W kg^{-1}) to O (10^{-6} W kg^{-1}), and relatively large ε was found just above the sea floor at the shallow stations in the shelf region as well as at intermediate layers in various stations. Examples for the vertical profiles of ε are shown in Fig.10.21.1 and 2 for shallow stations and deep stations, respectively.

At the shallow stations, the magnitude of turbulent dissipation rate ε was largest just above the bottom except for in the surface layer. It sometimes exceeded 10^{-6} W kg^{-1} near the sea floor. Then, it gradually decreased upward in the bottom mixed layer. The vertical eddy diffusivity Kz had similar profiles with values exceeding 10^{-1} m^2 s^{-1} just above the bottom, whose large values are caused by both large ε and weak stratification in the mixed layer. Associated with the strong turbulence above the bottom, turbidity was high in the bottom mixed layer which also had a distribution decreasing upward.

The magnitude of ε just above the bottom varies between 10^{-7} to 10^{-6} W kg^{-1} both along the sections B and C. The variations could be caused by tidal phase. The magnitude of ε along the section C was not much different from that along the section B. On the other hand, turbidity in the bottom layer in the section C as much higher than that in the section B. It was probably caused by the property of the sediments.

Another relatively large value of ε were found in intermediate layer such as at C3. The relatively large values of ε can be found in both casts repeated during about 10 min, and is expected to be caused by breaking of internal waves. Intensified turbulence in the intermediate layers could be strongly related to forming detailed structure of temperature and the other components, while careful comparison is necessary to make clear the relationship between the turbulence and vertical structure.

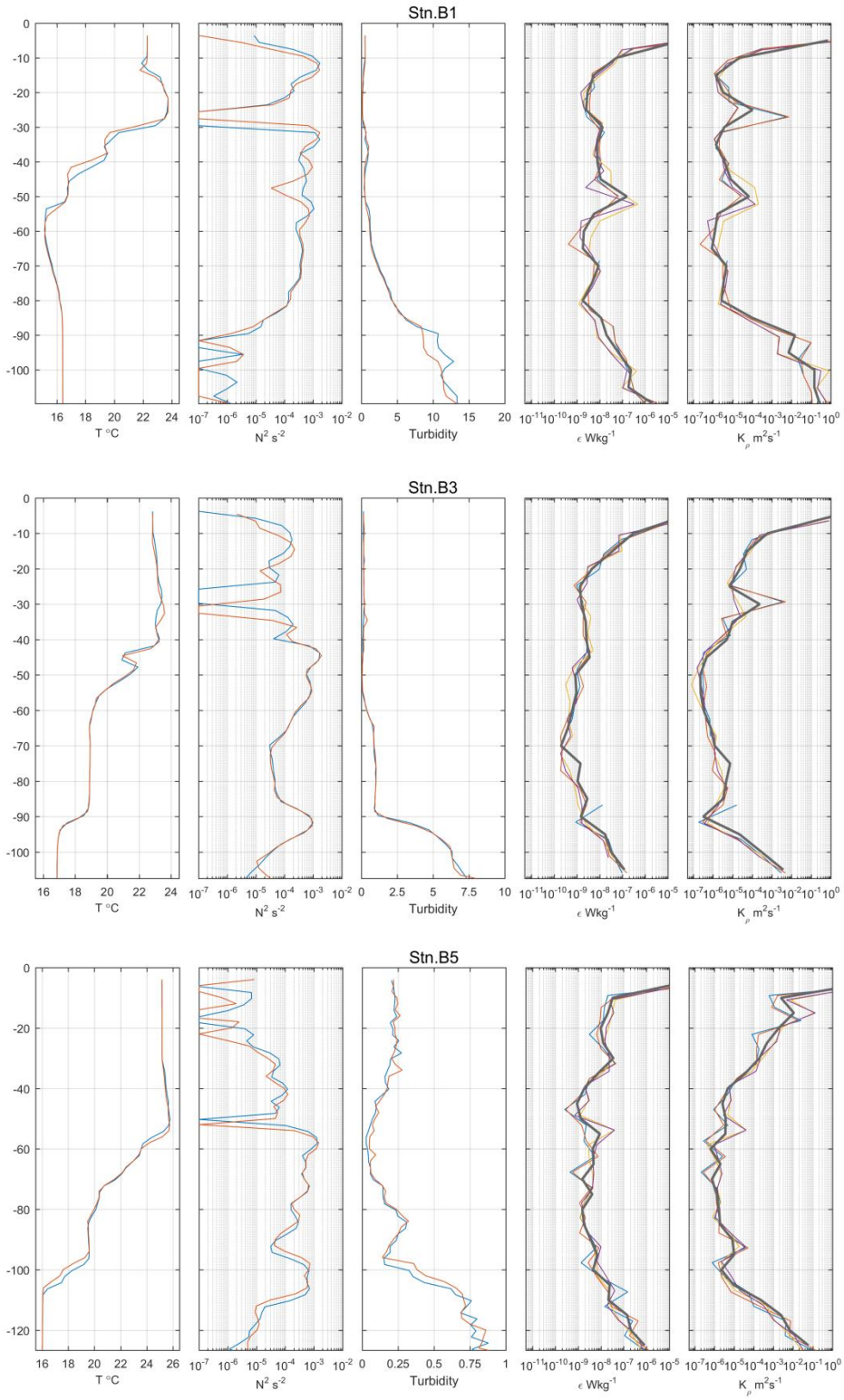

Fig.10.21.1 Vertical profiles of (left to right) temperature, square of buoyancy frequency, turbidity, ε and Kz at (upper to lower) Stn.B1, B3 and B5. Different colors show different casts at the same station for left three panels. The lines in right two panels are from two shear probes of the two casts and thick black line shows averaged one where noisy data have been eliminated.

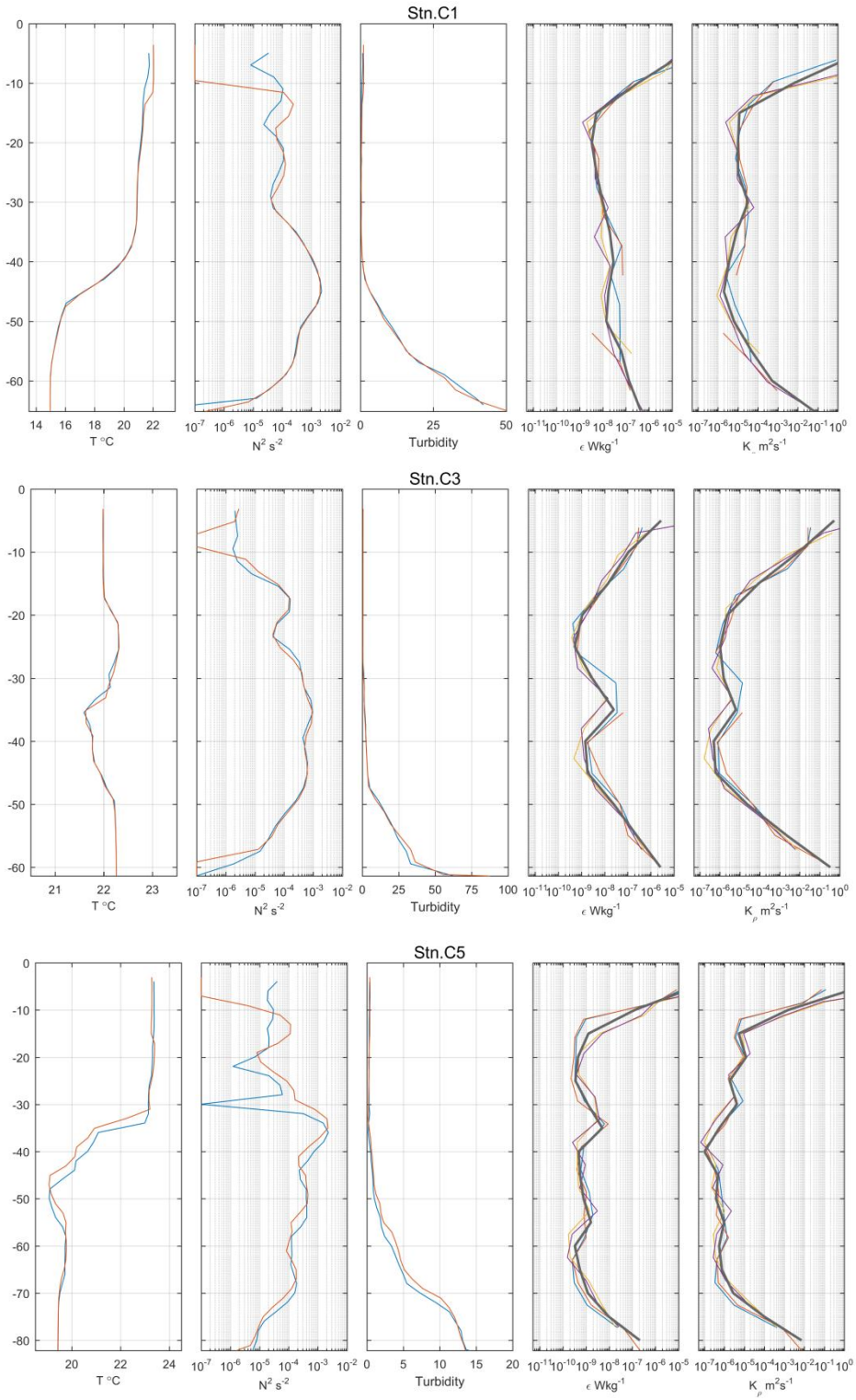

Fig.10.21.1 (continue) Vertical profiles of (left to right) temperature, square of buoyancy frequency, turbidity, ε and Kz at (upper to lower) Stn.C1, C3 and C5.

In the deep water, TurboMAP was not able to approach the bottom, and stopped the lowering at 500 m, while the fish continued to descend for a while as mentioned above. Fig. 10.21.2 shows examples for the vertical profiles obtained at B8, C8 and J3. In general, the magnitude of ε was smaller than that obtained in the shallow region, mostly

less than 10^{-8} W kg^{-1}. However, we can see maxima of ε at intermediate layers such as around 240m, 350m and 440m at B8, and the ε around 440m exceeded 10^{-8} W kg^{-1}. Such maximum had relatively small vertical scale and might be related to step-like structure of temperature. Turbidity in the deep water was very low.

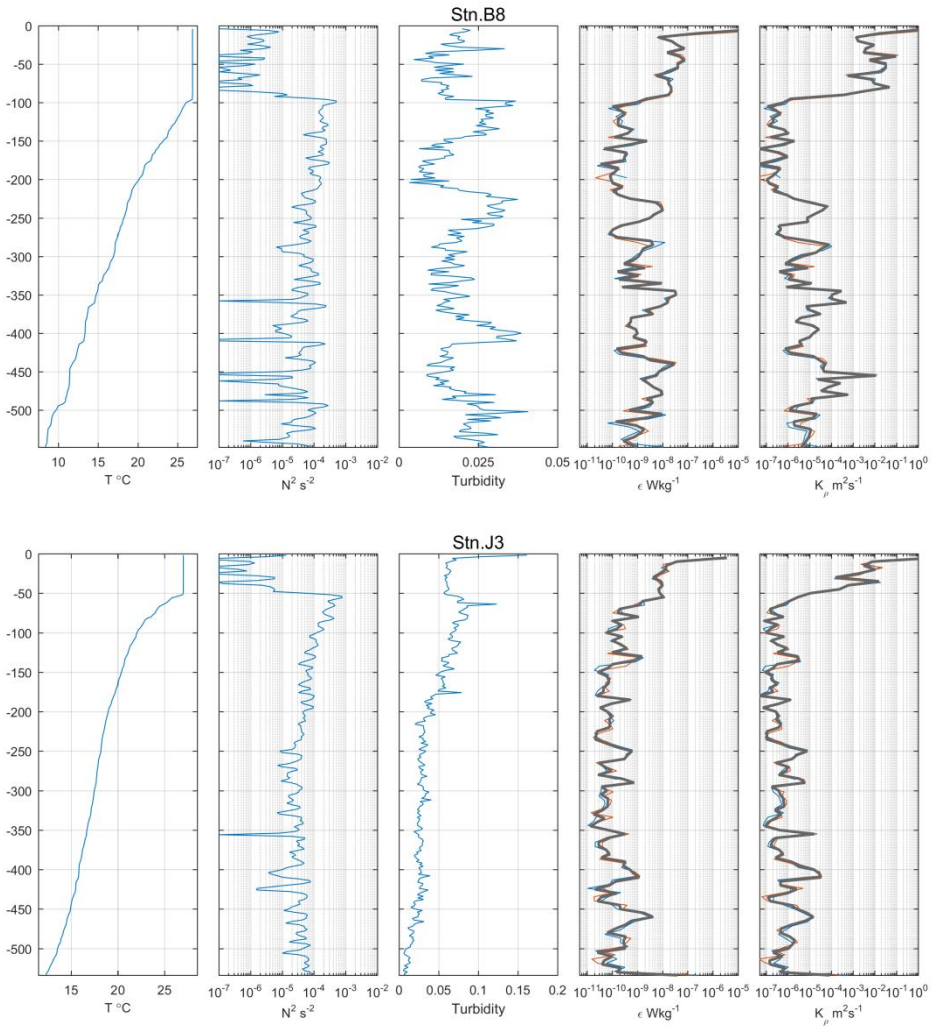

Fig.10.21.2 Same as Fig.10.21.1 but at at (upper) Stn.B8 and (lower) J3.

In the Tokara Strait, large value of ε was found. Vertical profiles of εand the other factors at Stn.A3 are shown in Fig. 10.21.3. Very large values of ε close to 10^{-6} W kg^{-1} were found not only near the bottom but also in the intermediate layer. It would be caused by breaking of internal waves generated around the complicated bottom topography in the strait.

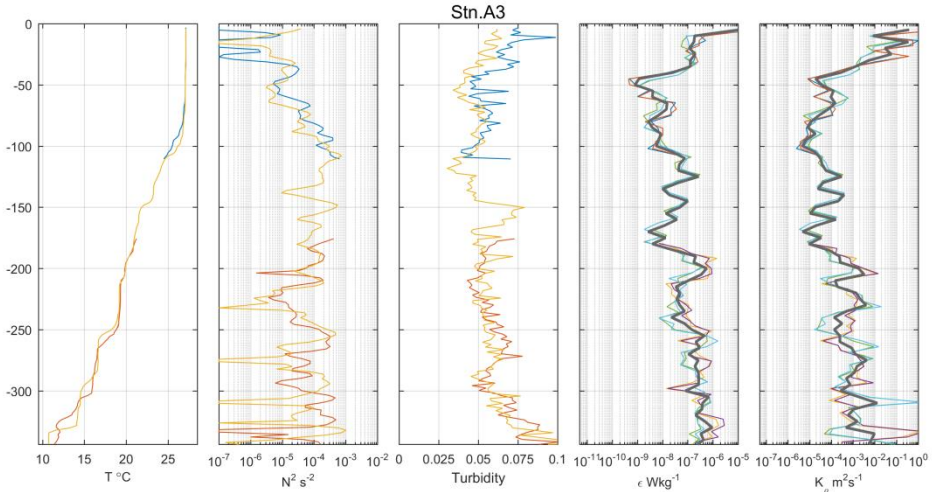

Fig.10.21.3 Same as Fig.10.20.1 but at at A3 obtained on 17 Oct.

Contour maps of the ε along the section B, C, D and I+A are shown in Fig. 10.21.4. It is clearly found that intensified turbulence appeared just above the bottom in the shallow region. Another distinct feature is intensified turbulence at A3 as mentioned above. The vertical section clearly shows that Tokara Strait should be a region for strong vertical mixing, which must affect the vertical structure of materials containing in the Kuroshio.

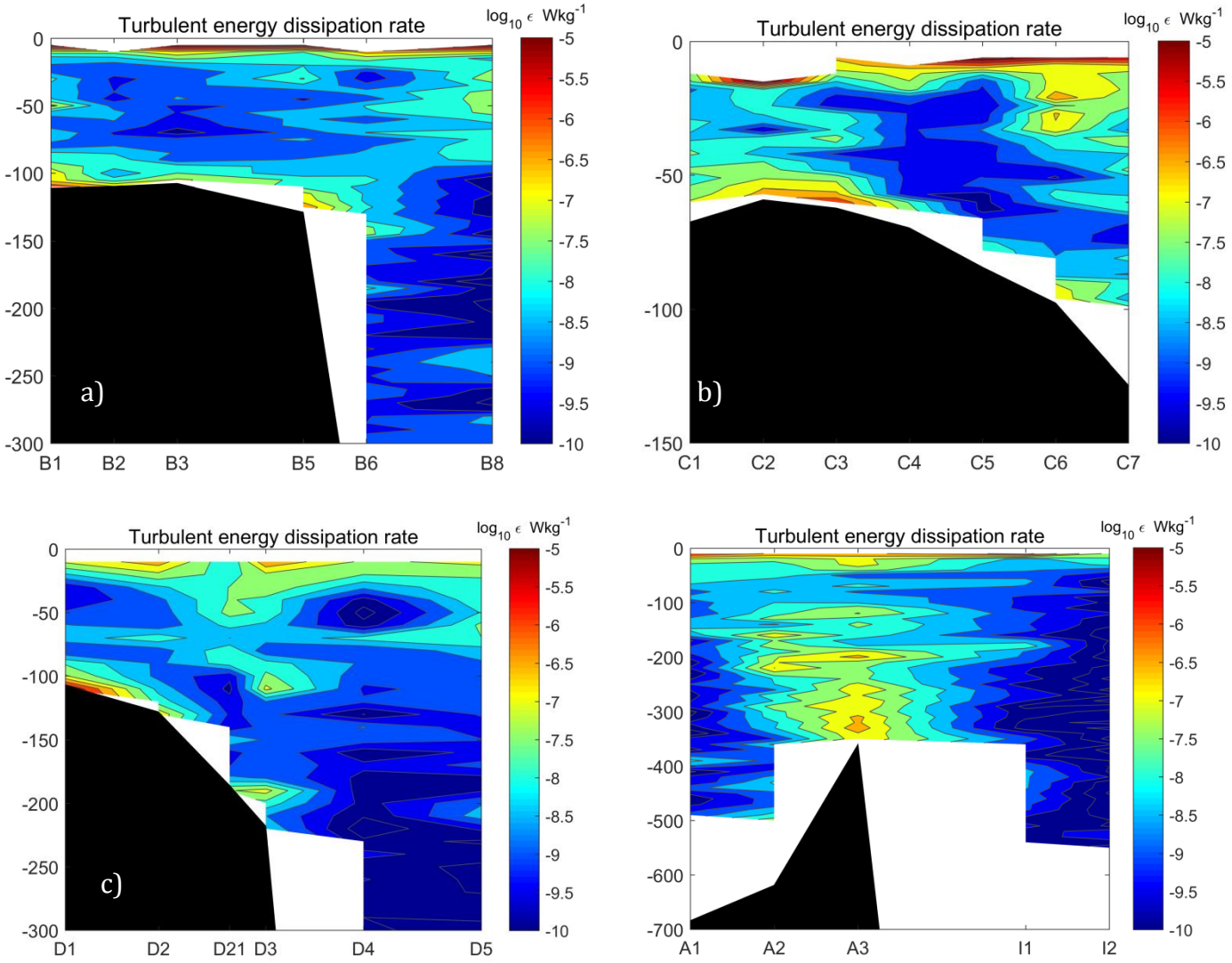

Fig.10.21.4 Vertical section of ε along (a) the section B, (b) the section C, (c) the section D and (d) the section I+A where measurement at A3 was carried out about 2 weeks before the other stations along the section I and A. Color grade is shown with log scale..

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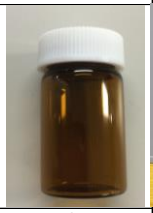
Sample bottles and sampling methods

	1st	2nd	3rd	4th	5th	6th	7th	8th
photo								
sample	DO	DIC	pH	Alkalinity	Salinity	^{18}O	Nutrient	Chl-a
group	Routine	OUC	Routine	Routine	Routine	Toyama Univ.	Routine	Routine
rinse (times)	3 (when wet)	-	3 (when wet)	3 (when wet)	3	3	3	3
overflow (times of bot. vol.)	3	2	2	2	-		-	-
volume					bottle neck	full	0.9	bottle neck
remark	measure w.temp	cap wash	without gas	without gas		without gas		

	9th	10th	11th	12th	13th	14th	15th	16th
photo								
sample	Pa/Th and Nd	δ15N in NO3	Size POM	nif-H	nanomol nuts	Nano-Nutrient	Phytoplankton	Ba
group	Routine	Nagasaki Univ.	Nagasaki Univ.	Nagasaki Univ.	Nagasaki Univ.	Nagasaki Univ.	Nagoya Univ.	Toyama Univ.
rinse (times)	3	2	2	3	3	3	3	3
overflow (times of bot. vol.)					-	-	-	-
volume	full	full		bottle neck	80 mL line	80 mL line	bottle shoulder	bottle mouth
remark	special tube		special tube	glove	glove	glove		special tube

	17th	18th	19th					
photo								
sample	Ba Isotope	REEs/Ra	Particulate trace metal					
group	Toyama Univ.	Toyama Univ.	Academia Sinica					
rinse (times)	3	3	1					
overflow (times of bot. vol.)		-	-					
volume	bottle shoulder	bottle neck	96 L					
remark	special tube	glove, special tube	large volume					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