

Preliminary Report of the R/V Hakuho Maru KH-11-7 Cruise

TRIANGULUM Expedition – ASIAN GEOTRACES

July 16, 2011 --- August 4, 2011

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(Shotaro Takano, Jun Yamamoto, and Yoshiki Sohrin)

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(Hajime Obata, Shin Wakiyama, Taejin Kim, Asami Suzuki and Toshitaka Gamo)

10. 2. 2. Isotopic distributions of Nd in the western North Pacific Ocean.

(Hirofumi Tazoe and Hajime Obata)

10.3. Chemical speciation of selenium and biogenic selenium.

(Akira Nishiuchi, Koichi Takeda and Yuzuru Nagaguchi)

10.4. Water mass structure analysis GP10 line (165E) in the western North Pacific Ocean using rare earth element.

(Shunji Sasaki, shoko Hirayama, Jing Zhang)

10.5. Biogeochemical studies on Ba in seawaters from the western North Pacific.

(Yoshihisa Kato and Ray Ito)

10.6. Does Nd isotopic composition of foraminifera faithfully reflect that of

- ambient seawater? (Hiroshi Amakawa)
- 10.7. Lead isotopes distributions in the North Pacific Ocean.
(Céline Gallon, A. Russell Flegal)
- 10.8. Cadmium concentration & isotopic compositions in the North Pacific Ocean.
(Cheryl Zurbrick and A. Russell Flegal)
- 10.9. Elemental and isotopic composition of trace metals and phytoplankton community structures.
(Tung-Yuan Ho, Hsu-Han Yang, and Shun-Chung Yang)
- 10.10.1. Anthropogenic radionuclide in the ocean: Feasibility using ^{236}U and ^{135}Cs to construct the circulation of seawater.
(Akinobu Kadokura, Haruka Chiga and Aya Sakaguchi)
10. 10.2. Anthropogenic radionuclide in the seawater: offshore area of Fukushima dai-ichi nuclear power plant.
(Haruka Chiga, Akinobu Kadokura and Aya Sakaguchi)
- 10.12. Measurements of volatile organic compounds in surface seawater
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(Sachi Taniyasu, Nobuyoshi Yamashita, Masatoshi Yamada, Toshitaka Gamo)
- 10.14. Density. (Tsurushima)
- 10.15. Chemical composition of atmospheric aerosol.
(Koichi Takeda, Akira Nishiuchi and Yuzuru Nagaguchi)
- 10.16. (Rei Ito, Hideki Minami)
- 10.17. Proxy-based reconstruction of water mass circulation in the Pacific: Fish teeth Nd isotopes and Cd/Ca of benthic foraminifera. (Keiji Horikawa and Tomohiro Kodaira)
- 10.18. Reconstruction for glacial-deglacial change in the North Pacific deepwater properties. (Yusuke Okazaki)
- 10.19. Spatial patterns of archaea and phytoplankton biomarkers in the Northwestern Pacific Ocean. (Shu-qin Tao, Meixun (Max) Zhao)
- 10.20. Biogeochemical study of Fe(II) in the western North Pacific using an in-situ analyzer. (Shin Wakiyama, Hajime Obata, Toshitaka Gamo and Kei

Okamura)

10.21.1. Seabed disturbance above the seismogenic zone and tsunami sources area of the 2011 Tohoku-oki Earthquake along the East Japan margin of the Pacific.

(Akira Takeuchi, Badalahu Bao and Yuko Furusawa)

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(Badalahu Bao, Yuko Furusawa and Akira Takeuchi)

10.22. Helium isotope change related to the M9.0 earthquake.

(Yuji Sano and Naoto Takahata)

10.23. Distribution of dissolved methane. (Urumu Tsunogai)

10.24. Bacteria structure (Chiaki Kato)

10.25. Cold seep geochemistry in pore water and bottom water off NE Japan.

(Kyohei Matsumoto, Jing Zhang)

10.26. Mineral composition in surface sediments. (Harue Masuda)

10.27. The concentrations of artificial radionuclides in seawater, sediments and plankton around off Fukushima.

(Tatsuo Aono, Jian Zheng, Kenji Oguma, Hajime Obata and Jing Zhang)

10.28. Transport process of anthropogenic radionuclides in the region off Fukushima. (Shigeyoshi Ootosaka and Hisashi Narita)

10.29. Distribution of radionuclides released from Fukushima NPP accident in northwest Pacific region.

(Seiya Nagao, Mutusuo Inoue, Y. Hamajima and Masayoshi Yamamoto)

10.30. Argo float deployment in the North Pacific.

(Toshio Suga, Shigeki Hosoda, Kanako Sato and Mizue Hirano)

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1 Introduction

1) Summary of the KH-11-7 cruise

The Hakuho Maru KH-15-3 cruise, which is also called the “TRIANGULUM 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 16 July to 4 August 2011 (a total of 20 days) in the East China Sea and adjacent Kuroshio area. The cruise left Tokyo on 16 July and returned on 4 August.

This cruise was a part of the international GEOTRACES project and aimed to elucidate marine environmental changes by carrying out interdisciplinary observations and research on the distribution of trace elements and isotopes in the western North Pacific.

The specific research topics addressed are as follows.

- Vertical and spatial distribution of trace element concentrations and isotopes in the western North Pacific by longitudinal observation
- Elucidation of the distribution, speciation, and functions of trace elements that control biological activities.
- Elucidation of ocean circulation processes by trace elements and isotopes
- Distribution of trace elements and isotopes in the boundary region of the ocean
- Study on plankton community and trace metals in suspended particles
- Atmospheric and oceanic monitoring of volatile organic compounds (VOC) released by marine phytoplankton
- Paleoceanographic research using trace elements and isotopes

In response to the earthquake and tsunami disaster, including the Fukushima Daiichi nuclear power plant accident prior to the cruise, we conducted the following observation and research in the waters off Fukushima and Sanriku.

- Microbial and isotope geochemical studies in the epicenter of the Tohoku-Pacific Ocean Earthquake and surrounding seas.
- Detection and analysis of seafloor deformation in the epicenter and tsunami wave source areas of the Tohoku earthquake

- Research on the diffusion of radioactive materials off the coast of Fukushima and surrounding seas

2) The Research Voyage

This research voyage was a continuation of the KH-10-2 research voyage conducted in 2010, and as part of the Far East Asia GEOTRACES Project II, foreign researchers from the Ocean University of China and Academia Sinica in Taiwan were invited. In addition, in response to the Great East Japan Earthquake that occurred on March 11, 2011, we included research related to earthquakes and tsunamis, such as seabed deformation in earthquake epicenter and tsunami origin areas, and research to understand the diffusion of radioactive materials in the waters of and around the Fukushima region. A total of 17 students from graduate schools in Japan and overseas were on board the vessel. Despite the impact of Typhoon No. 6, the voyage was relatively short (20 days) and included 22 CTD water sampling, 10 multiple core sampling, 4 GAMOS sensor sampling, 2 plankton sampling by NorPac net, 4 ARGO sampling, and 19 XCTD/XBT sampling at 26 stations along the 165°E longitudinal observation line, off Sanriku and off Fukushima. In addition, two sediment traps were deployed at the end of the voyage, and we were able to obtain many valuable samples and data.

It is our great pleasure to thank Captain Takatoshi SEINO 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 (B) No. 22403001 and (A) No. 23253001 from MEXT of Japan.

Jing ZHANG (Chief Scientist)
and the Shipboard Scientific Party
4 August, 2011

2. Caution about the cruise data

The KH-11-7 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-11-7 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 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 DAC**
- **Submit CTD and underway data (both raw and processed files; sensor information and calibration) to national DAC (e.g., BCO-DMO) and BODC.**

As soon as possible, 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 Participants

3.1. List of scientists

| | Family Name | Given Name | Affiliation | ~ Onahama | Onahama ~ |
|----|-------------|------------|---------------------------------|-----------|-----------|
| 1 | ZAHNG | Jing | Univ. Toyama | ○ | ○ |
| 2 | TAKEUCHI | Akira | Univ. Toyama | ○ | ○ |
| 3 | HORIKAWA | Keiji | Univ. Toyama | ○ | ○ |
| 4 | OBATA | Hajime | Univ. Tokyo | ○ | ○ |
| 5 | OGUMA | Kenji | Univ. Tokyo | ○ | ○ |
| 6 | TAKEUCHI | Makoto | Univ. Tokyo | ○ | ○ |
| 7 | TAO | Shu-Qin | Ocean Univ. China | ○ | ○ |
| 8 | YANG | Hsu-Han | Academia Sinica | ○ | |
| 9 | YANG | Shun-Chung | Academia Sinica | ○ | |
| 10 | OOKI | Atsushi | Hokkaido univ. | ○ | ○ |
| 11 | WAKIYAMA | Shin | Univ. Tokyo | ○ | ○ |
| 12 | ITO | Rei | Tokai univ. | ○ | ○ |
| 13 | HASEGAWA | Kazuya | Tokai univ. | ○ | ○ |
| 14 | BAO | Badalahu | Univ. Toyama | ○ | ○ |
| 15 | SASAKI | Shunji | Univ. Toyama | ○ | ○ |
| 16 | HIRAYAMA | Shoko | Univ. Toyama | ○ | ○ |
| 17 | MATSUMOTO | Kyouhei | Univ. Toyama | ○ | ○ |
| 18 | KODAIRA | Tomohiro | Univ. Toyama | ○ | ○ |
| 19 | FURUSAWA | Yuko | Univ. Toyama | ○ | ○ |
| 20 | YAMAMOTO | Jun | Kyoto Univ. | ○ | ○ |
| 21 | TAKANO | Shotaro | Kyoto Univ. | ○ | ○ |
| 22 | NISHIUCHI | Akira | Kinki Univ. | ○ | ○ |
| 23 | TAKEDA | Koichi | Kinki Univ. | ○ | ○ |
| 24 | KADOKURA | Akinobu | Hiroshima Univ. | ○ | ○ |
| 25 | CHIGA | Haruka | Hiroshima Univ. | ○ | ○ |
| 26 | OKAZAKI | Yusuke | JAMSTEC | ○ | ○ |
| 27 | TANIYASU | Sachi | Natl. Inst. Adv. Ind. Sci. Tech | ○ | ○ |
| 28 | AONO | Tatsuo | NIRS | | ○ |
| 29 | OTOSAKA | Shigeki | JAEA | | ○ |
| 30 | NAKAI | Akihiko | NHK | | ○ |
| 31 | YOSHIDA | Kazuhiro | Marine Works Japan Ltd. | ○ | ○ |

3.2. Sharing of the routine shipboard tasks

3.2.1. KH-11-07 Part for GEOTRACES research

Routing analysis (*: Leader) 2011.07.16 ~ 07.28

| | | | |
|------------|---------------------------------------|------------------------------|-----------------|
| Salinity | A. Takeuchi* S. Wakiyama | (K. Oguma) Bao Badalahu | Shu-Qin Tao |
| DO | S. Taniyasu* K. Hasegawa | R. Ito | |
| Nutrients | A. Nishiuchi | K. Takeda | |
| Alkalinity | A. Ooki* S. Hirayama T. Kodaira | S. Takano | H. Chiga |
| pH | H. Obata* S. Sasaki J. Yamamoto | Y. Okazaki Hsu-Han YANG | A. Kadokura |
| Chl-a | K. Horikawa* K. Matsumoto | Y. Hurusawa | Shun-Chung YANG |

Working Group (* : Leader)

| | 0-6 (am / pm) | 6-12 (am / pm) | |
|----------------|--|---|------------------------------|
| CTD Setting | A. Takeuchi* | K. Horikawa* | |
| Operating | B. Bao | Y. Hurusawa | |
| Sampling | H. Chiga | A. Kadokura | |
| DO sampling | K. Hasegawa S. Hirayama | R. Ito S. Sasaki | |
| XBT/XCTD | S. Hirayama | S. Sasaki | |
| Trace metal | H. Obata* S. Takano A. Nishiuchi | S. Wakiyama J. Yamamoto Shun-Chung YANG | K. Matsumoto Hsu-Han YANG |
| Multiple Corer | Y. Okazaki* R. Ito | K. Horikawa K. Hasegawa | T. Kodaira |
| ARGO Float | K. Horikawa | K. Matsumoto | |

3.2.2. KH-11-07 Part for earthquake related research

Routing analysis (*: Leader)

2011.07.31 ~ 08.02

| | | | |
|------------|---------------------------------------|------------------------------|-----------------|
| Salinity | A. Takeuchi* S. Wakiyama | (K. Oguma) Bao Badalahu | Shu-Qin Tao |
| DO | S. Taniyasu* K. Hasegawa | R. Ito | |
| Nutrients | A. Nishiuchi | K. Takeda | |
| Alkalinity | A. Ooki* S. Hirayama T. Kodaira | S. Takano | H. Chiga |
| pH | H. Obata* S. Sasaki J. Yamamoto | Y. Okazaki Hsu-Han YANG | A. Kadokura |
| Chl-a | K. Horikawa* K. Matsumoto | Y. Hurusawa | Shun-Chung YANG |

Working Group (* : Leader, ** : Sub Leader)

| CTD Setting | 0-6 (am / pm) | 6-12 (am / pm) | |
|-----------------------------|---|---|------------|
| Operating | H.Obata* | A.Ooki* | |
| Sampling | H.Horikawa** H.Chiga S.Wakiyama T.Kodaira Shun-Chung Yang | J.Zhang** A.Kadokura S.Taniyasu Y.Hurusawa Hsu-Han YANG | |
| DO·CH ₄ sampling | K.Hasegawa S.Hirayama | R.Ito S.Sasaki | |
| XBT/XCTD | S. Hirayama | S. Sasaki | |
| He sampling | K.Matsumoto | | |
| Multiple Corer | Y. Okazaki* R. Ito | K. Horikawa Shu-Qin Tao | |
| ARGO Float | K. Horikawa | K. Matsumoto | |
| Survey seafloor topography | A.Takeuchi | Bao Badalahu | Y.Hurusawa |

3.2.3. KH-11-07 Part for Fukushima ocean radionuclide impact studies

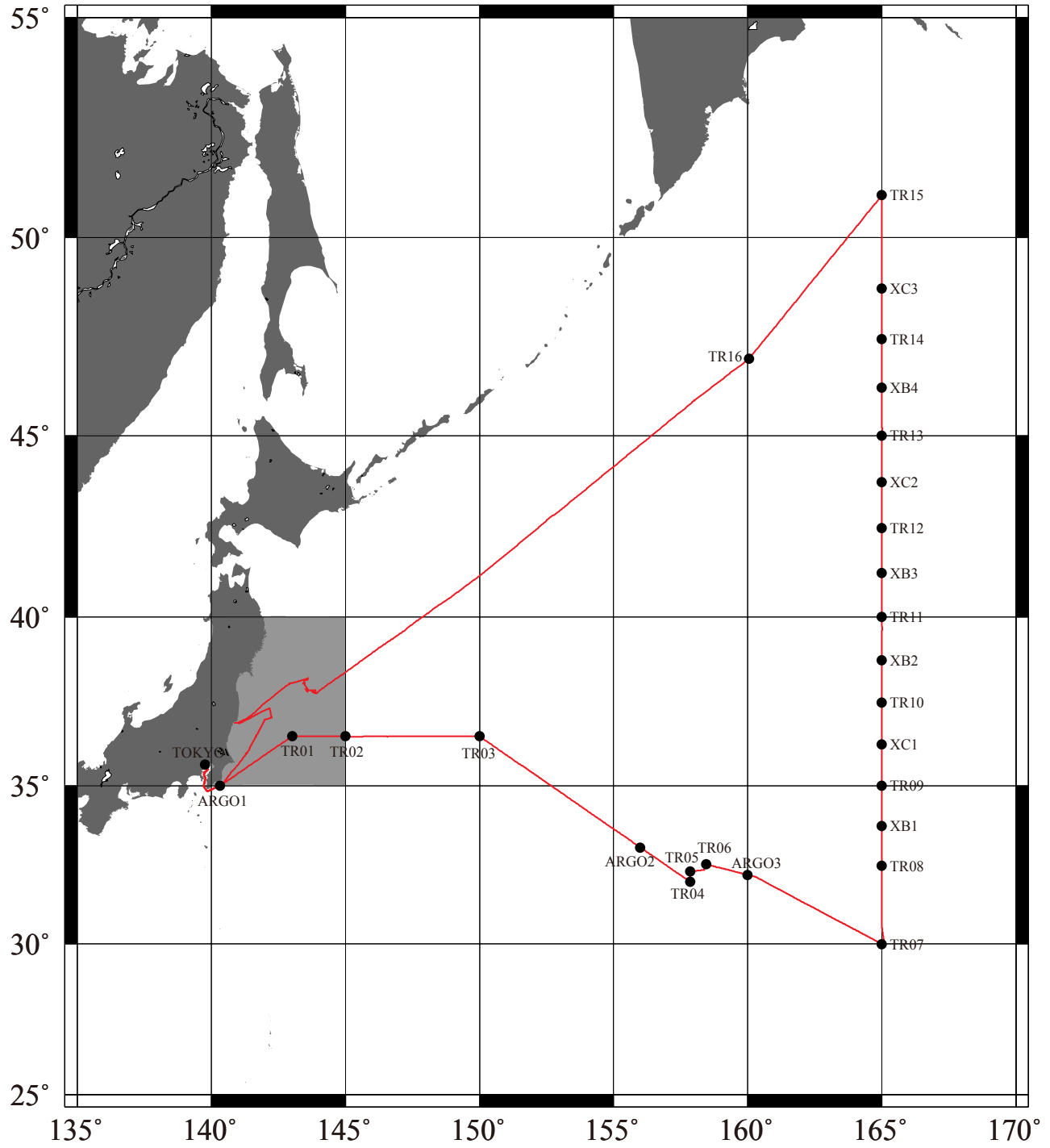
Working Group (* : Leader) 2011.08.02 ~ 08.04

| | | | |
|-------------------------------|----------------------------|----------------------------|------------|
| CTD Operating | S.Wakiyama H.Chiga | Y.Furusawa | |
| CTD Setting Sampling | S.Taniyasu* All members | A.Ooki* | |
| XBT/XCTD | S. Sasaki | S. Hirayama | K.Hasegawa |
| Multiple Corer | Y. Okazaki* R. Ito | K. Horikawa Shu-Qin Tao | |
| ARGO Float | K. Horikawa | K. Matsumoto | |
| Plankton net | T.Aono* | H.Obata | J.Zhang |
| Sediment Trap | S.Otosaka | R.Ito | K.Hasegawa |
| Survey seafloor topography | A.Takeuchi | Bao Badalahu | Y.Hurusawa |

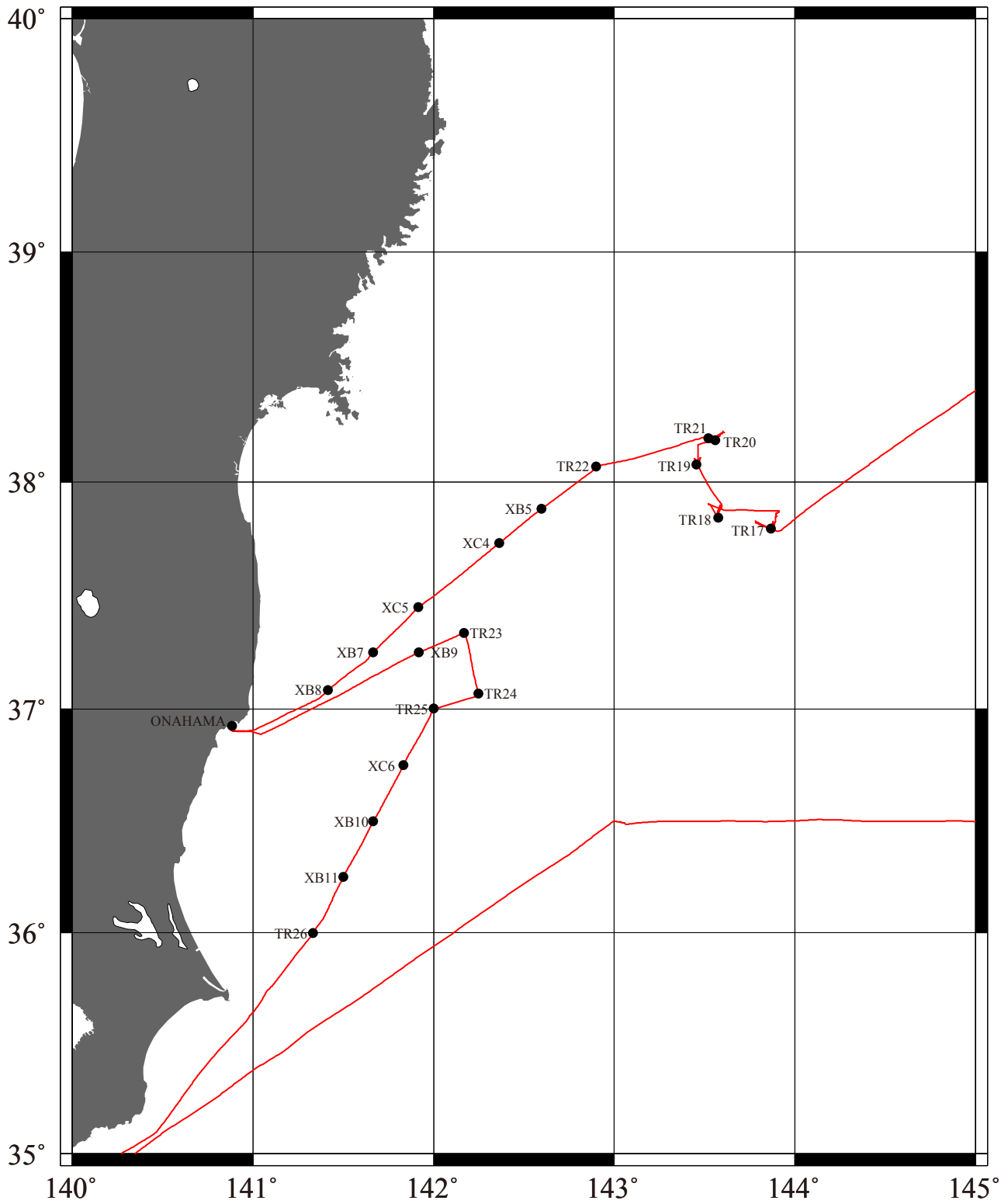
3.3. List of crew

| | Family Name | Given Name | Rating | ~ Onahama | Onahama ~ |
|----|-------------|------------|--|-----------|-----------|
| 1 | SEINO | Takatoshi | Captain | ○ | ○ |
| 2 | OKUBO | Suguru | Chief Officer | ○ | ○ |
| 3 | HAYASHI | Shinjiro | First Officer, Health Supervisor | ○ | ○ |
| 4 | KIYOMIYA | Tomonori | Second Officer | ○ | ○ |
| 5 | CHIBA | Masato | Jr. Second Officer | ○ | ○ |
| 6 | ITAHASHI | Kazuhiko | Third Officer | ○ | ○ |
| 7 | OZAKI | Nana | Jr. Third Officer | ○ | ○ |
| 8 | SASAI | Yuji | Chief Engineer | ○ | ○ |
| 9 | TAKAHASHI | Yoshimitsu | First Engineer | ○ | ○ |
| 10 | MIYAMOTO | Goro | Jr. First Engineer | ○ | ○ |
| 11 | SAKUMA | Yasuhiro | Second Engineer | ○ | ○ |
| 12 | HONDA | Toyohiko | Jr. Second Engineer, Health Supervisor | ○ | ○ |
| 13 | USAMI | Koichi | Third Engineer | ○ | ○ |
| 14 | MAKI | Tetsuji | Chief Electronics Officer | ○ | ○ |
| 15 | MORIWAKI | Yuka | Electronics Officer | ○ | ○ |
| 16 | SUZUKI | Akira | Boatswain | ○ | ○ |
| 17 | IKEDA | Hiroe | Second Boatswain | ○ | ○ |
| 18 | NISHIDATE | Shintaro | Associate Boatswain | ○ | ○ |
| 19 | URABE | Tsuyoshi | Associate Boatswain | ○ | ○ |
| 20 | OGAWA | Hiroyuki | Quarter Master | ○ | ○ |
| 21 | TERASAKA | Yukihiro | Quarter Master | ○ | ○ |
| 22 | MURASW | Hiroaki | Quarter Master | ○ | ○ |
| 23 | YAMAZAKI | Myuta | Sailor | ○ | ○ |
| 24 | OKAMOTO | Yasuyuki | No.1 Oiler | ○ | ○ |
| 25 | SATO | Masayoshi | No.2 Oiler | ○ | ○ |
| 26 | ISHII | Yoshihiko | No.3 Oiler | ○ | ○ |
| 27 | YOSHIDA | Minoru | No.4 Oiler | ○ | ○ |
| 28 | YOSHIDA | Sakae | No.5 Oiler | ○ | ○ |
| 29 | TANIGUCHI | Keiya | No.6 Oiler | ○ | ○ |
| 30 | AIZAWA | Kota | No.7 Oiler | ○ | ○ |
| 31 | SHIBATA | Kyohei | Machineman | ○ | ○ |
| 32 | SAKUMA | Seizo | Chief Steward | ○ | ○ |
| 33 | HAYASHI | Takumi | Steward | ○ | ○ |
| 34 | OKAMURA | Shinya | Steward | ○ | ○ |
| 35 | OYU | Shinobu | Steward | ○ | ○ |
| 36 | TAKAHASHI | Takuya | Steward | ○ | ○ |

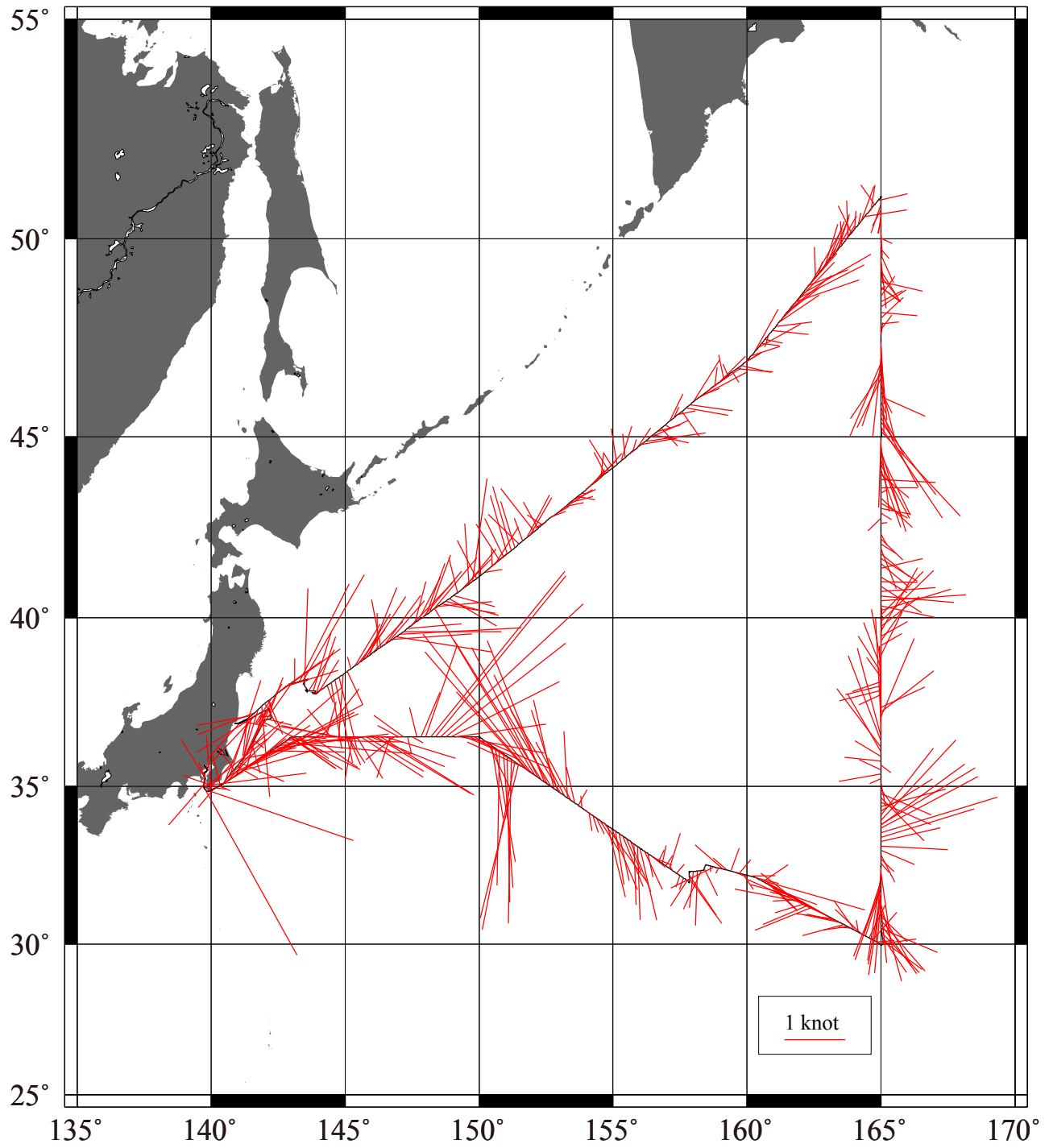
4. Cruise Track: KH-11-7 (Tokyo - Onahama - Tokyo)



Cruise Track: KH-11-7 (Off Fukushima)



5. Drift Chart: KH-11-7 (Tokyo - Onahama - Tokyo)



6. Station list

6.1. Part for GEOTRACES research

| Stn.name | Latitude | | | Longitude | | | Depth (m) | CTD | CTD clean | Multi core | XBT | XCTD | Net | Sediment trap | ARGO Float |
|----------|----------|-------|---|-----------|-------|---|-------------|-----|-----------|------------|-----|------|-----|---------------|------------|
| ARGO-1 | 34 | 59.88 | N | 140 | 19.48 | E | 576 | | | | | | | | 1 |
| TR01 | 36 | 29.73 | N | 143 | 2.09 | E | 7517 | 1 | | | | | | | |
| TR02 | 36 | 29.52 | N | 145 | 0.13 | E | 5711 | 1 | | | | | | | |
| TR03 | 36 | 29.34 | N | 150 | 0.75 | E | 5862 | 1 | | | | | | | |
| ARGO-2 | 33 | 4.66 | N | 156 | 0.02 | E | 5312 | | | | | | | | 1 |
| TR04 | 31 | 59.23 | N | 157 | 51.24 | E | 2948 | 1 | 1 | 1 | | | | | |
| TR05 | 32 | 19.84 | N | 157 | 50.97 | E | 2618 | | | 1 | | | | | |
| TR06 | 32 | 33.38 | N | 158 | 27.54 | E | 2398 | | | 1 | | | | | |
| ARGO-3 | 32 | 12.97 | N | 160 | 0.14 | E | 4922 | | | | | | | | 1 |
| TR07 | 29 | 29.48 | N | 165 | 0.76 | E | 5883 | 1 | 2 | | | | | | |
| TR08 | 32 | 29.70 | N | 165 | 0.07 | E | 6198 | 1 | | | | | | | |
| XB-1 | 33 | 45.17 | N | 165 | 0.05 | E | 6094 | | | | 1 | | | | |
| TR09 | 34 | 59.95 | N | 165 | 0.16 | E | 5885 | 1 | | | | | | | |
| XC-1 | 36 | 15.32 | N | 164 | 59.92 | E | 5505 | | | | | 1 | | | |
| TR10 | 37 | 30.24 | N | 165 | 0.08 | E | 5322 | 1 | | | | | | | |
| XB-2 | 38 | 44.72 | N | 165 | 0.06 | E | 5296 | | | | 1 | | | | |
| TR11 | 39 | 59.84 | N | 165 | 1.05 | E | 5450 | 1 | 2 | | | | | | |
| XB-3 | 41 | 15.01 | N | 165 | 0.03 | E | 5037 | | | | 1 | | | | |
| TR12 | 42 | 30.53 | N | 164 | 59.84 | E | 5010 | 1 | | | | | | | |
| XC-2 | 43 | 45.09 | N | 164 | 59.98 | E | 5713 | | | | | 1 | | | |
| TR13 | 45 | 0.44 | N | 165 | 0.24 | E | 5932 | 1 | 2 | | | | | | |
| XB-4 | 46 | 15.02 | N | 164 | 59.97 | E | 5891 | | | | 1 | 1 | | | |
| TR14 | 47 | 29.87 | N | 165 | 0.14 | E | 5892 | 1 | | | | | | | |
| XC-3 | 48 | 44.65 | N | 165 | 0.02 | E | 5900 | | | | 1 | 1 | | | |
| TR15 | 50 | 59.86 | N | 165 | 0.45 | E | 2666 | 1 | 2 | | | | | | |
| TR16 | 47 | 0.41 | N | 160 | 2.82 | E | 5224 | 1 | 2 | | | | | | |

6.2. Part for Earthquake research and Fukushima ocean radionuclide impact studies

| Stn.name | Latitude | | | Longitude | | | Depth (m) | CTD | CTD clean | Multi core | XBT | XCTD | Net | Sediment trap | ARGO Float |
|----------|----------|-------|---|-----------|-------|---|----------------|-----|--------------|---------------|-----|------|-----|------------------|---------------|
| | | | | | | | | | | | | | | | |
| TR17 | 37 | 48.46 | N | 143 | 52.42 | E | 7036 | | 1 | 1 | | | | | |
| TR18 | 37 | 52.01 | N | 143 | 34.48 | E | 5239 | 1 | | 1 | | | | | |
| TR19 | 38 | 05.54 | N | 143 | 27.80 | E | 3833 | 1 | | 1 | | | | | |
| TR20 | 38 | 12.03 | N | 143 | 34.90 | E | 3388 | 1 | | | | | | | |
| TR21 | 38 | 14.10 | N | 143 | 31.64 | E | 3403 | 1 | | 1 | | | | | |
| TR22 | 38 | 03.96 | N | 142 | 54.00 | E | 1691 | 1 | | | | | | | |
| XB-5 | 37 | 53.02 | N | 142 | 36.05 | E | 1094 | | | | 1 | | | | |
| XC-4 | 37 | 44.67 | N | 142 | 23.01 | E | 995 | | | | | 1 | | | |
| XB-6 | 37 | 34.99 | N | 142 | 08.19 | E | 597 | | | | 1 | | | | |
| XC-5 | 37 | 27.24 | N | 141 | 55.41 | E | 510 | | | | | 1 | | | |
| XB-7 | 37 | 15.21 | N | 141 | 40.19 | E | 292 | | | | 1 | | | | |
| XB-8 | 37 | 04.99 | N | 141 | 25.01 | E | 180 | | | | 1 | | | | |
| XB-9 | 37 | 14.9 | N | 141 | 54.8 | E | 689 | | | | 1 | | | | |
| TR23 | 37 | 20.04 | N | 142 | 10.06 | E | 992 | 1 | | 1 | | | 1 | 1 | |
| TR24 | 37 | 04.02 | N | 142 | 14.88 | E | 2129 | 1 | | 1 | | | | | |
| TR25 | 36 | 59.97 | N | 142 | 00.13 | E | 1358 | 1 | | | | | | | |
| ARGO-4 | 37 | 00.10 | N | 142 | 00.11 | E | 1347 | | | | | | | | 1 |
| XC-6 | 36 | 45.29 | N | 141 | 50.19 | E | 2032 | | | | | 1 | | | |
| XB-10 | 36 | 30.14 | N | 141 | 40.07 | E | 2021 | | | | 1 | | | | |
| XB-11 | 36 | 15.13 | N | 141 | 30.11 | E | 1454 | | | | 1 | | | | |
| TR26 | 36 | 00.14 | N | 141 | 20.06 | E | 1187 | 1 | | 1 | | | 1 | 1 | |

7. Event log

| Date (GMT) | Time (GMT) | Latitude | Longitude | Depth(m) | Station | Ship logs |
|------------|------------|------------|-------------|----------|---------|--|
| 2011/07/16 | 04:52 | 35 38.793N | 139 46.309E | 0 | | LET GO ALL LINES |
| 2011/07/16 | 04:59 | 35 38.778N | 139 46.287E | 0 | | UP & DOWN ANCHOR |
| 2011/07/16 | 05:32 | 35 35.610N | 139 47.023E | 0 | | ENTERED TOKYO WEST PASSAGE |
| 2011/07/16 | 05:51 | 35 33.101N | 139 50.435E | 0 | | CLEARED OUT TOKYO WEST PASSAGE |
| 2011/07/16 | 06:07 | 35 29.548N | 139 51.140E | 0 | | ENTERED EAST FAIRWAY |
| 2011/07/16 | 06:14 | 35 28.265N | 139 49.895E | 0 | | CLEARED OUT EAST FAIRWAY |
| 2011/07/16 | 07:03 | 35 19.786N | 139 42.717E | 0 | | ENTERED URAGA SUIDO TRAFFIC ROUTE |
| 2011/07/16 | 07:43 | 35 12.712N | 139 46.264E | 0 | | CLEARED OUT URAGA SUIDO TRAFFIC ROUTE |
| 2011/07/16 | 07:48 | 35 11.527N | 139 45.875E | 0 | | R/UP ENG'S |
| 2011/07/16 | 08:10 | 35 05.876N | 139 43.886E | 0 | | A/CO TO 188° |
| 2011/07/16 | 08:39 | 34 58.330N | 139 43.225E | 0 | | A/CO TO 146° |
| 2011/07/16 | 09:09 | 34 51.098N | 139 49.316E | 0 | | A/CO TO 090° |
| 2011/07/16 | 09:23 | 34 50.436N | 139 54.408E | 0 | | A/CO TO 065° |
| 2011/07/16 | 09:56 | 34 54.088N | 140 04.573E | 0 | | SUNSET & PUT ON REGULATION LIGHTS |
| 2011/07/16 | 10:45 | 34 59.686N | 140 18.258E | 0 | | S/B ENG'S |
| 2011/07/16 | 10:45 | 34 59.688N | 140 18.262E | 0 | | USED ENG'S VAR'LY |
| 2011/07/16 | 10:52 | 34 59.880N | 140 19.483E | 661 | ARGO1 | LET GO ARGO FLOAT |
| 2011/07/16 | 11:10 | 35 01.716N | 140 23.647E | 240 | | R/UP ENG'S |
| 2011/07/16 | 11:18 | 35 03.018N | 140 25.729E | 167 | | S/CO ON 055° |
| 2011/07/16 | 19:23 | 36 23.219N | 142 48.600E | 0 | | SUNRISE & TURNED OFF REGULATION LIGHTS |
| 2011/07/16 | 20:00 | 36 29.499N | 142 58.947E | 0 | | S/B ENG'S USED ENG'S VAR'LY |
| 2011/07/16 | 20:00 | 36 29.501N | 142 58.952E | 0 | | USED HELM VAR'LY |
| 2011/07/16 | 20:09 | 36 29.966N | 143 00.244E | 7193 | | STOPPED ENG'S |
| 2011/07/16 | 20:11 | 36 29.943N | 143 00.303E | 7206 | | CHANGED ENG'S TO E/M |
| 2011/07/16 | 20:46 | 36 29.817N | 143 01.220E | 7451 | KE3 | CTD-CMS STARTED |
| 2011/07/16 | 21:33 | 36 29.735N | 143 02.116E | 7489 | KE3 | CTD-CMS DEEPEST |
| 2011/07/16 | 22:35 | 36 29.592N | 143 03.261E | 7626 | KE3 | CTD-CMS FINISHED |
| 2011/07/16 | 22:46 | 36 29.218N | 143 03.604E | 7678 | | CHANGED ENG'S TO T/M |
| 2011/07/16 | 22:46 | 36 29.217N | 143 03.605E | 7678 | | SLOW AHEAD ENG'S |
| 2011/07/16 | 22:56 | 36 29.245N | 143 05.329E | 7546 | | S/CO ON 090° |
| 2011/07/16 | 23:07 | 36 29.605N | 143 08.912E | 7337 | | R/UP ENG'S |
| 2011/07/17 | 03:46 | 36 29.939N | 144 42.311E | 5732 | | COM'CED LIFEBOAT STATION DRILL |

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|------------|-------|------------|-------------|------|-------|--|
| 2011/07/17 | 04:05 | 36 29.963N | 144 48.191E | 5750 | | FINISHED LIFEBOAT STATION DRILL |
| 2011/07/17 | 04:27 | 36 30.022N | 144 55.443E | 5688 | | ENTERED SECTION 2 |
| 2011/07/17 | 04:36 | 36 29.946N | 144 58.476E | 5709 | | S/B ENG'S |
| 2011/07/17 | 04:46 | 36 29.801N | 144 59.868E | 5712 | | STOPPED ENG'S |
| 2011/07/17 | 04:48 | 36 29.784N | 144 59.891E | 5711 | | CHANGED ENG'S TO E/M |
| 2011/07/17 | 05:01 | 36 29.754N | 145 00.005E | 5711 | TR02 | CTD-CMS STARTED |
| 2011/07/17 | 05:46 | 36 29.531N | 145 00.138E | 0 | TR02 | CTD-CMS DEEPEST |
| 2011/07/17 | 06:55 | 36 29.152N | 145 00.431E | 5716 | TR02 | CTD-CMS FINISHED |
| 2011/07/17 | 07:05 | 36 28.790N | 145 00.604E | 5725 | | CHANGED ENG'S TO T/M |
| 2011/07/17 | 07:10 | 36 28.767N | 145 01.248E | 5740 | | S/CO ON 090° |
| 2011/07/17 | 07:30 | 36 29.489N | 145 06.932E | 5736 | | R/UP ENG'S |
| 2011/07/17 | 09:35 | 36 29.712N | 145 49.511E | 5483 | | SUNSET & PUT ON REGULATION LIGHTS |
| 2011/07/17 | 18:58 | 36 30.109N | 149 07.377E | 5836 | | SUNRISE & TURNED OFF REGULATION LIGHTS |
| 2011/07/17 | 21:23 | 36 29.916N | 149 58.668E | 5870 | | S/B ENG'S USED ENG'S VAR'LY |
| 2011/07/17 | 21:23 | 36 29.916N | 149 58.673E | 5870 | | USED HELM VAR'LY |
| 2011/07/17 | 21:31 | 36 30.010N | 149 59.784E | 5867 | | STOPPED ENG'S |
| 2011/07/17 | 21:33 | 36 29.975N | 149 59.832E | 5867 | | CHANGED ENG'S TO E/M |
| 2011/07/17 | 21:52 | 36 29.678N | 150 00.136E | 5865 | TR03 | CTD-CMS STARTED |
| 2011/07/17 | 22:38 | 36 29.340N | 150 00.763E | 5863 | TR03 | CTD-CMS DEEPEST |
| 2011/07/17 | 23:40 | 36 29.113N | 150 01.659E | 5863 | TR03 | CTD-CMS FINISHED |
| 2011/07/17 | 23:52 | 36 29.128N | 150 02.119E | 5863 | | CHANGED ENG'S TO T/M |
| 2011/07/17 | 23:52 | 36 29.127N | 150 02.120E | 5863 | | S/CO ON 125° |
| 2011/07/18 | 00:11 | 36 26.976N | 150 05.782E | 5855 | | R/UP ENG'S |
| 2011/07/18 | 09:04 | 35 07.354N | 152 27.237E | 6076 | | SUNSET & PUT ON REGULATION LIGHTS |
| 2011/07/18 | 22:15 | 33 05.333N | 155 59.080E | 5322 | | S/B ENG'S USED ENG'S VAR'LY |
| 2011/07/18 | 22:22 | 33 04.691N | 156 00.030E | 5310 | ARGO2 | LET GO ARGO FLOAT |
| 2011/07/18 | 22:36 | 33 02.841N | 156 02.861E | 5278 | | R/UP ENG'S |
| 2011/07/19 | 05:13 | 32 00.920N | 157 49.754E | 2902 | | S/B ENG'S |
| 2011/07/19 | 05:23 | 32 00.076N | 157 50.990E | 2920 | | STOPPED ENG'S |
| 2011/07/19 | 05:25 | 32 00.041N | 157 51.018E | 2921 | | CHANGED ENG'S TO E/M |
| 2011/07/19 | 05:39 | 31 59.787N | 157 51.230E | 2931 | TR04 | CTD-CMS STARTED |
| 2011/07/19 | 06:03 | 31 59.253N | 157 51.246E | 2947 | TR04 | CTD-CMS DEEPEST |
| 2011/07/19 | 06:46 | 31 58.566N | 157 51.370E | 2968 | TR04 | CTD-CMS FINISHED |
| 2011/07/19 | 07:20 | 32 00.590N | 157 49.881E | 2805 | TR04 | MULTIPLE CORER STARTED |
| 2011/07/19 | 08:20 | 32 00.438N | 157 49.910E | 2902 | TR04 | MULTIPLE CORER HIT BOTTOM |
| 2011/07/19 | 08:23 | 32 00.439N | 157 49.898E | 2903 | TR04 | MULTIPLE CORER LEFT BOTTOM |

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|------------|-------|------------|-------------|------|-------|--|
| 2011/07/19 | 08:35 | 32 00.424N | 157 49.893E | 2902 | TR04 | SUNSET & PUT ON REGULATION LIGHTS |
| 2011/07/19 | 09:18 | 31 59.796N | 157 49.562E | 2917 | TR04 | MULTIPLE CORER FINISHED |
| 2011/07/19 | 09:40 | 32 00.107N | 157 50.966E | 2912 | TR04 | CTD-CMS STARTED |
| 2011/07/19 | 10:39 | 31 59.731N | 157 50.948E | 2925 | TR04 | CTD-CMS DEEPEST |
| 2011/07/19 | 11:50 | 31 59.228N | 157 50.874E | 2938 | TR04 | CTD-CMS FINISHED |
| 2011/07/19 | 12:02 | 31 59.637N | 157 50.881E | 2927 | | CHANGED ENG'S TO T/M |
| 2011/07/19 | 12:02 | 31 59.641N | 157 50.883E | 2927 | | SLOW AHEAD ENG'S |
| 2011/07/19 | 13:09 | 32 15.209N | 157 50.912E | 2685 | | COM'CED SEABEAM SURVEY |
| 2011/07/19 | 13:45 | 32 19.832N | 157 51.069E | 2618 | | FINISHED SEABEAM SURVEY |
| 2011/07/19 | 13:45 | 32 19.833N | 157 51.069E | 2615 | | STOPPED ENG'S |
| 2011/07/19 | 13:47 | 32 19.893N | 157 51.060E | 2617 | TR05 | CHANGED ENG'S TO E/M |
| 2011/07/19 | 13:56 | 32 19.884N | 157 51.127E | 2613 | TR05 | MULTIPLE CORER STARTED |
| 2011/07/19 | 14:53 | 32 19.842N | 157 50.974E | 2619 | TR05 | MULTIPLE CORER HIT BOTTOM |
| 2011/07/19 | 14:55 | 32 19.846N | 157 50.978E | 2618 | TR05 | MULTIPLE CORER LEFT BOTTOM |
| 2011/07/19 | 15:46 | 32 19.872N | 157 50.750E | 2621 | TR05 | MULTIPLE CORER FINISHED |
| 2011/07/19 | 16:00 | 32 20.084N | 157 51.684E | 2613 | | CHANGED ENG'S TO T/M |
| 2011/07/19 | 16:03 | 32 20.116N | 157 51.951E | 2610 | | S/CO ON 083° |
| 2011/07/19 | 16:19 | 32 20.213N | 157 55.828E | 2590 | | R/UP ENG'S |
| 2011/07/19 | 17:46 | 32 22.969N | 158 22.874E | 2530 | | A/CO TO 021° |
| 2011/07/19 | 17:47 | 32 23.175N | 158 23.014E | 2530 | | STARTED SEA BEAM SURVEY |
| 2011/07/19 | 18:24 | 32 32.353N | 158 27.243E | 2405 | | USED ENG'S VAR'LY |
| 2011/07/19 | 18:31 | 32 33.346N | 158 27.617E | 2402 | | FINISHED SEA BEAM SURVEY |
| 2011/07/19 | 18:33 | 32 33.394N | 158 27.571E | 2396 | | STOPPED ENG'S |
| 2011/07/19 | 18:34 | 32 33.397N | 158 27.578E | 2399 | | SUNRISE & TURNED OFF REGULATION LIGHTS |
| 2011/07/19 | 18:37 | 32 33.397N | 158 27.619E | 2399 | | CHANGED ENG'S TO E/M |
| 2011/07/19 | 18:45 | 32 33.398N | 158 27.690E | 2396 | TR06 | MULTIPLE CORER STARTED |
| 2011/07/19 | 19:39 | 32 33.383N | 158 27.551E | 2396 | TR06 | MULTIPLE CORER HIT BOTTOM |
| 2011/07/19 | 19:40 | 32 33.379N | 158 27.539E | 2394 | TR06 | MULTIPLE CORER LEFT BOTTOM |
| 2011/07/19 | 20:26 | 32 33.271N | 158 27.412E | 2397 | TR06 | MULTIPLE CORER FINISHED |
| 2011/07/19 | 20:52 | 32 33.083N | 158 27.543E | 2399 | | CHANGED ENG'S TO T/M |
| 2011/07/19 | 20:52 | 32 33.082N | 158 27.546E | 2399 | | SLOW AHEAD ENG'S |
| 2011/07/19 | 20:52 | 32 33.081N | 158 27.552E | 2398 | | S/CO ON 104° |
| 2011/07/19 | 21:15 | 32 31.928N | 158 32.700E | 2464 | | R/UP ENG'S |
| 2011/07/20 | 01:51 | 32 13.293N | 159 58.733E | 4916 | | S/B ENG'S |
| 2011/07/20 | 01:59 | 32 12.981N | 160 00.107E | 4924 | ARGO3 | LET GO ARGO FLOAT |
| 2011/07/20 | 02:10 | 32 12.510N | 160 02.526E | 4970 | | R/UP ENG'S |

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|------------|-------|------------|-------------|------|------|--|
| 2011/07/20 | 03:06 | 32 08.250N | 160 20.348E | 5221 | | A/CO TO 118° |
| 2011/07/20 | 08:17 | 31 27.732N | 161 48.611E | 5786 | | SUNSET & PUT ON REGULATION LIGHTS |
| 2011/07/20 | 18:13 | 30 14.775N | 164 28.787E | 5858 | | SUNRISE & TURNED OFF REGULATION LIGHTS |
| 2011/07/20 | 20:03 | 30 00.554N | 164 59.031E | 5661 | | S/B ENG'S USED ENG'S VAR'LY |
| 2011/07/20 | 20:03 | 30 00.552N | 164 59.035E | 5661 | | USED HELM VAR'LY |
| 2011/07/20 | 20:11 | 29 59.942N | 165 00.122E | 5863 | | STOPPED ENG'S |
| 2011/07/20 | 20:13 | 29 59.938N | 165 00.147E | 5864 | | CHANGED ENG'S TO E/M |
| 2011/07/20 | 20:23 | 29 59.934N | 165 00.343E | 5866 | TR07 | GAMOS STARTED |
| 2011/07/20 | 21:40 | 29 59.664N | 165 01.550E | 5806 | TR07 | GAMOS DEEPEST |
| 2011/07/20 | 22:47 | 29 59.325N | 165 02.282E | 5880 | TR07 | GAMOS FINISHED |
| 2011/07/20 | 23:28 | 29 59.907N | 165 00.164E | 5864 | TR07 | CTD-CMS STARTED |
| 2011/07/21 | 01:20 | 29 59.487N | 165 00.762E | 5 | TR07 | CTD-CMS DEEPEST |
| 2011/07/21 | 03:34 | 29 58.950N | 165 01.706E | 5892 | TR07 | CTD-CMS FINISHED |
| 2011/07/21 | 04:22 | 30 00.140N | 165 00.105E | 5859 | TR07 | CTD-CMS STARTED |
| 2011/07/21 | 05:06 | 30 00.014N | 165 00.318E | 5865 | TR07 | CTD-CMS DEEPEST |
| 2011/07/21 | 06:04 | 29 59.713N | 165 00.654E | 5861 | TR07 | CTD-CMS FINISHED |
| 2011/07/21 | 08:01 | 30 00.072N | 165 00.011E | 5843 | TR07 | SUNSET & PUT ON REGULATION LIGHTS |
| 2011/07/21 | 08:33 | 30 00.101N | 165 00.191E | 5851 | TR07 | CTD-CMS STARTED |
| 2011/07/21 | 09:03 | 30 00.005N | 165 00.424E | 5852 | TR07 | CTD-CMS DEEPEST |
| 2011/07/21 | 09:44 | 29 59.733N | 165 00.599E | 5858 | TR07 | CTD-CMS FINISHED |
| 2011/07/21 | 10:18 | 29 59.875N | 165 00.594E | 5859 | | CHANGED ENG'S TO S/M |
| 2011/07/21 | 10:22 | 29 59.937N | 165 00.647E | 5863 | | DRIFTING STARTED |
| 2011/07/21 | 13:33 | 30 00.703N | 165 04.157E | 5812 | | FINISHED DRIFTING & SLOW AHED ENG'S |
| 2011/07/21 | 13:36 | 30 00.626N | 165 04.216E | 5812 | | USED ENG'S VAR'LY |
| 2011/07/21 | 14:30 | 29 59.921N | 164 59.949E | 5849 | | STOPPED ENG'S |
| 2011/07/21 | 14:30 | 29 59.919N | 164 59.953E | 5848 | | DRIFTING STARTED |
| 2011/07/21 | 18:12 | 30 00.953N | 165 03.856E | 5816 | | SUNRISE & TURNED OFF REGULATION LIGHTS |
| 2011/07/21 | 18:43 | 30 01.108N | 165 04.581E | 5791 | | CHANGED ENG'S TO T/M |
| 2011/07/21 | 19:00 | 30 01.226N | 165 04.917E | 5797 | | DRIFTING FINISHED |
| 2011/07/21 | 19:01 | 30 01.234N | 165 04.937E | 5796 | | SLOW AHEAD ENG'S |
| 2011/07/21 | 19:05 | 30 01.421N | 165 05.073E | 5790 | | S/CO ON 000° |
| 2011/07/21 | 19:20 | 30 04.186N | 165 04.759E | 5780 | | R/UP ENG'S |
| 2011/07/22 | 04:40 | 32 28.559N | 165 00.067E | 6209 | | S/B ENG'S |
| 2011/07/22 | 04:53 | 32 29.997N | 165 00.047E | 6192 | | STOPPED ENG'S |
| 2011/07/22 | 04:57 | 32 29.985N | 165 00.073E | 6194 | | CHANGED ENG'S TO E/M |

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|------------|-------|------------|-------------|------|------|--|
| 2011/07/22 | 05:01 | 32 29.965N | 165 00.097E | 6194 | TR08 | CTD-CMS STARTED |
| 2011/07/22 | 05:49 | 32 29.704N | 165 00.074E | 6199 | TR08 | CTD-CMS DEEPEST |
| 2011/07/22 | 06:48 | 32 29.555N | 165 00.176E | 6198 | TR08 | CTD-CMS FINISHED |
| 2011/07/22 | 07:00 | 32 29.735N | 165 00.008E | 6198 | | CHANGED ENG'S TO T/M |
| 2011/07/22 | 07:00 | 32 29.739N | 165 00.008E | 6198 | | S/CO ON 000° |
| 2011/07/22 | 07:00 | 32 29.759N | 165 00.010E | 6198 | | SLOW AHEAD ENG'S |
| 2011/07/22 | 07:20 | 32 33.391N | 164 59.973E | 6187 | | R/UP ENG'S |
| 2011/07/22 | 08:05 | 32 45.432N | 165 00.063E | 6202 | | SUNSET & PUT ON REGULATION LIGHTS |
| 2011/07/22 | 11:35 | 33 43.870N | 165 00.001E | 6092 | | S/B ENG'S |
| 2011/07/22 | 11:41 | 33 45.082N | 165 00.036E | 6094 | XB1 | LET GO XBT |
| 2011/07/22 | 12:00 | 33 48.502N | 165 00.074E | 6065 | | R/UP ENG'S |
| 2011/07/22 | 16:16 | 34 58.695N | 165 00.031E | 5862 | | S/B ENG'S |
| 2011/07/22 | 16:27 | 35 00.081N | 165 00.079E | 5890 | | STOPPED ENG'S |
| 2011/07/22 | 16:30 | 35 00.079N | 165 00.099E | 5890 | | CHANGED ENG'S TO E/M |
| 2011/07/22 | 16:35 | 35 00.061N | 165 00.129E | 5890 | TR09 | CTD-CMS STARTED |
| 2011/07/22 | 17:19 | 34 59.952N | 165 00.165E | 5885 | TR09 | CTD-CMS DEEPEST |
| 2011/07/22 | 18:01 | 34 59.889N | 165 00.113E | 5884 | TR09 | SUNRISE & TURNED OFF REGULATION LIGHTS |
| 2011/07/22 | 18:19 | 34 59.849N | 165 00.032E | 5880 | TR09 | CTD-CMS FINISHED |
| 2011/07/22 | 18:31 | 35 00.213N | 164 59.791E | 5891 | | CHANGED ENG'S TO T/M |
| 2011/07/22 | 18:31 | 35 00.218N | 164 59.791E | 5891 | | S/CO ON 000° |
| 2011/07/22 | 19:01 | 35 06.379N | 165 00.000E | 5907 | | R/UP ENG'S |
| 2011/07/22 | 23:08 | 36 13.616N | 164 59.962E | 5500 | | S/B ENG'S |
| 2011/07/22 | 23:22 | 36 15.379N | 164 59.911E | 5508 | XC1 | LET GO XCTD |
| 2011/07/22 | 23:50 | 36 19.924N | 165 00.108E | 5556 | | R/UP ENG'S |
| 2011/07/23 | 03:51 | 37 28.786N | 165 00.057E | 5323 | | S/B ENG'S |
| 2011/07/23 | 04:01 | 37 30.098N | 164 59.920E | 5319 | | STOPPED ENG'S |
| 2011/07/23 | 04:04 | 37 30.119N | 164 59.920E | 5318 | | CHANGED ENG'S TO E/M |
| 2011/07/23 | 04:08 | 37 30.118N | 164 59.929E | 5319 | TR10 | CTD-CMS STARTED |
| 2011/07/23 | 04:52 | 37 30.244N | 165 00.089E | 5322 | TR10 | CTD-CMS DEEPEST |
| 2011/07/23 | 05:53 | 37 30.211N | 164 59.893E | 5319 | TR10 | CTD-CMS FINISHED |
| 2011/07/23 | 06:05 | 37 30.686N | 164 59.903E | 5321 | | CHANGED ENG'S TO T/M |
| 2011/07/23 | 06:06 | 37 30.772N | 164 59.914E | 5321 | | S/CO ON 000° |
| 2011/07/23 | 07:20 | 37 43.161N | 164 59.770E | 5290 | | R/UP ENG'S |
| 2011/07/23 | 08:18 | 37 58.154N | 164 59.649E | 5342 | | SUNSET & PUT ON REGULATION LIGHTS |
| 2011/07/23 | 11:09 | 38 43.771N | 165 00.045E | 5287 | | S/B ENG'S |
| 2011/07/23 | 11:16 | 38 45.018N | 165 00.032E | 5298 | XB2 | LET GO XBT |

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|------------|-------|------------|-------------|------|------|--|
| 2011/07/23 | 11:40 | 38 49.213N | 164 59.855E | 5343 | | R/UP ENG'S |
| 2011/07/23 | 15:47 | 39 58.671N | 165 00.043E | 5462 | | S/B ENG'S |
| 2011/07/23 | 15:56 | 40 00.054N | 165 00.142E | 5447 | | STOPPED ENG'S |
| 2011/07/23 | 15:57 | 40 00.084N | 165 00.185E | 5447 | | CHANGED ENG'S TO E/M |
| 2011/07/23 | 16:05 | 40 00.213N | 165 00.393E | 5452 | TR11 | GAMOS STARTED |
| 2011/07/23 | 17:26 | 40 00.994N | 165 02.554E | 5468 | TR11 | GAMOS DEEPEST |
| 2011/07/23 | 17:52 | 40 01.092N | 165 02.998E | 5469 | TR11 | SUNRISE & TURNED OFF REGULATION LIGHTS |
| 2011/07/23 | 18:44 | 40 01.316N | 165 04.284E | 5474 | TR11 | GAMOS FINISHED |
| 2011/07/23 | 19:42 | 40 00.037N | 165 00.327E | 5439 | TR11 | CTD-CMS STARTED |
| 2011/07/23 | 21:23 | 39 59.844N | 165 01.055E | 5450 | TR11 | CTD-CMS DEEPEST |
| 2011/07/23 | 23:15 | 39 59.586N | 165 01.078E | 5456 | TR11 | CTD-CMS FINISHED |
| 2011/07/24 | 00:17 | 39 59.993N | 165 00.044E | 5444 | TR11 | CTD-CMS STARTED |
| 2011/07/24 | 01:02 | 40 00.208N | 165 00.274E | 5451 | TR11 | CTD-CMS DEEPEST |
| 2011/07/24 | 02:02 | 40 00.590N | 165 00.442E | 5452 | TR11 | CTD-CMS FINISHED |
| 2011/07/24 | 02:35 | 40 00.048N | 164 59.892E | 5441 | TR11 | CTD-CMS STARTED |
| 2011/07/24 | 03:13 | 40 00.366N | 165 00.066E | 5446 | TR11 | CTD-CMS DEEPEST |
| 2011/07/24 | 03:58 | 40 00.805N | 165 00.295E | 5462 | TR11 | CTD-CMS FINISHED |
| 2011/07/24 | 04:12 | 40 01.286N | 165 00.329E | 5456 | | CHANGED ENG'S TO T/M |
| 2011/07/24 | 04:12 | 40 01.288N | 165 00.328E | 5456 | | S/CO ON 000° |
| 2011/07/24 | 04:33 | 40 05.322N | 165 00.135E | 5452 | | R/UP ENG'S |
| 2011/07/24 | 08:25 | 41 08.758N | 164 59.870E | 5242 | | SUNSET & PUT ON REGULATION LIGHTS |
| 2011/07/24 | 08:43 | 41 13.965N | 165 00.010E | 5071 | | S/B ENG'S USED HELM VAR'LY |
| 2011/07/24 | 08:50 | 41 15.022N | 165 00.038E | 5037 | XB3 | LET GO XBT |
| 2011/07/24 | 09:08 | 41 18.208N | 164 59.981E | 4908 | | R/UP ENG'S |
| 2011/07/24 | 13:24 | 42 28.601N | 164 59.989E | 5008 | | S/B ENG'S |
| 2011/07/24 | 13:33 | 42 30.054N | 164 59.996E | 5008 | | STOPPED ENG'S |
| 2011/07/24 | 13:35 | 42 30.132N | 164 59.975E | 5008 | | CHANGED ENG'S TO E/M |
| 2011/07/24 | 13:51 | 42 30.181N | 164 59.907E | 5007 | TR12 | CTD-CMS STARTED |
| 2011/07/24 | 14:38 | 42 30.533N | 164 59.849E | 5010 | TR12 | CTD-CMS DEEPEST |
| 2011/07/24 | 15:38 | 42 30.856N | 164 59.764E | 5012 | TR12 | CTD-CMS FINISHED |
| 2011/07/24 | 15:49 | 42 30.918N | 164 59.671E | 5012 | | CHANGED ENG'S TO T/M |
| 2011/07/24 | 15:49 | 42 30.918N | 164 59.670E | 5012 | | SLOW AHEAD ENG'S |
| 2011/07/24 | 16:00 | 42 31.991N | 164 59.643E | 5014 | | S/CO ON 000° |
| 2011/07/24 | 16:11 | 42 34.434N | 164 59.663E | 5081 | | R/UP ENG'S |
| 2011/07/24 | 17:45 | 43 00.397N | 164 59.972E | 5399 | | SUNRISE & TURNED OFF REGULATION LIGHTS |

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| 2011/07/24 | 20:22 | 43 44.065N | 164 59.962E | 5710 | | S/B ENG'S USED ENG'S VAR'LY |
| 2011/07/24 | 20:27 | 43 45.024N | 164 59.976E | 5715 | XC2 | LET GO XCTD |
| 2011/07/24 | 20:50 | 43 48.563N | 165 00.045E | 5643 | | R/UP ENG'S |
| 2011/07/25 | 01:15 | 44 58.262N | 164 59.969E | 5920 | | S/B ENG'S |
| 2011/07/25 | 01:28 | 44 59.938N | 164 59.971E | 5913 | | STOPPED ENG'S |
| 2011/07/25 | 01:30 | 44 59.937N | 164 59.960E | 5914 | | CHANGED ENG'S TO E/M |
| 2011/07/25 | 01:34 | 44 59.929N | 164 59.944E | 5915 | TR13 | GAMOS STARTED |
| 2011/07/25 | 02:55 | 44 59.499N | 165 00.035E | 5905 | TR13 | GAMOS DEEPEST |
| 2011/07/25 | 04:11 | 44 59.385N | 164 59.911E | 5906 | TR13 | GAMOS FINISHED |
| 2011/07/25 | 04:35 | 45 00.198N | 164 59.769E | 5950 | TR13 | CTD-CMS STARTED |
| 2011/07/25 | 06:32 | 45 00.438N | 165 00.231E | 5927 | TR13 | CTD-CMS DEEPEST |
| 2011/07/25 | 08:32 | 45 00.734N | 165 01.639E | 5899 | TR13 | CTD-CMS FINISHED |
| 2011/07/25 | 08:35 | 45 00.740N | 165 01.649E | 5900 | TR13 | SUNSET & PUT ON REGULATION LIGHTS |
| 2011/07/25 | 09:16 | 45 00.119N | 164 59.898E | 5942 | TR13 | CTD-CMS STARTED |
| 2011/07/25 | 10:08 | 45 00.063N | 165 00.358E | 5905 | TR13 | CTD-CMS DEEPEST |
| 2011/07/25 | 11:09 | 44 59.904N | 165 00.942E | 5911 | TR13 | CTD-CMS FINISHED |
| 2011/07/25 | 12:38 | 44 59.919N | 165 00.178E | 5909 | TR13 | CTD-CMS STARTED |
| 2011/07/25 | 13:18 | 44 59.644N | 165 00.642E | 5912 | TR13 | CTD-CMS DEEPEST |
| 2011/07/25 | 14:05 | 44 59.371N | 165 01.050E | 5906 | TR13 | CTD-CMS FINISHED |
| 2011/07/25 | 14:20 | 44 59.627N | 165 01.137E | 5913 | | CHANGED ENG'S TO T/M |
| 2011/07/25 | 14:24 | 44 59.996N | 165 01.198E | 5911 | | S/CO ON 000° |
| 2011/07/25 | 14:45 | 45 04.287N | 165 01.075E | 5922 | | R/UP ENG'S |
| 2011/07/25 | 17:35 | 45 48.222N | 164 59.898E | 5899 | | SUNRISE & TURNED OFF REGULATION LIGHTS |
| 2011/07/25 | 19:10 | 46 14.001N | 164 59.978E | 5889 | | S/B ENG'S USED ENG'S VAR'LY |
| 2011/07/25 | 19:16 | 46 15.033N | 164 59.978E | 5891 | XB4 | LET GO XCTD |
| 2011/07/25 | 19:24 | 46 15.640N | 164 59.951E | 5889 | XB4 | LET GO XBT |
| 2011/07/25 | 19:40 | 46 18.303N | 164 59.917E | 5852 | | R/UP ENG'S |
| 2011/07/26 | 00:12 | 47 28.371N | 165 00.059E | 5887 | | S/B ENG'S |
| 2011/07/26 | 00:24 | 47 29.919N | 164 59.954E | 5891 | | STOPPED ENG'S |
| 2011/07/26 | 00:25 | 47 29.963N | 164 59.945E | 5891 | | CHANGED ENG'S TO E/M |
| 2011/07/26 | 00:29 | 47 29.982N | 164 59.881E | 5892 | TR14 | CTD-CMS STARTED |
| 2011/07/26 | 01:16 | 47 29.875N | 165 00.135E | 5892 | TR14 | CTD-CMS DEEPEST |
| 2011/07/26 | 02:15 | 47 29.808N | 165 00.632E | 5911 | TR14 | CTD-CMS FINISHED |
| 2011/07/26 | 02:28 | 47 30.186N | 165 00.461E | 5912 | | CHANGED ENG'S TO T/M |
| 2011/07/26 | 02:31 | 47 30.429N | 165 00.450E | 5912 | | S/CO ON 000° |
| 2011/07/26 | 02:40 | 47 32.401N | 165 00.425E | 5900 | | R/UP ENG'S |

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| 2011/07/26 | 06:57 | 48 43.928N | 164 59.939E | 5896 | | S/B ENG'S USED ENG'S VAR'LY |
| 2011/07/26 | 07:03 | 48 45.043N | 165 00.042E | 5900 | XC3 | LET GO XCTD |
| 2011/07/26 | 07:10 | 48 45.706N | 165 00.053E | 5898 | XC3 | LET GO XBT |
| 2011/07/26 | 07:30 | 48 49.384N | 164 59.886E | 5916 | | R/UP ENG'S |
| 2011/07/26 | 08:49 | 49 10.355N | 164 59.878E | 5558 | | SUNSET & PUT ON REGULATION LIGHTS |
| 2011/07/26 | 15:35 | 50 58.759N | 165 00.134E | 4830 | | S/B ENG'S |
| 2011/07/26 | 15:42 | 51 00.013N | 165 00.161E | 4809 | | ENTERED SECTION 3 |
| 2011/07/26 | 15:45 | 51 00.154N | 165 00.171E | 4806 | | STOPPED ENG'S |
| 2011/07/26 | 15:47 | 51 00.172N | 165 00.176E | 4804 | | CHANGED ENG'S TO E/M |
| 2011/07/26 | 15:53 | 51 00.234N | 165 00.222E | 4806 | TR15 | GAMOS STARTED |
| 2011/07/26 | 17:18 | 51 00.576N | 165 00.700E | 4784 | TR15 | SUNRISE & TURNED OFF REGULATION LIGHTS |
| 2011/07/26 | 17:35 | 51 00.550N | 165 00.798E | 4782 | TR15 | GAMOS DEEPEST |
| 2011/07/26 | 18:50 | 51 00.596N | 165 01.401E | 4767 | TR15 | GAMOS FINISHED |
| 2011/07/26 | 19:16 | 50 59.972N | 164 59.912E | 4797 | TR15 | CTD-CMS STARTED |
| 2011/07/26 | 20:49 | 50 59.866N | 165 00.451E | 4799 | TR15 | CTD-CMS DEEPEST |
| 2011/07/26 | 22:28 | 50 59.569N | 165 00.802E | 4819 | TR15 | CTD-CMS FINISHED |
| 2011/07/26 | 23:09 | 51 00.019N | 165 00.118E | 4807 | TR15 | CTD-CMS STARTED |
| 2011/07/26 | 23:55 | 50 59.824N | 165 00.400E | 4809 | TR15 | CTD-CMS DEEPEST |
| 2011/07/27 | 00:52 | 50 59.585N | 165 00.518E | 4820 | TR15 | CTD-CMS FINISHED |
| 2011/07/27 | 01:57 | 51 00.029N | 164 59.981E | 4807 | TR15 | CTD-CMS STARTED |
| 2011/07/27 | 02:32 | 50 59.845N | 165 00.055E | 4812 | TR15 | CTD-CMS DEEPEST |
| 2011/07/27 | 03:11 | 50 59.731N | 165 00.304E | 4813 | TR15 | CTD-CMS FINISHED |
| 2011/07/27 | 03:25 | 50 59.815N | 165 00.395E | 4810 | | CHANGED ENG'S TO T/M |
| 2011/07/27 | 03:36 | 50 59.061N | 164 59.319E | 4838 | | S/CO ON 219° |
| 2011/07/27 | 03:50 | 50 56.454N | 164 55.894E | 5053 | | R/UP ENG'S |
| 2011/07/27 | 08:57 | 49 57.151N | 163 39.765E | 5822 | | SUNSET & PUT ON REGULATION LIGHTS |
| 2011/07/27 | 17:45 | 48 12.656N | 161 30.306E | 5496 | | SUNRISE & TURNED OFF REGULATION LIGHTS |
| 2011/07/27 | 23:20 | 47 01.559N | 160 04.119E | 5240 | | S/B ENG'S |
| 2011/07/27 | 23:31 | 47 00.021N | 160 02.923E | 5228 | | STOPPED ENG'S |
| 2011/07/27 | 23:33 | 47 00.004N | 160 02.900E | 5228 | | CHANGED ENG'S TO E/M |
| 2011/07/27 | 23:44 | 46 59.990N | 160 02.769E | 5226 | TR16 | CTD-CMS STARTED |
| 2011/07/28 | 01:25 | 47 00.413N | 160 02.826E | 5224 | TR16 | CTD-CMS DEEPEST |
| 2011/07/28 | 03:11 | 47 01.042N | 160 02.755E | 5201 | TR16 | CTD-CMS FINISHED |
| 2011/07/28 | 03:57 | 46 59.966N | 160 02.975E | 5218 | TR16 | CTD-CMS STARTED |
| 2011/07/28 | 04:40 | 47 00.112N | 160 03.111E | 5220 | TR16 | CTD-CMS DEEPEST |

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| 2011/07/28 | 05:38 | 47 00.473N | 160 03.250E | 5220 | TR16 | CTD-CMS FINISHED |
| 2011/07/28 | 07:27 | 47 00.015N | 160 03.145E | 5224 | TR16 | CTD-CMS STARTED |
| 2011/07/28 | 07:49 | 47 00.023N | 160 03.265E | 5225 | TR16 | CTD-CMS DEEPEST |
| 2011/07/28 | 08:18 | 47 00.034N | 160 03.416E | 5218 | TR16 | CTD-CMS FINISHED |
| 2011/07/28 | 08:30 | 47 00.020N | 160 03.449E | 5220 | | CHANGED ENG'S TO T/M SLOW AHEAD ENG'S |
| 2011/07/28 | 08:33 | 46 59.934N | 160 03.418E | 5224 | | S/CO ON 233° |
| 2011/07/28 | 08:50 | 46 57.853N | 159 59.987E | 5180 | | R/UP ENG'S |
| 2011/07/28 | 09:00 | 46 56.252N | 159 56.864E | 5160 | | SUNSET & PUT ON REGULATION LIGHTS |
| 2011/07/28 | 15:03 | 45 55.102N | 158 00.330E | 4978 | | A/CO TO 231° |
| 2011/07/28 | 18:16 | 45 21.373N | 157 01.339E | 5396 | | SUNRISE & TURNED OFF REGULATION LIGHTS |
| 2011/07/29 | 09:14 | 42 45.443N | 152 33.999E | 5236 | | SUNSET & PUT ON REGULATION LIGHTS |
| 2011/07/29 | 18:10 | 41 10.479N | 150 00.344E | 5168 | | A/CO TO 234° |
| 2011/07/29 | 18:54 | 41 03.438N | 149 47.591E | 5402 | | SUNRISE & TURNED OFF REGULATION LIGHTS |
| 2011/07/30 | 09:30 | 38 45.946N | 145 38.410E | 5252 | | SUNSET & PUT ON REGULATION LIGHTS |
| 2011/07/30 | 15:28 | 37 47.365N | 143 55.488E | 7151 | | S/B ENG'S |
| 2011/07/30 | 15:35 | 37 47.046N | 143 54.038E | 7305 | | STARTED SEA BEAM SURVEY |
| 2011/07/30 | 16:19 | 37 49.218N | 143 46.991E | 6396 | | FINISHED SEA BEAM SURVEY |
| 2011/07/30 | 16:51 | 37 47.685N | 143 51.784E | 7040 | | STOPPED ENG'S |
| 2011/07/30 | 16:52 | 37 47.700N | 143 51.772E | 7038 | | CHANGED ENG'S TO E/M |
| 2011/07/30 | 17:20 | 37 47.694N | 143 52.032E | 7029 | TR17 | CTD-CMS STARTED |
| 2011/07/30 | 19:25 | 37 48.451N | 143 52.379E | 7043 | TR17 | SUNRISE & TURNED OFF REGULATION LIGHTS |
| 2011/07/30 | 19:35 | 37 48.463N | 143 52.419E | 7034 | TR17 | CTD-CMS DEEPEST |
| 2011/07/30 | 22:05 | 37 49.591N | 143 52.800E | 6954 | TR17 | CTD-CMS FINISHED |
| 2011/07/30 | 22:38 | 37 47.689N | 143 51.849E | 7045 | TR17 | MULTIPLE CORER STARTED |
| 2011/07/31 | 01:04 | 37 47.701N | 143 51.935E | 7034 | TR17 | MULTIPLE CORER HIT BOTTOM |
| 2011/07/31 | 01:06 | 37 47.697N | 143 51.934E | 7037 | TR17 | MULTIPLE CORER LEFT BOTTOM |
| 2011/07/31 | 03:03 | 37 48.845N | 143 53.196E | 7096 | TR17 | MULTIPLE CORER FINISHED |
| 2011/07/31 | 03:10 | 37 48.964N | 143 53.249E | 7074 | | STARTED FREE FALL OF NO2WINCH WIRE |
| 2011/07/31 | 04:00 | 37 49.847N | 143 53.610E | 6936 | | COM'CED OIL POLLUTION PREVENTION STATION COMMUNI |
| 2011/07/31 | 04:30 | 37 50.281N | 143 53.595E | 6957 | | FINISHED OIL POLLUTION PREVENTION COMMUNICATION |
| 2011/07/31 | 05:02 | 37 50.695N | 143 53.557E | 6974 | | FREE FALL OF NO2WINCH WIRE DEEPEST |

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| 2011/07/31 | 07:22 | 37 52.093N | 143 54.560E | 7046 | | FINISHED FREE FALL OF NO2WINCH WIRE |
| 2011/07/31 | 07:35 | 37 52.376N | 143 54.651E | 7045 | | CHANGED ENG'S TO T/M |
| 2011/07/31 | 07:35 | 37 52.377N | 143 54.650E | 7045 | | SLOW AHEAD ENG'S |
| 2011/07/31 | 08:41 | 37 52.979N | 143 34.978E | 5221 | | STARTED SEA BEAM SURVEY |
| 2011/07/31 | 09:03 | 37 54.136N | 143 31.354E | 4823 | | FINISHED SEA BEAM SURVEY |
| 2011/07/31 | 09:33 | 37 50.479N | 143 34.544E | 5267 | | STOPPED ENG'S |
| 2011/07/31 | 09:35 | 37 50.493N | 143 34.549E | 5265 | | CHANGED ENG'S TO E/M |
| 2011/07/31 | 09:35 | 37 50.493N | 143 34.549E | 5265 | | SUNSET & PUT ON REGULATION LIGHTS |
| 2011/07/31 | 09:39 | 37 50.534N | 143 34.542E | 5264 | TR18 | CTD-CMS STARTED |
| 2011/07/31 | 11:30 | 37 52.009N | 143 34.490E | 5252 | TR18 | CTD-CMS DEEPEST |
| 2011/07/31 | 13:38 | 37 53.776N | 143 35.064E | 5183 | TR18 | CTD-CMS FINISHED |
| 2011/07/31 | 14:14 | 37 51.767N | 143 34.291E | 5254 | TR18 | MULTIPLE CORER STARTED |
| 2011/07/31 | 15:48 | 37 51.961N | 143 34.521E | 5251 | TR18 | MULTIPLE CORER HIT BOTTOM |
| 2011/07/31 | 15:50 | 37 51.961N | 143 34.525E | 5 | TR18 | MULTIPLE CORER LEFT BOTTOM |
| 2011/07/31 | 17:12 | 37 53.494N | 143 35.702E | 5275 | TR18 | MULTIPLE CORER FINISHED |
| 2011/07/31 | 17:23 | 37 54.081N | 143 35.600E | 5234 | | CHANGED ENG'S TO T/M |
| 2011/07/31 | 18:10 | 38 04.057N | 143 27.891E | 3882 | | STARTED SEA BEAM SURVEY |
| 2011/07/31 | 18:23 | 38 05.730N | 143 27.076E | 3809 | | FINISHED SEA BEAM SURVEY |
| 2011/07/31 | 18:47 | 38 04.451N | 143 27.413E | 3884 | | STOPPED ENG'S |
| 2011/07/31 | 18:49 | 38 04.488N | 143 27.405E | 3893 | | CHANGED ENG'S TO E/M |
| 2011/07/31 | 18:55 | 38 04.612N | 143 27.373E | 3869 | TR19 | CTD-CMS STARTED |
| 2011/07/31 | 19:27 | 38 05.194N | 143 27.648E | 3846 | TR19 | SUNRISE & TURNED OFF REGULATION LIGHTS |
| 2011/07/31 | 20:14 | 38 05.541N | 143 27.798E | 3832 | TR19 | CTD-CMS DEEPEST |
| 2011/07/31 | 21:45 | 38 06.497N | 143 28.640E | 3721 | TR19 | CTD-CMS FINISHED |
| 2011/07/31 | 22:25 | 38 04.003N | 143 27.463E | 3943 | TR19 | MULTIPLE CORER STARTED |
| 2011/07/31 | 23:43 | 38 04.526N | 143 27.654E | 3864 | TR19 | MULTIPLE CORER HIT BOTTOM |
| 2011/07/31 | 23:45 | 38 04.529N | 143 27.651E | 3864 | TR19 | MULTIPLE CORER LEFT BOTTOM |
| 2011/08/01 | 00:54 | 38 04.640N | 143 27.749E | 3878 | TR19 | MULTIPLE CORER FINISHED |
| 2011/08/01 | 01:07 | 38 05.424N | 143 27.822E | 3836 | | CHANGED ENG'S TO T/M |
| 2011/08/01 | 01:32 | 38 09.936N | 143 28.313E | 3459 | | STARTED SEABEAM SURVEY |
| 2011/08/01 | 01:48 | 38 10.441N | 143 31.260E | 3444 | | FINISHED SEABEAM SURVEY |
| 2011/08/01 | 02:03 | 38 10.387N | 143 32.909E | 3458 | | STOPPED ENG'S |
| 2011/08/01 | 02:05 | 38 10.426N | 143 32.966E | 3390 | | CHANGED ENG'S TO E/M |
| 2011/08/01 | 02:30 | 38 10.926N | 143 33.559E | 3346 | TR20 | CTD-CMS STARTED |
| 2011/08/01 | 03:46 | 38 12.030N | 143 34.890E | 3388 | TR20 | CTD-CMS DEEPEST |
| 2011/08/01 | 05:17 | 38 13.103N | 143 36.235E | 3585 | TR20 | CTD-CMS FINISHED |

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| 2011/08/01 | 05:29 | 38 12.992N | 143 36.177E | 3587 | | CHANGED ENG'S TO T/M |
| 2011/08/01 | 06:01 | 38 11.398N | 143 31.211E | 3440 | | STOPPED ENG'S |
| 2011/08/01 | 06:02 | 38 11.420N | 143 31.230E | 3441 | | CHANGED ENG'S TO E/M |
| 2011/08/01 | 06:08 | 38 11.478N | 143 31.331E | 3440 | TR21 | MULTIPLE CORER STARTED |
| 2011/08/01 | 07:19 | 38 11.346N | 143 31.244E | 3439 | TR21 | MULTIPLE CORER HIT BOTTOM |
| 2011/08/01 | 07:21 | 38 11.343N | 143 31.244E | 3442 | TR21 | MULTIPLE CORER LEFT BOTTOM |
| 2011/08/01 | 08:23 | 38 11.007N | 143 31.115E | 3442 | TR21 | MULTIPLE CORER FINISHED |
| 2011/08/01 | 08:32 | 38 10.985N | 143 31.120E | 3441 | TR21 | CTD-CMS STARTED |
| 2011/08/01 | 09:37 | 38 11.402N | 143 31.620E | 3415 | TR21 | SUNSET & PUT ON REGULATION LIGHTS |
| 2011/08/01 | 09:40 | 38 11.412N | 143 31.641E | 3409 | TR21 | CTD-CMS DEEPEST |
| 2011/08/01 | 11:24 | 38 12.096N | 143 32.609E | 3409 | TR21 | CTD-CMS FINISHED |
| 2011/08/01 | 11:36 | 38 12.137N | 143 32.177E | 3387 | | CHANGED ENG'S TO T/M |
| 2011/08/01 | 11:36 | 38 12.137N | 143 32.175E | 3387 | | S/CO ON 258° |
| 2011/08/01 | 12:02 | 38 10.850N | 143 25.948E | 3437 | | R/UP ENG'S |
| 2011/08/01 | 13:34 | 38 04.434N | 142 55.820E | 1711 | | S/B ENG'S |
| 2011/08/01 | 13:45 | 38 04.011N | 142 53.951E | 1689 | | STOPPED ENG'S |
| 2011/08/01 | 13:47 | 38 04.013N | 142 53.938E | 1689 | | CHANGED ENG'S TO E/M |
| 2011/08/01 | 13:52 | 38 04.018N | 142 53.938E | 1689 | TR22 | CTD-CMS STARTED |
| 2011/08/01 | 14:31 | 38 03.968N | 142 54.005E | 1690 | TR22 | CTD-CMS DEEPEST |
| 2011/08/01 | 15:18 | 38 03.884N | 142 54.190E | 1693 | TR22 | CTD-CMS FINISHED |
| 2011/08/01 | 15:30 | 38 03.611N | 142 53.933E | 1699 | | CHANGED ENG'S TO T/M |
| 2011/08/01 | 15:30 | 38 03.609N | 142 53.930E | 1699 | | S/CO ON 232° |
| 2011/08/01 | 16:45 | 37 52.891N | 142 35.822E | 1095 | XB5 | LET GO XBT |
| 2011/08/01 | 17:39 | 37 43.961N | 142 21.912E | 995 | XC4 | LET GO XCTD |
| 2011/08/01 | 18:32 | 37 34.837N | 142 07.945E | 604 | | LET GO XBT |
| 2011/08/01 | 19:20 | 37 26.928N | 141 54.966E | 511 | XC5 | LET GO XCTD |
| 2011/08/01 | 19:25 | 37 26.263N | 141 54.045E | 506 | | SUNRISE & TURNED OFF REGULATION LIGHTS |
| 2011/08/01 | 19:28 | 37 25.829N | 141 53.500E | 500 | | S/CO ON 225° |
| 2011/08/01 | 20:22 | 37 14.967N | 141 39.900E | 293 | XB7 | LET GO XBT |
| 2011/08/01 | 20:25 | 37 14.273N | 141 39.098E | 281 | | A/CO TO 230° |
| 2011/08/01 | 21:18 | 37 04.919N | 141 24.918E | 177 | XB8 | LET GO XBT |
| 2011/08/01 | 21:21 | 37 04.649N | 141 24.558E | 179 | | A/CO TO 241° |
| 2011/08/01 | 21:21 | 37 04.641N | 141 24.547E | 179 | | CHANGED ENG'S TO S/M |
| 2011/08/01 | 23:43 | 36 54.315N | 141 00.207E | 71 | | A/CO TO 270° |
| 2011/08/02 | 00:16 | 36 54.108N | 140 53.335E | 29 | | USED HELM VAR'LY |
| 2011/08/02 | 00:35 | 36 55.472N | 140 53.077E | 15 | | 3 SCIENTISTS EMBARKED HER |

| | | | | | | |
|------------|-------|------------|-------------|------|------|-----------------------------------|
| 2011/08/02 | 00:39 | 36 55.440N | 140 53.105E | 16 | | 2 SCIENTISTS DISEMBARKED HER |
| 2011/08/02 | 00:49 | 36 54.903N | 140 53.014E | 0 | | CHANGED ENG'S TO T/M |
| 2011/08/02 | 01:15 | 36 54.037N | 140 58.120E | 0 | | R/UP ENG'S |
| 2011/08/02 | 01:16 | 36 54.032N | 140 58.269E | 0 | | S/CO ON 090° |
| 2011/08/02 | 01:29 | 36 53.242N | 141 02.654E | 0 | | A/CO TO 062° |
| 2011/08/02 | 04:28 | 37 15.013N | 141 55.074E | 692 | XB9 | LET GO XBT |
| 2011/08/02 | 04:28 | 37 15.022N | 141 55.095E | 693 | | S/CO ON 067° |
| 2011/08/02 | 05:11 | 37 19.608N | 142 08.507E | 994 | | S/B ENG'S |
| 2011/08/02 | 05:21 | 37 20.160N | 142 10.021E | 986 | | STOPPED ENG'S |
| 2011/08/02 | 05:22 | 37 20.168N | 142 10.034E | 984 | | CHANGED ENG'S TO E/M |
| 2011/08/02 | 05:29 | 37 20.191N | 142 10.059E | 988 | TR23 | MULTIPLE CORER STARTED |
| 2011/08/02 | 06:00 | 37 19.966N | 142 10.051E | 992 | TR23 | MULTIPLE CORER HIT BOTTOM |
| 2011/08/02 | 06:02 | 37 19.973N | 142 10.052E | 991 | TR23 | MULTIPLE CORER LEFT BOTTOM |
| 2011/08/02 | 06:25 | 37 19.911N | 142 10.258E | 995 | TR23 | MULTIPLE CORER FINISHED |
| 2011/08/02 | 06:45 | 37 20.047N | 142 10.018E | 989 | TR23 | CTD-CMS STARTED |
| 2011/08/02 | 06:53 | 37 20.046N | 142 10.062E | 990 | TR23 | CTD-CMS DEEPEST |
| 2011/08/02 | 07:03 | 37 20.041N | 142 10.120E | 993 | TR23 | CTD-CMS FINISHED |
| 2011/08/02 | 07:19 | 37 20.054N | 142 09.997E | 989 | TR23 | CTD-CMS STARTED |
| 2011/08/02 | 07:28 | 37 20.073N | 142 09.964E | 987 | TR23 | NORPAC NET STARTED |
| 2011/08/02 | 07:41 | 37 20.093N | 142 09.945E | 990 | TR23 | NORPAC NET FINISHED |
| 2011/08/02 | 07:43 | 37 20.088N | 142 09.935E | 989 | TR23 | NORPAC NET STARTED |
| 2011/08/02 | 07:46 | 37 20.081N | 142 09.928E | 988 | TR23 | CTD-CMS DEEPEST |
| 2011/08/02 | 07:50 | 37 20.086N | 142 09.905E | 987 | TR23 | NORPAC NET FINISHED |
| 2011/08/02 | 08:01 | 37 20.084N | 142 09.851E | 986 | TR23 | NORPAC NET FINISHED |
| 2011/08/02 | 08:16 | 37 20.140N | 142 09.896E | 986 | TR23 | CTD-CMS FINISHED |
| 2011/08/02 | 08:33 | 37 20.132N | 142 09.910E | 987 | TR23 | SETTING OF SEDIMENT TRAP STARTED |
| 2011/08/02 | 08:40 | 37 20.068N | 142 10.035E | 992 | TR23 | SETTING OF SEDIMENT TRAP FINISHED |
| 2011/08/02 | 09:06 | 37 20.244N | 142 10.273E | 989 | | CHANGED ENG'S TO T/M |
| 2011/08/02 | 09:06 | 37 20.243N | 142 10.275E | 990 | | SLOW AHEAD ENG'S |
| 2011/08/02 | 09:39 | 37 13.073N | 142 12.447E | 1343 | | SUNSET & PUT ON REGULATION LIGHTS |
| 2011/08/02 | 10:17 | 37 04.048N | 142 14.853E | 2128 | | STOPPED ENG'S |
| 2011/08/02 | 10:18 | 37 04.043N | 142 14.851E | 2125 | | CHANGED ENG'S TO E/M |
| 2011/08/02 | 10:20 | 37 04.040N | 142 14.842E | 2134 | TR24 | CTD-CMS STARTED |
| 2011/08/02 | 11:07 | 37 04.025N | 142 14.894E | 2129 | TR24 | CTD-CMS DEEPEST |
| 2011/08/02 | 11:58 | 37 04.266N | 142 14.892E | 2113 | TR24 | CTD-CMS FINISHED |
| 2011/08/02 | 12:12 | 37 03.944N | 142 15.036E | 2137 | TR24 | MULTIPLE CORER STARTED |
| 2011/08/02 | 13:05 | 37 03.979N | 142 15.030E | 2136 | TR24 | MULTIPLE CORER HIT BOTTOM |

| | | | | | | |
|------------|-------|------------|-------------|------|------|--|
| 2011/08/02 | 13:07 | 37 03.980N | 142 15.029E | 2135 | TR24 | MULTIPLE CORER LEFT BOTTOM |
| 2011/08/02 | 13:48 | 37 03.818N | 142 15.392E | 2151 | TR24 | MULTIPLE CORER FINISHED |
| 2011/08/02 | 14:02 | 37 03.583N | 142 15.037E | 2153 | TR24 | CHANGED ENG'S TO T/M |
| 2011/08/02 | 14:02 | 37 03.570N | 142 15.019E | 2153 | TR24 | S/CO ON 252° |
| 2011/08/02 | 15:00 | 37 00.024N | 142 00.044E | 1368 | | STOPPED ENG'S |
| 2011/08/02 | 15:02 | 37 00.030N | 142 00.048E | 1371 | | CHANGED ENG'S TO E/M |
| 2011/08/02 | 15:06 | 37 00.035N | 142 00.062E | 1368 | TR25 | CTD-CMS STARTED |
| 2011/08/02 | 15:38 | 36 59.972N | 142 00.133E | 1358 | TR25 | CTD-CMS DEEPEST |
| 2011/08/02 | 16:18 | 37 00.030N | 142 00.235E | 1343 | TR25 | CTD-CMS FINISHED |
| 2011/08/02 | 16:33 | 37 00.107N | 142 00.245E | 1344 | TR25 | CHANGED ENG'S TO T/M |
| 2011/08/02 | 16:37 | 37 00.119N | 142 00.135E | 1364 | TR25 | LET GO ARGO FLOAT |
| 2011/08/02 | 16:41 | 36 59.768N | 141 59.923E | 1376 | | S/CO ON 208° |
| 2011/08/02 | 17:49 | 36 44.953N | 141 49.977E | 2041 | XC6 | LET GO XCTD |
| 2011/08/02 | 18:58 | 36 29.995N | 141 39.979E | 2024 | XB10 | LET GO XBT |
| 2011/08/02 | 19:41 | 36 20.994N | 141 34.162E | 1764 | | SUNRISE & TURNED OFF REGULATION LIGHTS |
| 2011/08/02 | 20:06 | 36 14.965N | 141 30.005E | 1462 | XB11 | LET GO XBT |
| 2011/08/02 | 21:19 | 35 59.909N | 141 19.900E | 1164 | | STOPPED ENG'S |
| 2011/08/02 | 21:19 | 35 59.909N | 141 19.900E | 1169 | | CHANGED ENG'S TO E/M |
| 2011/08/02 | 21:25 | 35 59.909N | 141 19.964E | 1178 | TR26 | MULTIPLE CORER STARTED |
| 2011/08/02 | 21:56 | 36 00.004N | 141 20.140E | 1199 | TR26 | MULTIPLE CORER HIT BOTTOM |
| 2011/08/02 | 21:58 | 36 00.010N | 141 20.139E | 1195 | TR26 | MULTIPLE CORER LEFT BOTTOM |
| 2011/08/02 | 22:23 | 36 00.006N | 141 20.440E | 1223 | TR26 | MULTIPLE CORER FINISHED |
| 2011/08/02 | 22:40 | 36 00.062N | 141 20.021E | 1193 | TR26 | CTD-CMS STARTED |
| 2011/08/02 | 22:48 | 36 00.140N | 141 20.049E | 1203 | TR26 | NORPAC NET STARTED |
| 2011/08/02 | 22:57 | 36 00.137N | 141 20.061E | 1187 | TR26 | NORPAC NET FINISHED |
| 2011/08/02 | 23:00 | 36 00.135N | 141 20.052E | 1190 | TR26 | NORPAC NET STARTED |
| 2011/08/02 | 23:07 | 36 00.134N | 141 20.040E | 1188 | TR26 | NORPAC NET FINISHED |
| 2011/08/02 | 23:10 | 36 00.142N | 141 20.058E | 1187 | TR26 | CTD-CMS DEEPEST |
| 2011/08/02 | 23:11 | 36 00.143N | 141 20.061E | 1187 | TR26 | NORPAC NET STARTED |
| 2011/08/02 | 23:18 | 36 00.148N | 141 20.041E | 1183 | TR26 | NORPAC NET FINISHED |
| 2011/08/02 | 23:46 | 36 00.153N | 141 19.987E | 1177 | TR26 | CTD-CMS FINISHED |
| 2011/08/03 | 00:01 | 36 00.093N | 141 19.774E | 1157 | TR26 | SETTING OF SEDIMENT TRAP STARTED |
| 2011/08/03 | 00:12 | 36 00.013N | 141 19.977E | 1179 | TR26 | SETTING OF SEDIMENT TRAP FINISHED |
| 2011/08/03 | 00:33 | 35 59.743N | 141 19.985E | 1181 | | CHANGED ENG'S TO T/M |
| 2011/08/03 | 00:33 | 35 59.742N | 141 19.984E | 1177 | | S/CO ON 219° |
| 2011/08/03 | 01:01 | 35 55.487N | 141 15.732E | 809 | | R/UP ENG'S |

| | | | | | | |
|------------|-------|------------|-------------|-----|--|--------------------------------------|
| 2011/08/03 | 05:01 | 35 04.579N | 140 25.694E | 122 | | A/CO TO 242° |
| 2011/08/03 | 06:54 | 34 50.345N | 139 52.758E | 111 | | A/CO TO 270° |
| 2011/08/03 | 07:02 | 34 50.590N | 139 49.883E | 106 | | A/CO TO 326° |
| 2011/08/03 | 07:36 | 34 58.323N | 139 43.505E | 55 | | A/CO TO 015° |
| 2011/08/03 | 08:11 | 35 07.689N | 139 46.371E | 576 | | A/CO TO 009° |
| 2011/08/03 | 08:30 | 35 12.742N | 139 46.975E | 0 | | S/B ENG'S |
| 2011/08/03 | 08:30 | 35 12.742N | 139 46.975E | 0 | | ENTERED URAGA SUIDO TRAFFIC ROUTE |
| 2011/08/03 | 09:30 | 35 24.442N | 139 46.428E | 26 | | CLEARED OUT NAKA-NO-SE TRAFFIC ROUTE |
| 2011/08/03 | 09:45 | 35 26.070N | 139 48.543E | 30 | | SUNSET & PUT ON REGULATION LIGHTS |
| 2011/08/03 | 10:45 | 35 34.133N | 139 52.101E | 29 | | CHANGED ENG'S TO S/M |
| 2011/08/03 | 10:56 | 35 34.398N | 139 52.795E | 29 | | STOPPED ENG'S |
| 2011/08/03 | 10:58 | 35 34.413N | 139 52.790E | 29 | | LET GO ANCHOR |
| 2011/08/03 | 23:07 | 35 34.429N | 139 52.771E | 29 | | S/B ENG'S |
| 2011/08/03 | 23:23 | 35 34.429N | 139 52.762E | 29 | | COM'CED HEAVE IN ANCHOR |
| 2011/08/03 | 23:35 | 35 34.395N | 139 52.776E | 29 | | UP & DOWN ANCHOR |
| 2011/08/04 | 00:00 | 35 34.200N | 139 49.059E | 29 | | ENTERED TOKYO WEST PASSAGE |
| 2011/08/04 | 00:16 | 35 35.743N | 139 46.972E | 29 | | CLEARED OUT TOKYO WEST PASSAGE |
| 2011/08/04 | 00:50 | 35 38.775N | 139 46.291E | 29 | | LET GO ANCHOR |
| 2011/08/04 | 00:52 | 35 38.786N | 139 46.302E | 29 | | SENT OUT 1ST SHORE LINE |

8. Explanatory notes

8.1. Research Vessel Hakuho-Maru

| | | |
|-------------------------------------|------------------------------|--|
| Keel laid | 9.May.88 | Research equipment |
| Launching | 28.Oct.88 | 7 Winches (swell compensator for Nos. 1 & 2 Winches) |
| Completion | 1.May.89 | No.1 Winch: 14f x15,000 m |
| Length (overall) | 100.00 m | No.2 Winch: 8.15f x12,000 m (Titanium armoured) |
| Length (p.p.) | 90.00 m | No.3 Winch: 6.4f x12,000 m (Titanium) |
| Breadth (molded) | 16.20 m | No.4, 5, 7, 8 Winches |
| Depth (molded) | 8.90 m | 10 Laboratories |
| Gross tonnage (JG) | 3,987 T | No.1 & 3: Dry lab., No.2: RI lab., No.7: Wet lab. |
| Propulsion system | diesel/electric-motor driven | No.4: Clean room, No.5 & 6: Semi-dry lab. |
| Main engine | 1,900 ps x 4 sets | No.10: Cold lab, etc. |
| Prop. Generator | 1,085 kw x 2 sets | 11 ton gantry |
| Twin propellers, twin rudders | | 11 ton beam crane & 3 ton deck crane |
| Main generator | 715 KVA x 3 sets | Instruments |
| Bow thruster | 4.2 T x 2 sets | Seabeam, Subbottom profiler, |
| Stern thruster | 6.8T x 1 set | Oceanfloor imaging system, |
| Cruising speed | 16.0 kn | Air gun compressor, |
| Endurance | 12,000 n.m. | Marine meteorological observation system, |
| Complement | 89 (include. sci. 35) | Acoustic biomass investigation system, |
| Builder | | Meteorological satellite receiving system, |
| Shimonoseki Shipyard & Engine Works | | CTD/DO, Precise gyrocompass, |
| Mitsubishi Heavy Industries, Ltd. | | Data processing system, etc. |

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:



Port call at Hakodate on June 19-21, 2010.

8.2 Sampling

8.2.1 Water sampling

8.2.1.1. CTD-Carousel sampling system

The CTD-CMS (CTD-Carousel Multi Sampling System) used during the KH-10-2 cruise consists of the following instruments.

CTD fish (Seabird, Model SBE-911-plus, 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 (Chelsea, Aquatracka Mk III)

Pinger (Benthos, Model BFP-312 or Model 2216)

Altimeter (Benthos, Model PSA-916)

Lowered ADCP Teledyne RDI WorkHorse 300 kHz

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 pinger 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.



8. 2. 1. 2. Clean sampling

In order to reduce the contamination level as low as possible, all the Niskin-X bottles were cleaned before the cruise by filling the bottles with 1% Extran MA01 (1 day), 0.1M HCl (pH=1, 1day), and Milli-Q water (more than 2 days), successively. Teflon spigots were pre-washed by soaking in 1% of Extran MA02 (1 day) and 1M HCl(1 day). The spigots were cleaned by heating in conc. HClO₄:conc. H₂SO₄:conc. HNO₃=1:1:1 mixture (120°C, 3 hrs), 6M HCl (120°C, 3 hrs), and Milli-Q water (100°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). The O-rings were cleaned by heating in 0.1M HCl (at 60°C, 12hrs), and Milli-Q water (at 68°C, 12 hrs).

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

According to a GEOTRACES recommendation, sub-samples for trace element analyses were taken inside a clean space, called “BUBBLE”, in the 7th laboratory on board the ship. This space has a volume of about 10 m³ (2500 x 2000 x 2000), into which clean air is introduced from outside through two HEPA filter units. Up to 8 Niskin-X bottles can be hold vertically on a wooden frame in the BUBBLE. Compressed clean air was provided from the top air vent of each Niskin-X bottle to take filtrated seawater samples inside the BUBBLE.

8.2.2. Plankton sampling—KH15

In pelagic zone, generally, net-plankton collected by several net according to the purpose and the sea condition. The North pacific standard net (Norpac net, Motoda, 1957) was devised as a standard net for sampling epipelagic phyto- and zooplankton. Phyto-net is a conical net (mouth diameter, 45 cm; mesh size, 20 μm) commonly used for phytoplankton in pelagic water column. Zoo-net is similar shape with phyto-net and is a conical net with the mouth diameter of 60 cm and comprises a bridle, a ring and a net with mesh sizes from 95 μm to 330 μm. In the present cruise both a phyto-net (single type) and a zoo-net (single type) was used for sampling plankton of euphotic zone. Zooplankton samples were towed obliquely through desired depth layer (ca. 200 m) with a retrieval speed of ca. 1.0 m/s. and phytoplankton samples were towed vertically from the ca. 40 m to the surface with a retrieval speed of 1.0 m/s.

Specifications of plankton nets

1. Zooplankton net

Model: Home-made

Mouth diameter: 1 m

Mesh size: 330 μm

Length: 6 m

2. Phytoplankton net

Model: Home-made

Mouth diameter: 0.45 m

Mesh size: 20 μm

Length: 2 m

8.2.3. Aerosol sampling

The atmospheric particles were continuously collected using high-volume virtual dichotomous air sampler (Kimoto Electric. Co. Ltd., Model AS-9) and low-volume virtual dichotomous air sampler (Kimoto Electric. Co. Ltd., Model AN-200). The mean flow rate was operated at 13 m³ h⁻¹. The sampler was mounted on the upper deck of the ship where was 13m above the sea surface. The virtual impactor separated coarse (diameter, $d > 2.5 \mu\text{m}$) and fine ($d < 2.5 \mu\text{m}$) particles, wherein both the fractions were collected on a single 90 mm diameter Teflon (Advantec, PF040 PTFE). The collection efficiency was 95% for 0.3 μm sized particles.

8.2.4. Sediment trap

Details see 10.28.

8.2.5. Sediment sampling (Multiple corer)

Yusuke Okazaki (JAMSTEC, okazakiy@jamstec.go.jp) and Keiji Horikawa (University of Toyama, horikawa@sci.u-toyama.ac.jp)

Surface sediments were obtained in the northwestern North Pacific (Table 6.1) using a multiple-corer (AORI, 450 kg weight) with eight 60 cm polycarbonate core tubes (9 cm diameter). The coring sites were determined based on sea-floor topographic survey by 3.5 kHz sub-bottom profiler (BATHY2000) and SeaBeam 2100 equipped onboard. The study area was divided into three according to our research purpose: (1) three sites (SHY sites) on the Shatsky Rise for paleoceanography (Fig. 1); (2) five sites off Tohoku (ES sites) relating to the 2011 Tohoku earthquake; (3) two sites (FS) for monitoring radioactivity from

the Fukushima nuclear power plants incident.

The obtained samples were stored in a cold room (ca. 4°C) after recovery and sliced onboard and distributed to sample requesters. One of the MC core at each site, we cut into half and measured sedimentary colour at every 1cm by using Minolta SPAD-503 spectrophotometer.

Shatsky Rise sites:

Three MC sites on the Shatsky Rise were ranging from 2400 to 2900 m water depths. Our main purpose is to reconstruct past deepwater properties. Thus, sediments were taken from depth-transect.

TR04-MC (SHY3)

Site TR04-MC was located on a gradual slope at the southern edge of the South High of the Shatsky Rise, which was close to the Ocean Drilling Program (ODP) Site 1211. Recovery of each MC core was ~30 cm. Sediments of TR04-MC were mainly composed of bioturbated calcareous ooze (Fig. 2a). Profiles of sedimentary colour components a^* and b^* decreased below 20 cm (Fig. 3). Considering previous studies on the Shatsky Rise, we assumed that bottom of TR04-MC reached to the last glacial maximum (LGM, 19 kyr B.P.).

TR05-MC (SHY2)

Site TR05-MC was located on a gradual slope at the southwestern part of the South High of the Shatsky Rise, which was close to the site of core S2612. Recovery of each MC core was ~30 cm. Sediments of TR05-MC were mainly composed of bioturbated calcareous ooze (Fig. 2b). Profiles of sedimentary colour components a^* and b^* decreased below 19 cm (Fig. 3), comparable to TR04-MC.

TR06-MC (SHY1)

Site TR06-MC was located on a gradual slope near the topographic high of the South High of the Shatsky Rise, which was close to the ODP Site 1209. Recovery of each MC core was ~18 cm. Sediments of TR06-MC were mainly composed of bioturbated calcareous ooze (Fig. 2c). Profiles of sedimentary colour components a^* decreased between 4 and 10 cm (Fig. 4), which showed different pattern from that of cores TR04-MC and TR05-MC. Weathering by bottom current on core TR06-MC should be evaluated before serving to paleoceanographic studies.

Earthquake sites (ES):

Five MC sites off Tohoku were ranging from 2400 to 7100 m water depths.

TR17-MC (ES5)

Site TR17-MC was located on the slope in the western side of the Japan Trench, near the trench axis from 7047 m water depth. Recovery of each MC core was ~6.5 cm. Sediments of TR17-MC were composed of soupy greenish silt.

TR18-MC (ES4)

Site TR18-MC was located on the slope of the Japan Trench from 5253 m water depth. Recovery of each MC core was ~25 cm. Sediments of TR17-MC were composed of homogeneous silty clay. The uppermost layer was a turbidite composed by fine silt with 3.5 cm thickness, which may occurred by the Tohoku earthquake on 11 March 2011.

TR19-MC (ES6)

Site TR19-MC was located on the slope of the Japan Trench from 3864 m water depth. Recovery of each MC core was ~16 cm. Sediments of TR19-MC were composed of homogeneous clay. The uppermost layer was a turbidite composed by fine sand with 3.5 cm thickness. The erosion boundary was apparent.

TR21-MC (ES7)

Site TR21-MC was located on the slope of the Japan Trench from 3442 m water depth. Recovery of each MC core was ~30 cm. Sediments of TR21-MC were composed of homogeneous clay. The uppermost layer with 6 cm thickness was very soupy. No bioturbation was apparent.

TR24-MC (ES2)

Site TR21-MC was located on the slope of the Japan Trench off Fukushima from 2138 m water depth. Recovery of each MC core was ~25 cm. Sediments of TR24-MC were composed of three section, (1) sandy turbidite layer in upper part, (2) black reduced layer with H₂S smelling in the middle, and (3) homogeneous and massive silty clay layer in the lower part.

Fukushima sites (FS):

Two MC sites off Fukushima were ranging from 900 to 1200 m water depths.

TR23-MC (FS1)

Site TR23-MC was located on the shelf edge ~90 km away from the Fukushima nuclear power plants. Recovery of each MC core was ~26 cm. Sediments of TR23-MC were composed of bioturbated sandy silt.

TR26-MC (FS5)

Site TR23-MC was located on the shelf edge off Kashima. Recovery of each MC core was ~28 cm. Sediments of TR26-MC were composed of homogeneous silty clay.

References:

Kawahata, H., K. Ohkushi, and Y. Hatakeyama, Comparative late Pleistocene paleoceanographic changes in the mid latitude boreal and austral western Pacific, *J. Oceanogr.*, 55, 747-761, 1999.

Yamane, M., Late Quaternary variations in water mass in the Shatsky Rise area, northwest Pacific Ocean, *Mar. Micropaleontol.*, 48, 205-223, 2003.

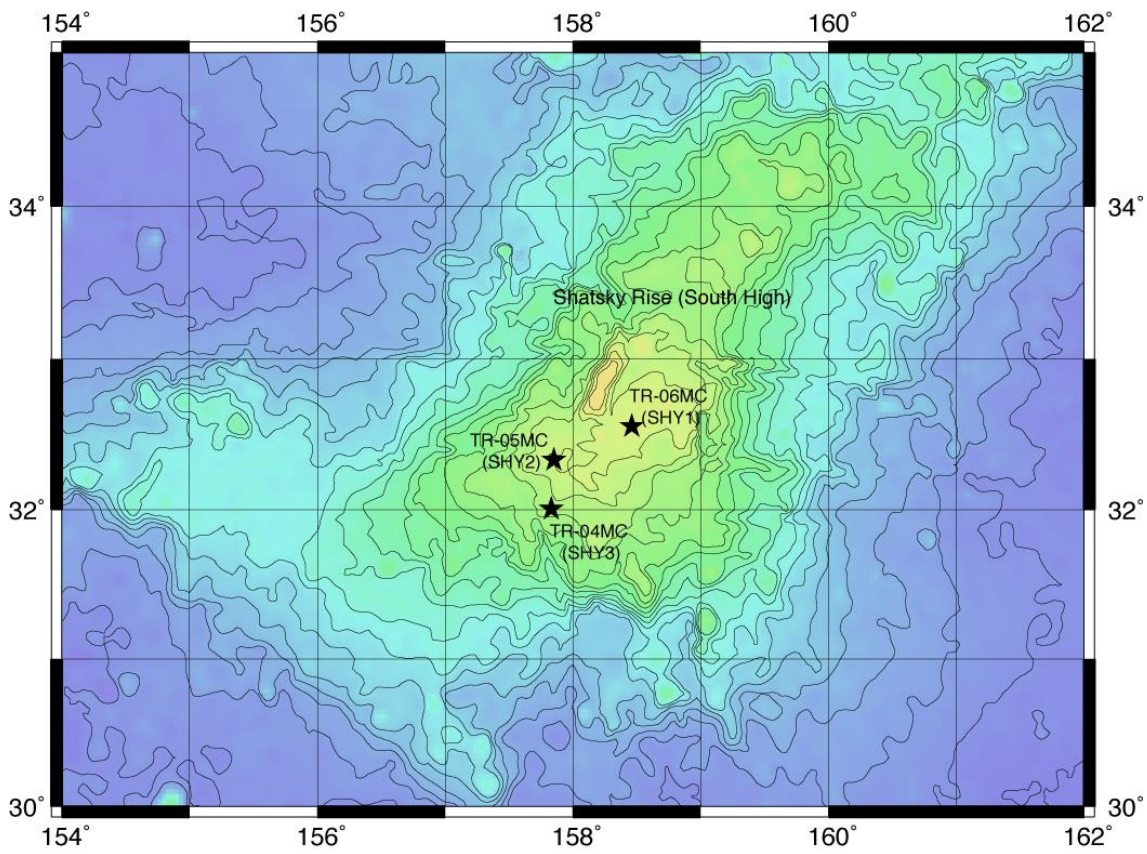


Figure 1. Map showing multiple core sites on the Shatsky Rise.

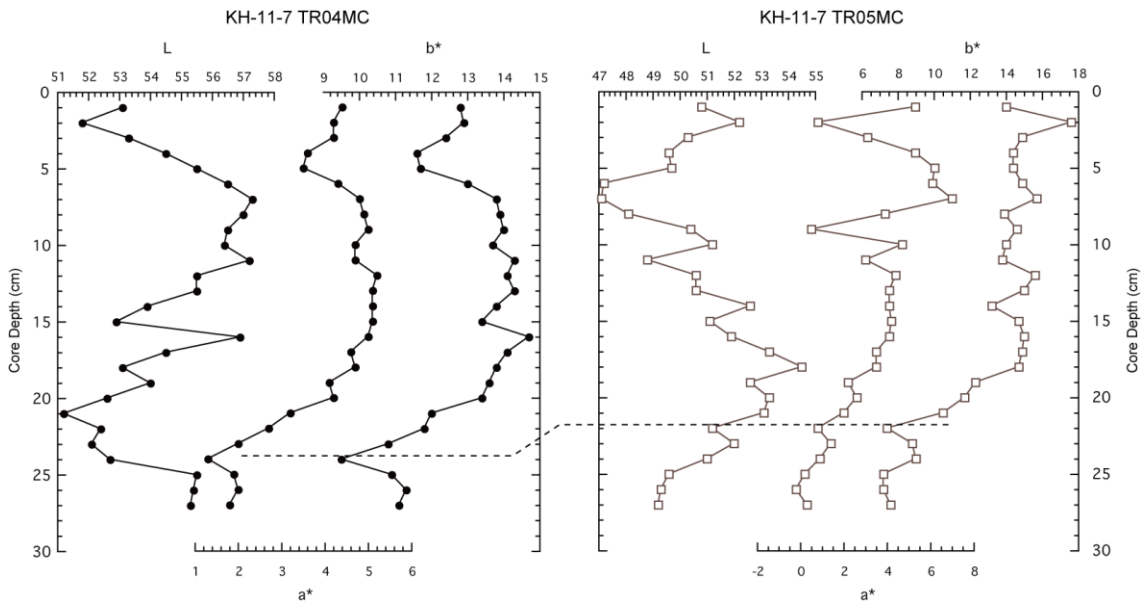


Figure 3. Profiles of sedimentary colour components L, a^* and b^* at Core TR04-MC (left) and Core TR05-MC (right).

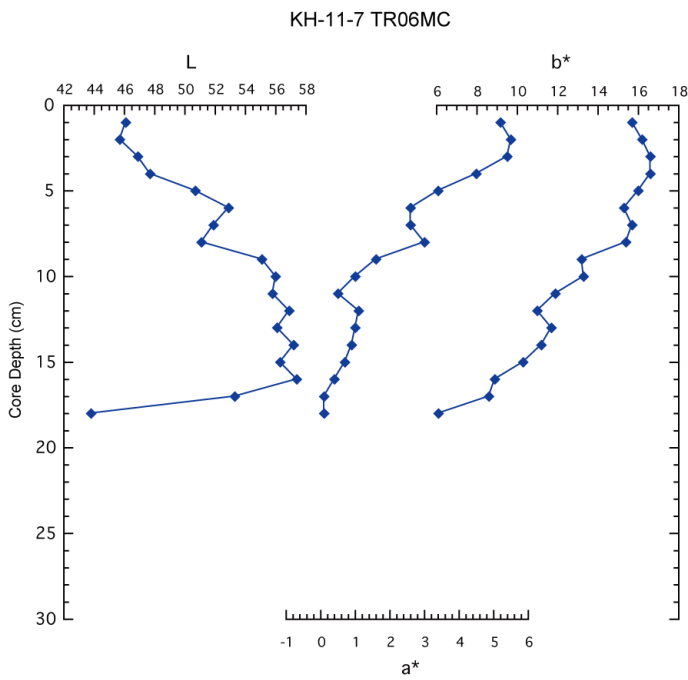


Figure 4. Profiles of sedimentary colour components L, a^* and b^* at Core TR06-MC.

8.2.6. Argo

Details see 10.30.

8.3. Routine analysis

8.3.1. Salinity

Salinity – analysis group

Salinity was measured with the Autosal (Model 8400B, Guildline Instruments Ltd., Canada) salinometer. Sampling bottle for salinity were prepared according to JGOFS protocols. The Autosal was standardized using the IAPSO standard seawater.

8.3.2. Dissolved Oxygen

1. Personnel

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Hisashi Narita (on-land, Tokai University)

2. Sampling

The sampling procedures followed the WHP Operations and Methods (C.H. Culberson, "Dissolved Oxygen", July, 1991). Seawater samples were collected with Niskin bottles attached to the CTD system. Seawater for dissolved oxygen measurement was transferred from the Niskin bottle to a calibrated sample flask (normally 103 cm³) using a silicon tube. The seawater was overflowed by three or more flask volumes. Temperature was measured by a digital thermometer during the overflowing. The MnCl₂ and the NaOH/NaI reagents were added immediately after the sampling. The stopper was inserted carefully into the flask, the flask then was shaken vigorously to mix the contents and disperse the precipitate finely throughout. After the precipitate had settled at least half-way down the flask (about 20~30 min), the flask was shaken again vigorously to disperse the precipitate. The sample flasks containing pickled samples were stored in the laboratory until they were titrated.

3. Measurement

After the re-shaking, the dissolved oxygen concentrations were measured using the Winkler titration method, employing automatic dissolved oxygen titration equipment with detection system using the UV LED (DOT-05; KIMOTO ELECYRIC CO., LTD.). The titration procedures followed the WHP Operations and Methods (C.H. Culberson, "Dissolved Oxygen", July, 1991). During this cruises, we used two sets of the automatic dissolved oxygen titration equipment. To achieve higher accuracy, all volumetric glassware and apparatus were calibrated by measuring the weight of pure water contained or delivered at standard temperature (20 °C). For instance, the volume of each sample flask (normally 103 cm³) was calibrated with a reproducibility of about 0.01 % (1 relative standard deviation, i.e., +/- 0.026 mL).

4. Standardization and calculation

The concentration of Na₂S₂O₃ titrant was calculated by 1/10 N KIO₃ standard solution (WAKO Pure Chemical Industries, LTD.) after diluting 10 times using a calibrated volumetric flask (500 ml) and pipette (50 ml). We also used KIO₃ solution (0.0010002 N) for standardization to cross checking. This KIO₃ solution was obtained using dissolved 0.35668 g pure potassium iodate weighed out accurately after being dried in an oven at 130 °C over 2 hr in pure water and diluted to volume of 1 L in a calibrated volumetric flask. The results show good agreement between each standardization. During this cruise, the concentration of Na₂S₂O₃ titrant did not show a significant change over time, so we used the average Na₂S₂O₃ titrant concentration for the dissolved oxygen calculation.

Dissolved oxygen concentrations calculated from the following equation were converted to units of micromole per liter of seawater (μmol/L) multiplying by 44.660, which equals 1000/molar volume of oxygen gas at STP (Wiess, 1981).

$$O_2 \text{ (ml/L)} = \frac{(V_x - V_{blank}) V_{IO_3} \cdot N_{IO_3} \cdot 5598}{(V_{std} - V_{blank})} - 1000 \cdot DO_{reg}$$
$$\frac{(V_{bot} - V_{reg})}{(V_{bot} - V_{reg})}$$

where V_x is thiosulfate titer of sample (ml), V_{blank} is thiosulfate titer of pure water blank (ml), V_{std} is thiosulfate titer of standard (ml), V_{bot} is volume of sample flask at the temperature of sampling (ml), V_{reg} is volume of sample displaced by reagents (ml), V_{IO_3} and N_{IO_3} are volume

and normality of iodate standard at 20 °C and DO_{reg} is absolute amount of oxygen added with reagents, 0.0017 ml (Murray *et al.*, 1968). The blank (V_{blank}) from the presence of redox species apart from oxygen in the reagents used the average value to each thiosulfate solution during this cruise (-0.0018 ml). The volume (V_{reg}) of sample displaced by two reagents used the calibrated volume at the standard temperature of each dispenser using pure water in the laboratory.

Replicate samples were taken at almost every CTD cast; usually 1~2 samples of each cast during this cruise. The difference of O_2 measurements during this cruise was $0.26 \pm 0.21 \mu\text{mol/l}$ ($0.22 \pm 0.24 \%$, $n=22$), as determined through replicate analyses.

5. Calibration of dissolved oxygen sensor

The calibration of the SES43 dissolved oxygen sensor was done using the Winkler titration value and corresponding sensor voltages to compute new slope and offset terms, employing the Seabird application notes (No. 64-2, revised February 2010). The accurate calibration of the sensor will be done after this cruise.

6. Data Archive

All of the raw and processed data from the KH-11-7 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

8.3.3. Nutrients

1. Personnel

Akira Nishiuchi, Koichi Takeda and Yuzuru Nakaguchi (Kinki University)

2. Introduction and Objective

All depth profiles of nutrient were obtained at the GEOTRACES sampling stations.

3. Analysis and 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 phosphoantimonymolybdenum 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 molybdate 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 820 nm.

4. Apparatus

Nutrients are analyzed by an auto analyzer AACS II (BLAN+LUBBE). All analytical data (nitrate, nitrite, phosphate and silicate) were corrected by using sea water reference material of nutrients (KANSO).

8.3.4 pH

1. Personnel

H. Obata (University of Tokyo), S. Sasaki (University of Toyama) and pH-measurement Group

2. Introduction and Objective

All depth profiles of pH were obtained at the GEOTRACES sampling stations.

3. Inventory information for the sampling

Sampling stations, date-time, layers are shown in the observation data sheets in this material.

4. Analysis and method

Seawater samples were collected in 100 mL polyethylene bottles with inner caps from

Niskin sampler. The sample bottles were capped after an overflow of about 100 mL seawater in order to avoid exchange of CO₂ with the atmosphere during sampling. All samples were stored in the 6th laboratory of R/V Hakuho Maru at room temperature and analyzed within a day after sampling. Samples were transferred into a closed and water jacketed glass measurement cell with a volume of ~30 mL. The cell temperature was maintained at a constant temperature of 25°C±0.1°C. The electric potential and temperature of the sample were measured for 15 minutes with an Ag/AgCl combined electrode (Radiometer Analytical A/S, GK2401C) and a temperature sensor (Radiometer Analytical A/S, T901) connected to a high precision pH meter (Radiometer Analytical A/S, model PHM93). A pH electrode and a temperature sensor were tightly inserted into the inner space of the pH cell through two tapered joints. Before measurement of samples, calibration of the pH meter was conducted using the RADIOMETER buffer solutions (pH 4.001; S11M002, pH 7.000; S11M004) which is controlled against reference standards to secure full traceability to the UPAC/NIST pH scale (NBS scale). Tris and 2-Aminopyridine buffers were employed to calibrate pH electrodes. The buffer solutions were kindly prepared by Dr. K. Okamura (Kochi Univ.) just before the cruise. Calibrations were made at the beginning and the end of set of measurements for every station. The e.m.f. values (mV) of the two buffers and unknown seawater samples were converted to pH values (SWS scale) according to the equations in the manual SOP 6 (Determination of the pH of sea water using a glass/reference electrode cell, August 30, 1996). The pH values of SWS scale were also indicated in the data sheets.

8.3.5 Total alkalinity (TA)

1. Personnel

A. Ooki (Hokkaido University), S. Hirayama (University of Toyama) and TA-measurement group members

2. Introduction and Objective

Total alkalinity (TA) is a key parameter to analyze the inorganic carbon budget in the ocean. We obtained depth profiles of TA at the GEOTRACES sampling stations.

3. Inventory information for the sampling

Sampling stations, date-time, layers are shown in the observation data sheets in this material.

4. Analysis and method

Discrete seawater samples were taken from Niskin bottles on CTD/carousel sampler and from a bucket for surface seawater. Seawater in the Niskin bottle (or bucket) was collected in a poly-propylene bottle with 250 mL volume using a silicone tube. More than 250 mL of seawater was overflowed from the bottle. The bottles were stored in a refrigerator at 5 °C until analysis.

A high precision open-cell potentiometric titration method was used for total alkalinity analysis, which is described in SOP 3b of Dickson *et al.* (*Guide to best practices for ocean CO₂ measurements*; 2007) and ISO 22719:2008 “Water quality – Determination of total alkalinity in seawater using high precision potentiometric titration.” This method is applicable for determining the oceanic level of total alkalinity (2,000 $\mu\text{mol kg}^{-1}$ to 2,500 $\mu\text{mol kg}^{-1}$) with practical salinity ranging from 30 to 40.

Seawater in the bottles were put in a water bath at 25 °C for 1 hour before the titration. 100 ml of seawater was collected in a tall beaker from the bottle using Knudsen pipette. The inner volume of the pipette has been calibrated before the cruise. The seawater sample was titrated with 0.1 M HCl/0.6 M NaCl solution by two-stage titration using an automatic total alkalinity titration analyzer (ATT-05; KIMOTO ELECYSRIC CO., LTD.). The seawater was first acidified to pH = 3.5 - 4.0 with stirring for 10 min to purge the dissolved CO₂ (first-stage titration), and then, the non-CO₂ seawater was acidified to pH = 3.0 (second-stage titration). The total alkalinity was calibrated based on a reference material measurement (The General Environmental Technos CO., LTD.) according to the same procedure.

3.2.6 Chlorophyll a

1. Personnel

J. Zhang (University of Toyama) and Chlorophyll-measurement Group

2. Introduction and Objective

All depth profiles of Chlorophyll a were obtained at the GEOTRACES sampling stations.

3. Inventory information for the sampling

Sampling stations, date-time, layers are shown in the observation data sheets in this

material.

4. Analysis and method

For routine data set of the cruise, chlorophyll *a* was determined by fluorometer. Surface seawater samples were collected by using a polyethylene bucket. Vertical samples were collected by 12 L Niskin bottle attached to the CTD-system. Sampling depth is at 13 layers (0-250 m) and collected in 250–2200 ml dark polyethylene bottles that were rinsed by seawater for 3 times. After sampling finished, seawater samples were immediately (< 2 hours) filtered through 25 mm Whatman GF/F glass fiber filter maintaining vacuum levels of 0.02 MPa or less. For clean stations, in addition to the GF/F filter, we have used membrane filters with different pore size (2 μm , 5 μm , and 10 μm) and measured size-fractionated concentrations of chlorophyll *a*. The filters were placed in polypropylene tubes, extracted in 7 ml N,N-dimethylformamide, stored keeping in freezer (-40°C) and dark condition until measurement. The concentration of chlorophyll *a* was measured by using a fluorometer (10-AU TURNER DESIGNS) with a chlorophyll optical kit for the non-acidification (Welschmeyer) method (Welschmeyer, 1994). The concentration of chlorophyll *a* of unknown samples was calibrated against chlorophyll *a* standard (Wako Pure Chemical Industries, Ltd.)

8.4. pH sensor

8.5. Bottom topographic observation

9. Routine data tables for the CTD hydrocast samples (Excel file)

10. Brief reports by the participants and on-land researchers

10.1. Distribution of trace metals (Al, Mn, Fe, Co, Ni, Cu, Zn, Cd, Pb, Pd, Pt, Au and Bi) and their isotopes (δCu and δW) in the Pacific Ocean

1. Personnel

Shotaro Takano (Kyoto University)

Jun Yamamoto (Kyoto University)

Yoshiki Sohrin (on-land, Kyoto University)

2. Introduction and Objectives

The distribution of trace metals in seawater is controlled by various physical, chemical and biological processes. In order to reveal the distribution and behavior of trace metals in the oceans, we have developed multi-elemental determination of trace metals in seawater based on concentration by solid phase extraction with chelating resins and detection by inductively coupled plasma mass spectrometry (Sohrin et al., 2008).

3. Analyze and Method

The target metals are concentrated by solid phase extraction using columns of chelating resins. The concentration of trace metals are determined by ICP-MS. The isotopic compositions are measured by multi-collector ICP-MS.

4. Sampling method

Seawater samples were collected using the clean CTD sampling system.

(1) Bioactive trace metals: Seawater samples for bioactive trace metals transferred from Niskin-X bottles to 500 mL polyethylene bottles (LDPE, Nalge) using a clean bell and acid-cleaned silicon tubing in a clean area constructed in the No.7 Lab. Some portions of the samples were filtered through a 0.2 μm polycarbonate membrane filter (Nuclepore) by the pressure of nitrogen gas using a closed filtration system in a clean room (No.4 Lab). All the filtered and unfiltered samples for bioactive trace metals were acidified with 20% HCl (Tampure AA-10, Tama Chemicals).

(2) Noble metals, Bi, δCu , δW : Seawater samples were passed through an AcroPak cartridge filter (Pall Life Sciences) by the pressure of compressed air and transferred from Niskin-X bottles to 4 L LDPE bottles (Nalge) for PGEs and δCu , 250 mL LDPE bottles for Bi, 20 L polyethylene tanks for δW . The filtered samples were acidified with HCl (Toxic metal analytical reagent grade, Wako) for δW , with HCl (Tampure AA-10) for Bi, and with HCl (Ultrapur 100, Kanto Chemicals) for δCu and noble metals.

5. Anticipated results and Work plan

We will reveal the distribution of bioactive trace metals (Al, Mn, Fe, Co, Ni, Cu, Zn, Cd, and Pb), noble metals (Pd, Pt, and Au), and Bi in the Pacific Ocean and. We will also reveal the isotopic composition of copper (δCu) and tungsten (δW).

Y. Sohrin, S. Urushihara, S. Nakatsuka, T. Kono, E. Higo, T. Minami, K. Norisuye, S. Umetani,

Anal. Chem. 80, 6267 (2008).

10. 2. 1. Distributions and speciation of trace elements in the western North Pacific.

Hajime Obata, Shin Wakiyama (onboard)

Taejin Kim, Asami Suzuki and Toshitaka Gamo (on land)

Marine Inorganic Chemistry Division, Atmosphere and Ocean Research Institute, University of Tokyo

1. Distributions of trace metals in the western North Pacific

1-1. Objective

Trace metals, such as Fe, Mn and Zn, are now thought to be essential for phytoplankton growth in the open oceans. However, detailed distributions of trace metals have not been investigated well in the western subarctic Pacific and the marginal seas. In this study, we will study the distributions of dissolved trace metals (Fe, Mn, Zn, Al etc.) in the western North Pacific, which is related to the international GEOTRACES project.

1-2. Information for sampling

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 μ m filter cartridge (Acropak, Pall) connected to sampler directly with pressured air. Filtered and unfiltered samples (500mL of PE bottle) are acidified to pH<1.8 with ultra pure HCl (Tamapure AA-100) and stored.

CTD sampling

Stations: TR- 7, 11, 13, 15, 16 and 17

1-3. Analytical methods

Iron will be determined by a flow analytical system by using chelating resin preconcentration and chemiluminescence (CL) detection (Obata et al., 1993; 1997), or cathodic stripping voltammetry (CSV) in the land-based laboratory. Manganese concentrations will be determined by a flow analytical system by using electrolytic column preconcentration and chemiluminescence (CL) detection (Nakayama et al., 1989). Zinc will be determined by cathodic stripping voltammetry (Ellwood et al., 2000) in the land-based laboratory. Aluminum will be determined by a flow analytical system by Lumogallion fluorescent detection (Obata et al., 2001).

1-4. Anticipated results and future work plan

We are expecting that the results reveal the transport processes of the trace metals to the ocean by comparing their behaviors.

2. Trace element speciation in the western North Pacific

2-1. Objective

Trace metals, such as Fe and Zn, are essential micronutrients for phytoplankton in the ocean. At low concentration levels, trace metals can limit the growth of marine phytoplankton in surface layers. Now, speciation is also considered to be an important factor of the biological availability of these trace metals. However, little is known about the organic complexation of trace metals in open-ocean waters. In this study, we will investigate trace metal speciation in the western North Pacific using cathodic stripping voltammetry (CSV). Additionally, we will investigate redox speciation of iodine in seawater using CSV. For better understanding of biogeochemical cycles of trace elements in the ocean, it is the first step to clarify the speciation of these elements in seawater.

2-2. Information for sampling

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 μ m filter cartridge (Acropak, Pall) connected to sampler directly with pressured air. Filtered samples (500mL of PE bottle) are frozen at -18°C and stored.

CTD sampling

Stations: TR- 7, 11, 13, 15, 16 and 17

We also collected seawater samples to study redox speciation of iodine and ^{129}I in the western North Pacific.

2-3. Analytical methods

On the land-based laboratory, ligand concentrations and conditional stability constants for Zn and Fe will be obtained from a titration using CSV (Ellwood et al., 2000; van den Berg, 2006; Laglera and van den Berg, 2009). For iodine redox speciation, iodide and total iodine in seawater will be determined by square-wave CSV (Luther et al., 1988; Campos, 1997).

2-4. Anticipated results and future work plan

We are expecting that the results show the distributions of reactive species of Zn and Fe in this area. By using the results, we will discuss the relationship between phytoplankton growth and bioavailability of the trace metals.

3. Platinum group elements in the western North Pacific

3-1. Objective

Anthropogenic platinum group elements are increasingly emitted and spread into the environments according to recent industrial uses. However, only few data have been reported on platinum group elements in the oceanic environments. In this study, we will investigate dissolved Pt concentrations in seawater of the western North Pacific. To study the marine geochemical cycles of Pt, we will try to determine palladium in the same seawater samples.

3-2. Samples

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

Stations: TR- 7, 11, 13, 15 and 16

3-3. Analytical methods

Using isotope dilution ICP-mass spectrometry (ID-ICPMS), platinum in seawater will be determined (Obata et al., 2006). After adding ¹⁹⁵Pt spike and ¹⁰⁵Pd spike, Pt and Pd will be preconcentrated with anion-exchange resins. Concentrated samples will be measured using a quadrupole inductivity coupled plasma mass spectrometer. The concentrations of these elements are calculated by the measured isotopic ratios using the equation for isotope dilution method.

3-4. Anticipated results and future work plan

We are expecting that the results show how far the anthropogenic substances containing PGE are transported to the western North Pacific.

4. Data Archive

All of the raw and processed data from the KH-11-7 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

10. 2. 2. Isotopic distributions of Nd in the western North Pacific Ocean

Hirofumi Tazoe (on land, Institute of Radiation Emergency Medicine, Hirosaki University)

Hajime Obata (onboard, Atmosphere and Ocean Research Institute, The University of Tokyo)

1. Introduction

Nd isotopic composition ($^{143}\text{Nd}/^{144}\text{Nd}$), one of the useful isotopic tracers in geochemistry, is frequently utilized in chemical oceanography because water masses show characteristic values reflecting the geology of Nd source areas. In the GEOTRACES program, Nd IC is one of the key parameters. In the western North Pacific Ocean, radiogenic Nd derived from volcanic islands might affect the variations of Nd IC in seawater, but the details have not been revealed yet. In this cruise, we will determine the vertical distribution for Nd IC in the western North Pacific Ocean as a part of the Japanese GEOTRACES project.

2. Information for sampling

Seawater samples for vertical profiles of Nd IC were collected using X-type Niskin samplers attached to CTD-CMS system. Seawater (10L) from Niskin bottle was passed through the 0.2 μm -pore size capsule filters, Acro Pak200 (Pall), with compressed air in the Bubble. Seawater samples are brought back to the land-based laboratory.

Sampling stations and depths

TR- 7, 11, 13, 15, 16: 20m, 100m, 200m, 400m, 600m, 800m, 1000m, 1500m, 2000m, 3000m, 4000m, 5000m, bottom

3. Analytical method

To the seawater samples, HCl and Fe carrier (0.25g) are added. By adding NH_4OH , Nd is coprecipitated with $\text{Fe}(\text{OH})_3$. The supernatant will be reduced by decantation and centrifuge, and Fe is removed by solvent extraction with di-isopropyl ether. Then, Nd will be purified with ion exchange resin, and Nd IC will be determined by a thermal ionization mass spectrometer in AORI, University of Tokyo.

4. Anticipated results and future work plan

We will reveal the variations of Nd IC in the western North Pacific, especially in the subarctic zone where volcanic substances might affect the Nd IC in seawater.

5. Data archive

All of the raw and processed data from the KH-11-7 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

10.3. Chemical speciation of selenium and biogenic selenium.

1. Personnel

Akira NISHIUCHI (Kinki University)

Koichi TAKEDA (Kinki University)

Yuzuru NAKAGUCHI (on-land, Kinki University)

2. Introduction and objectives

The dissolved selenium exist three chemical forms such as selenite (SeO_3^{2-}), selenate (SeO_4^{2-}) and organic selenium in the ocean. Oceanic selenium speciation has been reported by some investigators. The vertical profiles of selenite were very similar to those of silicate. Such a trend with high correlation coefficient ($r > 0.9$, $p < 0.01$) was recognized to the sea water samples. Nakaguchi et al., pointed out that the behavior of selenite in the water column is very similar to that of silicate in the North Pacific Ocean (Nakaguchi et al., 2009). The highest correlation coefficients of regression analysis were recognized between selenite and silicate. In the North Pacific, the distribution and behavior of selenite might be controlled by the particulate material rather than soft tissue. These results confirmed that the main sources of selenite are in process traced silicate, such as degradation of diatom and opal. In this study, the chemical speciation of the selenium in the North Pacific Ocean was carried out by using the seawater sample collected from R/V Hakuho-Maru KH-11-07 cruise. In addition, "Biogenic selenium" was determined by using the analytical method for "Biogenic silica".

3. Inventory information for the sampling

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. After collection, the water samples for selenium speciation were filtered through a 0.2 μm filter cartridge (Acropak, Pall).

4. Analysis and method

Selenium speciation

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.

Biogenic selenium in the suspended particles

The suspended particles were decomposed by the hydrolysis method with Na₂CO₃ solution. Biogenic silica was determined by the molybdenum blue spectrum analytical method. Biogenic selenium was determined by the analytical procedure for the determination of total selenium.

5. Data Archive

All of the raw and processed data from the KH-11-7 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

10.4. Water mass structure analysis GP10 line (165E) in the western North Pacific Ocean using rare earth element.

1. Personnel

Shunji Sasaki, shoko Hirayama, Jing Zhang

2. Introduction and objectives

In order to advance the research on ocean mixing and deeply analyze related oceanographic processes, characterization and quantification of water masses in the western North Pacific using multiple chemical tracers were conducted.

3. Expected output

- 1) Examination and quantification of various water masses mixing in the western North Pacific, and their transport to the downstream;
- 2) Quantification of nutrient fluxes from atmospheric deposition;
- 3) Identification and quantification of material (e.g. particulate matter) transport by Kuroshio.

10.5 Biogeochemical studies on Ba in seawaters from the western North Pacific

1. Personnel

Yoshihisa Kato (on-land, Tokai University)

Ray Ito (Tokai University)

2. Introduction and objectives

It is known that the vertical distribution of Ba in seawater is very like that of silicate. However, the correlation between the two is less than that between Ba and the silicate/nitrate ratio (Si/N). Previously, we have found out the linear relationship between Ba and Si/N in the western North Pacific section study from 30°N to 50°N. There is very possibility of using this relation as a paleoceanographic tool, as well as the case of the linearity of Ba versus alkalinity in the ocean. Our object is to confirm the relation between Ba and Si/N ratio in the western North Pacific.

3. Inventory information for the sampling

Seawater samples were collected at 15 hydrocast stations (TR-1, 2, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 and 17) and were filtrated through 0.45 μ m. The seawater samples will be analysed in the land based laboratory.

4. Analysis and method

Filtrated samples are concentrated to 2.5 times and measured by ICP-AES

5. Anticipated results and work plan

I clear vertical profile of Ba and confirm the relation between Ba and Si/N ratio in the western North Pacific.

6. Data Archive

All of the raw and processed data from the KH-11-7 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

10.6. Does Nd isotopic composition of foraminifera faithfully reflect that of ambient seawater? (Hiroschi Amakawa)

10.7. Lead isotopes distributions in the North Pacific Ocean

1. Personnel

Céline Gallon (University of California Santa Cruz)

A. Russell Flegal (University of California Santa Cruz)

2. Introduction and objectives

Although lead concentration and isotopic compositions have been extensively used to investigate lead sources and geochemistry in the environment, there is still a considerable lack of data for seawater. Because those lead data are considered to be *particularly fruitful to measure on all ocean sections and for which global coverage is highly desirable*, GEOTRACES designated lead concentrations and isotopic compositions as key parameters for the program. In the North Pacific, only three lead isotope concentration profiles have been published to date. Two deep vertical profiles were reported in the eastern North Pacific^{1,2} and one shallow vertical profile in the California coastal current system.³ And two of those three data sets are over 20 years old.^{1,3} We propose to add to this limited pool of data by measuring lead concentrations and isotopic compositions in seawater profiles collected during the KH-11-7 cruise.

Our objectives for this cruise are two-fold:

(1) It will provide a better assessment of the increasing impact of Asian industrial emissions on lead concentrations in the North Pacific², which would be consistent with recent observations of trace metals concentrations and lead concentrations and isotopic compositions in North Pacific aerosols and surface waters⁴⁻⁶.

(2) It was recently proposed that anthropogenic lead has invaded the North Pacific abyssal water, where it has become the predominant lead source². Measurements in deep waters will further test this hypothesis.

3. Inventory information for the sampling

Table. 1. A list of sampled seawater volume and depths at each site. Exact location of each station can be seen in Sec 6 and 9 in this cruise report.

| Sampling Depth | TR16 (K2) | KNOT (Cancelled) | TR15 (K1, GP10N1) | TR13 (GP10N2) | TR11 (GP10N3) | TR07 (GP10N4') |
|----------------|-----------|------------------|-------------------|---------------|---------------|----------------|
| 20 | 2+2+2 | | 2+2+2 | 2 | 2+2+2 | 2+2+2 |
| 100 | 2 | | 2 | | 2 | 2 |
| 200 | 2 | | 2 | | 2 | 2 |
| 300 | 2 | | 2 | | 2 | 2 |
| 600 | 2 | | 2 | | 2 | 2 |
| 1000 | 2 | | 2 | | 2 | 2 |
| 1500 | 2 | | 2 | | 2 | 2 |
| 2000 | 2+1 | | 2 | | 2 | 2+1 |
| 3000 | 2+1 | | 2 | | 2 | 2+1 |
| 4000 | 2+1 | | 2 | | 2 | 2+1 |
| 5000 | 2+1 | | 2 | | 2 | 2+1 |

4. Analysis and method

Seawater samples were collected using trace metal clean techniques in acid-cleaned 2L or 1L LDPE bottle. All samples will be acidified with Quartz distilled HCL to pH 2 upon return to UCSC laboratories.

Lead concentrations will be measured in all the samples using chelating resin direct flow injection on the high resolution Thermo Element XR inductively coupled plasma mass

spectrometer (ICP-MS) that is housed in the Institute of Marine Sciences at UCSC⁷.

For lead isotopic measurements (^{204}Pb , ^{206}Pb , ^{207}Pb and ^{208}Pb), samples will first be concentrated using an off-line chelating resin extraction method. Depending on the original lead concentration in the sample, 0.1 to 1L of seawater will be extracted and recovered in 1mL of 1.5 N ultrapure quartz-distilled nitric acid to a final lead concentration of ~2ppb. The analysis of lead isotopes abundances will be performed on the Thermo Element XR ICP-MS, using established procedures⁸. As part of the GEOTRACES intercalibration effort, two seawater samples (GSI and GDI) were analyzed using this set-up. Isotopic composition data were within ≤ 3 permil, ≤ 0.5 permil and ≤ 11 permil for $^{206}\text{Pb}/^{207}\text{Pb}$, $^{208}\text{Pb}/^{207}\text{Pb}$ and $^{206}\text{Pb}/^{204}\text{Pb}$, respectively of those measured at MIT⁹.

5. Anticipated results and work plan

Information obtained from this work will be combined with data from our past and ongoing studies of lead distributions in the North Pacific (e.g., IOC-IV, California Upwelling Transition Zone cruises) and the Antarctic waters (Amundsen Sea Polynya International Research Expedition). This extensive data set will enable us to trace lead fluxes and cycling throughout the Pacific.

6. Data Archive

All of the raw and processed data from the KH-11-7 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

References:

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10.8. Cadmium concentration & isotopic compositions in the North Pacific Ocean.

1. Personnel

Cheryl Zurbrick

A. Russell Flegal (on-land, University of California Santa Cruz)

2. Introduction and objectives

Cadmium concentrations in seawater have been used as a paleoproxy of ocean nutrient distributions (e.g., Ca/Cd)¹. With the recent advent of high resolution multi-collector inductively coupled plasma – mass spectrometry (MC-ICP-MS), cadmium isotopic composition measurements of seawater are now possible. But there are still only two depth profiles of cadmium isotopic ratios in the North Pacific Ocean², which is not enough to put together a comprehensive picture of cadmium isotope biogeochemistry in those waters. Therefore, we propose to address the applicability of cadmium isotopic ratios to investigate the sources and cycling of cadmium in the North Pacific Ocean with analyses of samples

collected during the KH-11-7 cruise.

Our objectives for this cruise are to (1) measure cadmium isotopic ratios in several vertical profiles, (2) compare those data with those of the two published profiles², and (3) synthesize all of those measurements with data obtained from comparable shallow depth profiles (>1000 m) in the northwest Pacific Ocean.

3. Inventory information for the sampling

Table. 1. A list of sampled seawater volume and depths at each site. Exact location of each station can be seen in Sec 6 and 9 in this cruise report.

| Sampling Depth | TR16 (K2) | KNOT (Cancelled) | TR15 (K1, GP10N1) | TR13 (GP10N2) | TR11 (GP10N3) | TR07 (GP10N4') |
|----------------|-----------|------------------|-------------------|---------------|---------------|----------------|
| 20 | 2+2+2 | | 2+2+2 | 2 | 2+2+2 | 2+2+2 |
| 100 | 2 | | 2 | | 2 | 2 |
| 200 | 2 | | 2 | | 2 | 2 |
| 300 | 2 | | 2 | | 2 | 2 |
| 600 | 2 | | 2 | | 2 | 2 |
| 1000 | 2 | | 2 | | 2 | 2 |
| 1500 | 2 | | 2 | | 2 | 2 |
| 2000 | 2+1 | | 2 | | 2 | 2+1 |
| 3000 | 2+1 | | 2 | | 2 | 2+1 |
| 4000 | 2+1 | | 2 | | 2 | 2+1 |
| 5000 | 2+1 | | 2 | | 2 | 2+1 |

4. Analysis and method

Seawater samples were collected using trace metal clean techniques in acid-cleaned 2 L LDPE bottles. All samples will be acidified to pH 1.8 with high purity (sub-boiling quartz distilled) HCl upon return to UCSC.

Cadmium concentrations and isotopic compositions (¹¹⁰Cd, ¹¹¹Cd, ¹¹²Cd, ¹¹³Cd and ¹¹⁴Cd) will be measured using a chelating resin direct flow injection on a Thermo Element

XR inductively coupled plasma mass spectrometer (ICP-MS) operated in magnetic sector mode³. These measurements will be made after a three step off-line chelating resin extraction method, with 0.5 to 6 L of seawater based on the cadmium concentration in the sample⁴. Samples will be extracted in 1.5 mL of high purity 0.1 M HNO₃ (sub-boiling quartz distilled) with a variable final concentration (at least 10 ppb). These samples will be analyzed on a Finnigan Neptune MC-ICP-MS (Thermo Fisher Scientific), using methods adapted from Ripperger and Rehkamper². As part of the GEOTRACES intercalibration effort, reference material NIST 3108 and two seawater samples (GSI and GDI) will be analyzed concurrently.

5. Anticipated results and work plan

These data will be combined with data from ongoing investigations of cadmium concentrations and isotopic compositions in the northwest Pacific Ocean and compared with cadmium isotopic data obtained on the fourth Intergovernmental Oceanographic Commissions cruise from Tokyo to Hawaii in 2002.

6. Data Archive

All of the raw and processed data from the KH-11-7 cruise will follow the general rules of (1) the Atmosphere and Ocean Research Institute (AORI), (2) the University of Tokyo, and (3) GEOTRACES data policy.

References:

¹Rickaby, R.E.M. and H. Elderfield. 1999. Planktonic foraminiferal Cd/Ca: Paleonutrients or Paleotemperature? *Paleoceanography*. 14: 293- 303.

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³Ndung'u, K., R. P. Franks, K. W. Bruland and A. R. Flegal. 2003. Organic complexation and total dissolved trace metal analysis in estuarine waters: comparison of solvent-extraction graphite furnace atomic absorption spectrometric and chelating resin flow injection inductively coupled plasma-mass spectrometric analysis. *Analytica Chimica Acta* 481, 127-138.

⁴Ripperger, S., M. Rehkamper, D. Porcelli, and A.N. Halliday. 2007. Cadmium isotope fractionation in seawater- A signature of biological activity. Earth and Planetary Science Letters. 261: 670 – 684.

10.9. Elemental and isotopic composition of trace metals and phytoplankton community structures

1. Personnel

Tung-Yuan Ho (on-land, Academia Sinica)

Hsu-Han Yang (Academia Sinica)

Shun-Chung Yang (Academia Sinica)

2. Objectives

The major research topics include: trace metal elemental composition in suspended particles, trace metal isotopic composition in suspended particles and seawater, and phytoplankton community structure.

a) Trace metal elemental composition in suspended particles

We will determine the elemental composition of Al, P, Si, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd, Pb, Th, and U in the suspended particles.

b) Trace metal isotopic composition in suspended particles and seawater

We will determine the isotopic composition of Cd, Zn, Ni and Fe in the seawater and suspended particles.

c) Phytoplankton community structure by pigment concentration

We will analyze the phytoplankton composition in the oligotrophic, HNLC and productive regions region..

3. Sampling and Method

The suspended particles were collected by using 0.45 μ m and 0.20 μ m online acid-washed 47 mm polycarbonate filters in the clean room. Dissolved trace metal samples were collected by filtering seawater through acid-washed Acropak capsules. The filter samples will be digested with HNO₃ and HF by microwave-assisted method then be determined by HR-ICPMS in our laboratory. For trace metal isotopic composition analysis in both seawater and particles, the trace metals will be purified through various column separation methods then will be determined by using MC-ICPMS with

double spike method. For pigment samples, 2.5 liters of seawater were gently pressure-filtered (<100 mmHg) through 47 mm Whatman GF/F filters and were kept frozen at -20°C onboard. The pigment samples will be extracted with 90% acetone and analyzed by HPLC in laboratory.

4. Anticipated results and work plan

We expect to publish at least 3 papers through this study. The analysis of elemental composition and pigment samples are expected to be done in 3 months. The analysis of isotopic composition may take 1-2 years or even longer time to finish due to the time-consuming steps for column chemistry.

5. Data Archive

We will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Archive Policy.

3. Sample information

| Station | Items | 10 | 20 | 40 | 75 | 100 | 150 | 200 | 300 | 500 | 700 | 1000 | 1500 | 2000 | 2500 |
|---------|-------------------|----|----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|
| KE3 | particle | Y | Y | Y | Y | Y | Y | Y | Y | | Y | Y | | Y | |
| | dissolved | | | | | | | | | | | | | | |
| | pigment | Y | Y | Y | Y | Y | Y | Y | | | | | | | |
| KE2 | particle | | | | | | | | | | | | | | |
| | dissolved | | | | | | | | | | | | | | |
| | pigment | Y | Y | Y | Y | Y | Y | Y | | | | | | | |
| KE1 | particle | | | | | | | | | | | | | | |
| | dissolved | | | | | | | | | | | | | | |
| | pigment | Y | Y | Y | Y | Y | Y | Y | | | | | | | |
| SHY3 | particle | | | | | | | | | | | | | | |
| | dissolved | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| | pigment | | | | | | | | | | | | | | |
| TR7 | Clean-cast | 20 | 50 | 100 | 150 | 200 | 300 | 400 | 600 | 800 | 1000 | 2000 | 3000 | 4000 | 5000 |
| | particle | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |

| | | | | | | | | | | | | | | | |
|------|--------------------|------------|----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|
| | dissolved | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| | pigment | | | | | | | | | | | | | | |
| | Clean-cast | Botto m | | | | | | | | | | | | | |
| | particle | Y | | | | | | | | | | | | | |
| | dissolved | Y | | | | | | | | | | | | | |
| | pigment | | | | | | | | | | | | | | |
| | Normal-cast | 10 | 20 | 40 | 75 | 100 | 150 | 200 | | | | | | | |
| | particle | | | | | | | | | | | | | | |
| | dissolved | Y | Y | Y | Y | Y | Y | Y | | | | | | | |
| | pigment | Y | Y | Y | Y | Y | Y | Y | | | | | | | |
| TR8 | Normal | 5 | 10 | 20 | 40 | 75 | 100 | 150 | 200 | | | | | | |
| | particle | | | | | | | | | | | | | | |
| | dissolved | | | | | | | | | | | | | | |
| | pigment | Y | Y | Y | Y | Y | Y | Y | Y | | | | | | |
| TR9 | Normal | 5 | 10 | 20 | 40 | 75 | 100 | 150 | 200 | 300 | 500 | 700 | 1000 | 2000 | |
| | particle | | | | | | | | | | | | | | |
| | dissolved | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | |
| | pigment | Y | Y | Y | Y | Y | Y | Y | Y | | | | | | |
| TR10 | Normal | 5 | 10 | 20 | 40 | 75 | 100 | 150 | 200 | 300 | 500 | 700 | 1000 | 2000 | |
| | particle | | | | | | | | | | | | | | |
| | dissolved | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | |
| | pigment | Y | Y | Y | Y | Y | Y | Y | Y | | | | | | |
| TR11 | Clean-cast | 20 | 50 | 100 | 150 | 200 | 300 | 400 | 600 | 800 | 1000 | 2000 | 3000 | 3500 | 4000 |
| | particle | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| | dissolved | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| | pigment | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | |
|------|--------------------|------------|------------|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|
| | Clean-cast | 5000 | Botto m | | | | | | | | | | | | |
| | particle | Y | Y | | | | | | | | | | | | |
| | dissolved | Y | Y | | | | | | | | | | | | |
| | pigment | | | | | | | | | | | | | | |
| | Normal-cast | 10 | 20 | 40 | 75 | 100 | 150 | 200 | | | | | | | |
| | particle | | | | | | | | | | | | | | |
| | dissolved | Y | Y | Y | Y | Y | Y | | | | | | | | |
| | pigment | Y | Y | Y | Y | Y | Y | Y | | | | | | | |
| TR12 | Normal | 5 | 10 | 20 | 30 | 50 | 75 | 100 | 150 | 200 | | | | | |
| | particle | | | | | | | | | | | | | | |
| | dissolved | | | | | | | | | | | | | | |
| | pigment | Y | Y | Y | Y | Y | Y | Y | Y | Y | | | | | |
| TR13 | Clean-cast | 20 | 50 | 100 | 150 | 200 | 300 | 400 | 600 | 800 | 1000 | 2000 | 3000 | 4000 | 5000 |
| | particle | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| | dissolved | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| | pigment | | | | | | | | | | | | | | |
| | Clean-cast | Botto m | | | | | | | | | | | | | |
| | particle | Y | | | | | | | | | | | | | |
| | dissolved | Y | | | | | | | | | | | | | |
| | pigment | | | | | | | | | | | | | | |
| | Normal-cast | 5 | 10 | 20 | 40 | 75 | 100 | 150 | 200 | | | | | | |
| | particle | | | | | | | | | | | | | | |
| | dissolved | Y | | Y | Y | Y | Y | Y | Y | | | | | | |
| | pigment | Y | Y | Y | Y | Y | Y | Y | Y | | | | | | |

| | | | | | | | | | | | | | | | |
|------|--------------------|----|----|-----|-----|-----|-----|-----|-----|-----|------|------|--------|--------|--|
| TR14 | Normal | 5 | 10 | 20 | 30 | 50 | 75 | 100 | 150 | 200 | | | | | |
| | particle | | | | | | | | | | | | | | |
| | dissolved | | | | | | | | | | | | | | |
| | pigment | Y | Y | Y | Y | Y | Y | Y | Y | Y | | | | | |
| TR15 | Clean-cast | 20 | 50 | 100 | 150 | 200 | 300 | 400 | 600 | 800 | 1000 | 3000 | Bottom | | |
| | particle | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | | |
| | dissolved | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | | |
| | pigment | | | | | | | | | | | | | | |
| | Normal-cast | 5 | 10 | 20 | 30 | 40 | 50 | 75 | 100 | 150 | 200 | | | | |
| | particle | | | | | | | | | | | | | | |
| | dissolved | | Y | Y | Y | Y | | Y | | | | | | | |
| | pigment | Y | Y | Y | Y | | Y | Y | Y | Y | Y | | | | |
| TR16 | Clean-cast | 20 | 50 | 100 | 150 | 200 | 300 | 400 | 600 | 800 | 1000 | 3000 | 5000 | Bottom | |
| | particle | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | |
| | dissolved | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | |
| | pigment | | | | | | | | | | | | | | |
| | Normal-cast | 5 | 10 | 20 | 30 | 50 | 75 | 100 | 150 | 200 | | | | | |
| | particle | | | | | | | | | | | | | | |
| | dissolved | | Y | Y | Y | Y | Y | | | | | | | | |
| | pigment | Y | Y | Y | Y | Y | Y | Y | Y | Y | | | | | |

10.10.1. Anthropogenic radionuclide in the ocean: Feasibility using ^{236}U and ^{135}Cs to construct the circulation of seawater

1. Personnel

Akinobu Kadokura (Hiroshima University)

Haruka Chiga (Hiroshima University)

Aya Sakaguchi (Hiroshima University)

2. Introduction and objectives

Recently, the uranium isotope ^{236}U ($T_{1/2} = 2.342 \times 10^7$ y, α -decay) and cesium isotope ^{135}Cs ($T_{1/2} = 2.3 \times 10^6$ y) has been recognized as one of the environmental radionuclide due to the development of instruments and measuring techniques of sufficient abundance sensitivity, and applications which use ^{236}U and ^{135}Cs as a proxy/tool for environmental and geochemical radionuclide studies are developing. The occurrence of ^{236}U and ^{135}Cs on the surface of the earth is mainly due to the global fallout, which is produced by atomicbombs as $^{235}\text{U}(n, \gamma)^{236}\text{U}$ reaction and fission of fissionable material such as U and Pu. After adding to the ocean from atmosphere, ^{236}U and ^{135}Cs might behave as a conservative (dissolved) element in sea water, and can be a useful tracer of water-mass movement. The final aims of this study are to measure the concentration of ^{236}U and ^{135}Cs in sea water samples, and to discuss the marine processes for transporting ^{236}U and ^{135}Cs together with other classically measured anthropogenic radionuclides such as (^{137}Cs) and Pu isotopes ($^{239,240}\text{Pu}$) to serve as an aid to clear the water circulation of ocean. In this cruise, some depths of seawater samples were taken in north pacific Ocean to compare with vertical distribution and concentration level of anthropogenic nuclides in the Japan Sea.

3. Inventory information for the sampling

The large volume sea water samples (50 L and 20 L) were taken at sampling stations TR4 and TR13. The depths of sampling are below: 20, 100, 500, 1000, 1500, 2000 and bottom at TR4 and 20, 100, 500, 1000, 1500, 2000, 3000, 4000, 5000 and bottom at TR13 by using Niskin-bottle. The water sample is putted into container directly after 3 times rinsing. The surface sediment core samples (8 cm in diameter, 5 cm in the length of core) were also collected at TR4 with multiple-corer. The sediments are cut into 1 cm segments from the surface of core and packed into plastic pack.

4. Analysis and method

About 50 or 20 L of water samples were filtered through 0.45 μm pore size membrane filter by using a pressured pump on the ship. The suspended solid (SS) on the filter is decomposed with $\text{HNO}_3\text{-HF-HClO}_4$ mix acid. The known amount of Cs carrier (^{133}Cs) and ^{233}U - ^{242}Pu mix spike is added to SS decomposed solution and acidified sea water sample. Cs is determined with α -spectrometry by using Ge semiconducting detector after removing

the interference nuclide, K-40, from the sample with ammonium molybdenum phosphate (AMP) and packed into sample tube. U and Pu isotopes are measured by using accelerator mass spectrometry (AMS) after purify these isotopes ($^{239}, ^{240}\text{Pu}$) from the sample and made the target for AMS. These details of chemical separations and measurements are given in Nakano (2008) and Sakaguchi et al. (2004 and 2009). The sediment sample is dried and leached with 10 M HCl on hotplate for 3 hours with occasional shaking. After centrifugation, U, Pu and Cs are purified from the solution fraction with above method and measured with same manner as water sample. As for ^{135}Cs measurement, the appropriate method for the measurement will be developed.

5. Anticipated results and work plan

We are planning to compare the result of vertical distribution of anthropogenic nuclides in North Pacific Ocean that are obtained from this cruise with data which is obtained from past work in the Japan Sea. It is expected to become clear the variation of anthropogenic nuclides in the Japan Sea from outer sea from this work.

6. Data Archive

All of the raw and processed data from the KH-11-7 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

10.10.2. Anthropogenic radionuclide in the seawater: offshore area of Fukushima dai-ichi nuclear power plant

1. Personnel

Akinobu Kadokura (Hiroshima University)

Haruka Chiga (Hiroshima University)

Aya Sakaguchi (on-land, Hiroshima University)

2. Introduction

By accident of Fukushima Dai-ichi nuclear power plants in the Great Tohoku-Kanto Earthquake struck on 11/March/2011, large amounts of volatile radionuclides such as ^{131}I , ^{134}Cs and ^{137}Cs has been dispersed to atmosphere, and deposited to surface soil and ocean. Furthermore, artificial radionuclides have been introduced from the broken of drain pipes

through aqueous medium. However, we have never known the situation of radionuclide contamination including components of fuel such as U and Pu isotopes in ocean around Fukushima area. To serve as an aid to search and predict the fate of artificial radionuclides released into ocean, U, Pu isotopes and ^{137}Cs should be measured as representatives for conservative/non-conservative nuclides in the ocean. The result obtained here might contribute to not only environmental science including ecology, fisheries and environmental preservation, but also oceanology/geochemistry..

3. Sampling

The large volume sea water samples (20 L) were taken at sampling stations TR23, TR24, TR25 and surface sea water samples are taken at some area while the ship is moving (Table. 1). The depths of sampling are below: 0, 10, 20, 50, 100, 300, 500, 700, 1000 m at TR23 by using Niskin-bottle. Furthermore. The water sample is putted into container directly after 3 times rinsing.

Table. 1. A list of sampling point of surface sea water taken.

| Sampling site | Latitude | Longitude |
|---------------|-----------|------------|
| FSK1 | N37-27.47 | E141-55.70 |
| FSK2 | N37-09.70 | E141-32.29 |
| FSK3 | N36-55.40 | E140-53.11 |
| FSK4 | N37-04.03 | E141-50.26 |
| FSK5 | N36-14.41 | E141-29.66 |
| FS2 | N37-00.00 | E142.00.00 |
| ES2 | N37.04.00 | E142.15.00 |

4. Analysis

About 20 L of water samples were filtered through 0.45 μm pore size membrane filter by using a pressured pump on the ship. The suspended solid (SS) on the filter is decomposed with $\text{HNO}_3\text{-HF-HClO}_4$ mix acid. The known amount of Cs carrier (^{133}Cs) and $^{233}\text{U}\text{-}^{242}\text{Pu}$ mix spike is added to SS decomposed solution and acidified sea water sample. Cs is determined with γ -spectrometry by using Ge semiconducting detector after removing the interference nuclide, K-40, from the sample with ammonium molybdenum phosphate (AMP) and packed into sample tube. U and Pu isotopes are measured by using accelerator mass spectrometry (AMS) after purify these isotopes ($^{239}, ^{240}\text{Pu}$) from the sample and made the target for AMS.

These details of chemical separations and measurements are given in Nakano (2008) and Sakaguchi et al. (2004 and 2009). The sediment sample is dried and leached with 10 M HCl on hotplate for 3 hours with occasional shaking. After centrifugation, U, Pu and Cs are purified from the solution fraction with above method and measured with same manner as water sample.

10.12. Measurements of volatile organic compounds in surface seawater

1. Personnel

Atsushi Ooki (Hokkaido University)

Yoko Yokouchi (on-land, National Institute for Environmental Studies)

2. Introduction and Objective

Various volatile organic compounds (VOCs) such as halocarbons and sulfur-containing compounds are emitted from the ocean surface into the atmosphere, and are believed to have substantial effects on the atmosphere. The partial pressures of VOCs were measured in the air of the marine boundary layer and in surface seawater during the cruise (KH-11-7). We collected seawater samples by CTD observation, and measured depth profile of VOCs concentrations.

3. Inventory information for the sampling

Under-way : Surface seawater sampling : 2011 7/17 – 8/1

Outside air sampling : 2011 7/17 – 8/1

Depth profile

Sampling stations : TR-7, TR-11, TR-13, TR-15

Sampling layers : 0, 5, 10, 20, 30, 40, 50, 75, 100, 125, 150, 200, 250 m

4. Analysis and method

Surface seawater was continuously pumped from a seawater intake on the bottom of the ship (5-m depth), and supplied to the laboratory (Pump seawater for research). Discrete seawater samples were taken from Niskin bottles on CTD/carousel sampler and from a bucket for surface seawater (0 m depth). The surface seawater was continuously supplied to a silicone membrane tube equilibrator at a flow rate of 20 L min⁻¹. Pure air was continuously supplied to the silicone tubes at a flow rate of 25 mL min⁻¹, regulating the inner

pressure to +0.14 MPa. The gas-phase sample of VOCs at equilibrium with the seawater could be obtained from the outlet of the silicone tube. The gas phase sample was dehumidified by means of Nafion[®] dryer and then transferred to a pre-concentration/GC-MS system. Discrete seawater samples were collected from Niskin bottle for depth profile measurement. Dissolved VOCs were obtained by Purge & Trap method. Partial pressures of CH₃Cl, CHClF₂, CCl₃F, C₂H₂F₄, CCl₂F₂, CH₂Br₂, CHCl₃, C₂Cl₄, CH₂Cl₂, C₂H₅I, CH₃I, CH₂ClI, CHBr₃, C₅H₈, COS, and CH₃Br in the sample were measured at 70 min intervals. A gravimetrically prepared standard gas (Taiyo Nissan, Inc., Tokyo) containing these chemical species at concentrations of 100–500 pptv was quantified according to the same procedures. The detection limits (S/N = 3) were .1–1 pptv for all species.

5. Results

Figure 1 shows the partial pressures (in patm) of CHBr₃ and CH₂Br₂ in surface seawater along 165°E line. High levels of these compounds were found in the Oyashio-Kuroshio mixed water region (35–42°N), apparently due to the influence of phytoplankton production. Figure 2 shows the depth profiles of CHBr₃ and CH₂Br₂ concentrations (in pmol l⁻¹). Concentration maximums were found in the sub-surface layer of the subtropical water (30°N) and the mixed water (40°N).

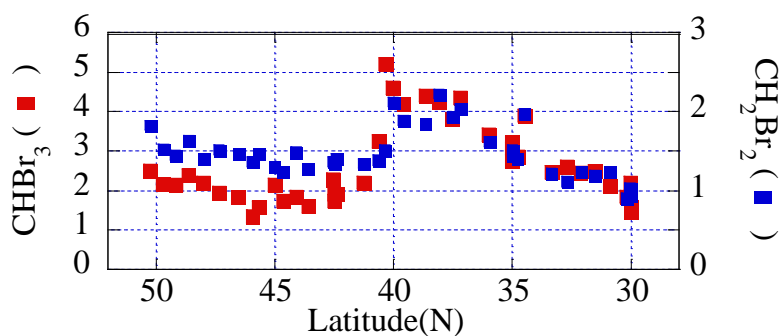


Figure 1 Partial pressures (patm) in surface seawater

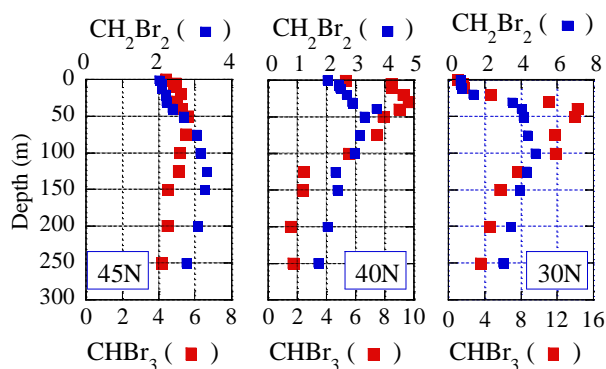


Figure 2 Depth profile of molar concentrations (pmol l⁻¹)

Note: These data need further calibrations.

10.13 Sample collection for measurement of PFCs during the cruise, KH-11-7 in the Northwestern Pacific Ocean

1. Personnel

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2. Introduction and objectives

Environmentally persistent perfluorinated acids (PFAs, shown in Figure 1) have appeared as a new class of global pollutants for the last ten years. These compounds in general, and perfluorooctane sulfonate (PFOS) in particular, have recently emerged as a priority environmental pollutant due to its widespread finding in biota including both Arctic and Antarctic species and its persistent and bioaccumulative nature. The physicochemical properties of PFAs are unique in that they have high water solubility despite the low reactivity of carbon-fluorine bond, which also imparts high stability in the environment. However, little is known on the distribution of PFAs in open oceans around the world, so far. We have conducted several international joint cruises, including South China Sea and Sulu Seas (KH02-4), the central to Eastern Pacific Ocean (KH03-1), North and middle Atlantic Ocean, Southern Pacific and Antarctic Ocean (KH04-5), Labrador Sea and coastal seawater from Asian countries (Japan, China, Hong Kong, Korea) (1-3) and Japan Sea and the Northwestern Pacific Ocean (KH10-2). Vertical profiles of PFAs in the marine water column were associated with the global ocean circulation theory. We found that vertical profiles of PFAs in water columns from the Labrador Sea reflected the influx of the North Atlantic Current in surface waters, the Labrador Current in subsurface waters, and the Denmark Strait Overflow Water in deep layers below 2000 m. Striking differences in the vertical and spatial distribution of PFAs, depending on the oceans, suggest that these persistent organic acids can serve as useful chemical tracers to allow us to study oceanic transportation by

major water currents. The results provide evidence that PFA concentrations and profiles in the oceans adhere to a pattern consistent with the global “Broecker’s Conveyor Belt” theory (3) of open ocean water circulation (8).

This year is beginning of the project “Chemical Oceanography to Elucidate Global Kinetics of Persistent Perfluorinated Chemicals (PFCs): B-1106” funded by the Ministry of the Environment, Japan. KH11-7 is the second research cruise after KT-11-6 by Tansei Maru to collect world wide scale samples.

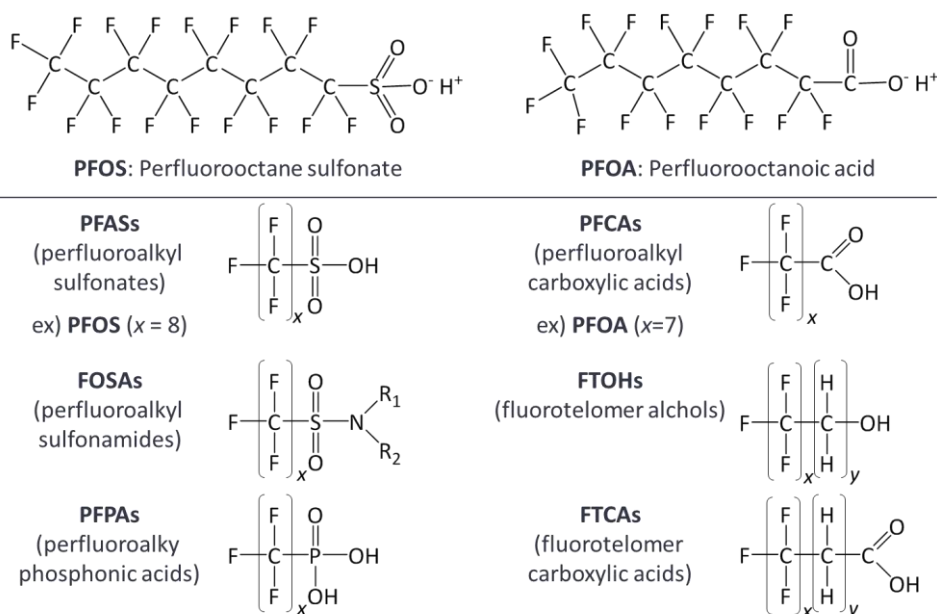


Figure 1. PFOS and related chemicals

3. Inventory information for the sampling

Seawater samples were taken by Conductivity temperature depth profiler-Carousel multiple sampling system (CTD-CMS) attached Niskin samplers of 12 L at twenty sampling stations (TR1-4, TR7, TR9, TR11, TR13, TR15-TR26, see detail in Table 1), and surface seawater samples were taken by stainless bucket from all CTD station. Sediment core samples were taken by multiple corer at station at eight sampling location (TR4, TR17-TR19, TR21, TR23, TR24 and T26). Each sediment core was sectioned for 1-5 cm segments using a stainless steel slicer. Two event of precipitation samples were collected using rain sampler with 1000cm² stainless funnel between TR9 and TR10, TR13-TR14.

Water, sediment and precipitation samples were stored at below -20°C until chemical analysis in AIST laboratory.

Table 1 CTD sampling locations

| Depth [m] | TR1 | TR2 | TR3 | TR4 | TR7 | TR9 | TR11 | TR13 | TR15 | TR16 | TR17 | TR18 | TR19 | TR20 | TR21 | TR22 | TR23 | TR24 | TR25 | TR26 |
|------------|-----|-----|------|-----|-----|-----|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 0 | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L |
| 10 | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L |
| 50 | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L |
| 75 | | | | | | | | | | | 1L | | | | | | | | | |
| 100 | 1L | 1L | 0.7L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L |
| 125 | | | 1L | | | | | | | | | | | | | | | | | |
| 150 | | | | | | | | | | | 1L | | | | | | | | | |
| 200 | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | | | | | | 1L | 1L | 1L | 1L |
| 250 | | | | | | | | | | | | 1L | 1L | | | | | | | |
| 300 | 1L | 1L | | | 1L | 1L | 1L | 1L | 1L | 1L | 1L | | | | | | 1L | 1L | 1L | 1L |
| 400 | | | | | | | | | | | | 1L | 1L | 1L | 1L | 1L | | | | |
| 500 | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | | | | | | 1L | 1L | 1L | 1L |
| 600 | | | | | | | | | | | 1L | 1L | 1L | | | | | | | |
| 700 | | | | | | | | | | | | | | | | | 1L | 1L | 1L | 1L |
| 800 | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | | | | |
| 1000 | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | | 1L | 1L | 1L |
| 1250 | | | | | | | | | | | | 1L | | | | | | | | |
| 1500 | 1L | 1L | 1L | | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | | 1L | 1L | | | 1L | | |
| 2000 | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | | | 1L | | |
| 2500 | | | | | | | | | | | | | | | | | | | | |
| 3000 | | | | | 1L | | 1L | 1L | 1L | 1L | 1L | 1L | 1L | | | | | | | |
| 3600 | | | | | | | | | | | | | 1L | | | | | | | |
| 4000 | | | | | 1L | | 1L | 1L | 1L | 1L | 1L | 1L | | | | | | | | |
| 4500 | | | | | | | | | | | | | | | | | | | | |
| 5000 | | | | | 1L | | 1L | 1L | | | 1L | | | | | | | | | |
| 6000 | | | | | | | | | | | 1L | | | | | | | | | |
| Bottom-250 | | | | | | | | | | | | | | | 1L | | | | | |
| Bottom-300 | | | | | | | | | | | | 1L | | 1L | | | | | | |
| Bottom | | | | | 1L | | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L | 1L |
| ChIMax | | | | 1L | 1L | 1L | | 1L | 1L | 1L | | 1L | 1L | | 1L | | | | | |

4. Analysis and method

Chemical analysis: Water samples are stored in clean 1 L polypropylene bottles and are kept frozen until analysis. Samples are thawed at room temperature, and a solid phase extraction method using OASIS®WAX cartridge (Waters Co.) is used for the determination of PFAs by HPLC tandem mass spectrometry (HPLC-MS/MS) as described elsewhere (4,5). Briefly, after preconditioning with 4 mL ammonium hydroxide in methanol, 4 mL methanol, and then 4 mL Millipore water, the cartridges were loaded with 900-1000 mL samples at approximately 1 drop sec⁻¹. The cartridges were then washed with 4 mL of 25 mM ammonium acetate buffer (pH 4) in Millipore water and dried by centrifugation at 3000rpm for 2 min. The elution was then divided into two fractions. The first fraction is carried out with 4 mL methanol and the second with 4 mL 0.1% ammonium hydroxide in methanol. Both fractions were reduced to 0.5 mL under a nitrogen stream and analyzed separately. HPLC-MS/MS, composed of a HP1100 liquid chromatograph (Agilent Technologies, Palo Alto, CA) interfaced with a Micromass® (Beverly, MA) Quattro Ultima Pt mass spectrometer is operated in the electrospray negative ionization mode. A 10- μ L aliquot of the sample extract is injected into a Betasil C18 column (2.1 mm i.d. \times 50 mm length, 5 μ m; Termo Hypersil-Keystone, Bellefonte, PA). The capillary is held at 1.2 kV. Cone-gas and desolvation-gas flows are kept at 60 and 650 L/h, respectively. Source and desolvation temperatures are kept at 120 and 420°C respectively. MS/MS parameters are optimized so as to transmit the [M-K]⁻ or [M-H]⁻ ions.

QAQC (Quality assurance and quality control): More than two hundreds of PFOS related chemicals were discussed for international regulation of use, namely Stockholm convention agreement (POPs; persistent organic pollutants) in 2008 because of potential risk to the environment and human being. Finally, PFOS and PFOSF were added to a list of international regulation in May 2009. Because of serious worldwide concern about PFOS, strong necessity to establish reliable standard operation procedure (SOP) was indicated. Hence, analytical method developed by AIST was validated by International Organization of Standard (ISO) and proved its reliability. This was successfully published as ISO25101 in 2009 (6). National standard, namely Japanese Industrial Standard (JIS) was also established after ISO25101 as JIS K 0450-70-1 in 2011 (7).

KH11-7 is the third international research cruise that conducted measurement of POPs in Open ocean waters using ISO method (ISO25101) after KH09-5 and KH10-2. Because

of recent scene of analytical chemistry, uncertainty and reliability of measurement supported by suitable QAQC is becoming to the essential issue. Our experimental result with ISO 25101 supported by the international QAQC (ISO17025 with Guide45) and Japanese Industrial Standard (JIS K 0450-70-1) provides the most reliable information of environmental chemistry in Open ocean research for now.

5. Anticipated results and work plan

Although everybody knows that the marine environment is three-dimensional, very few studies have investigated POPs including PFAs in deep sea water column. In Figure 2, concentrations of PFOS and PFOA in two water-column samples collected from South Pacific Ocean in KH04-5 (0-3730 m at 67°12'S 172°40'W, 0-5400 m at m at 50°01'S 169°59'W) were presented (modified from original figure by Yamashita, Concentrations of PFAs were consistently low (<10 pg/L) or below the limit of detection, from surface to bottom. These water columns are samplings of ocean currents that are more than 1000 years old, in terms of global circulation, as well as surface coastal streams derived from Antarctic circumpolar waters. Despite the fact that PO1 and PO2 are different masses of water, as evidenced by differences in the temperature and salinity profiles between PO1 and PO2, PFA concentration profiles were constant throughout both columns. Absence of PFAs in the water columns of the South Pacific Ocean showed that there is no direct input of PFAs to this remote region. Thus, the open ocean water in the South Pacific is less contaminated by PFAs than the water masses in other oceans. Vertical water samples collected in KH11-7 will provide current situation of PFAs in water column after five years.

We have collected twenty water column samples, eight sediment cores and two ocean precipitation samples during the cruise. The global circulation of ocean water and deep seawater might play a major role in scavenging of several POPs and therefore their role in the global fate of PFOS related chemicals must be examined to estimate the environmental destiny of persistent hazardous chemicals on our planet.

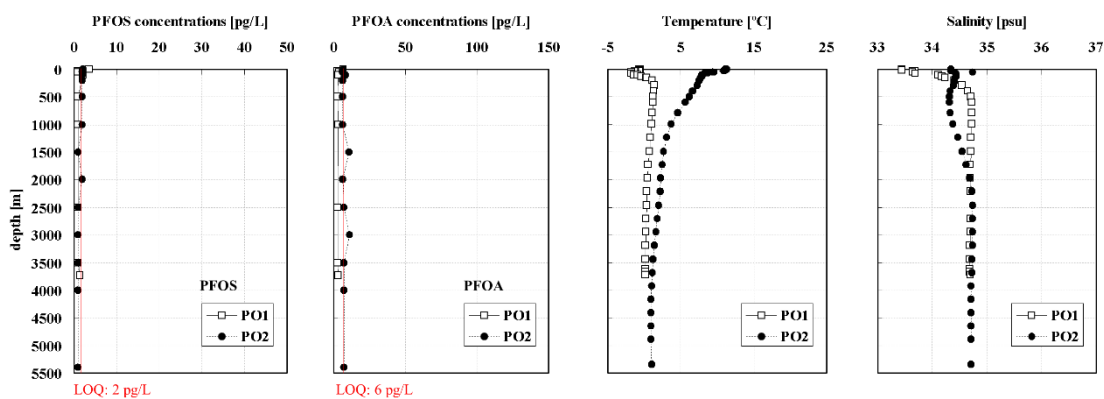


Figure 2. Concentrations of PFOS and PFOA in two water-column samples collected from South Pacific Ocean in KH04-5. (0-3730 m at 67°12'S 172°40'W, 0-5400 m at 50°01'S 169°59'W) (modified from original figure by Yamashita, Chemosphere 2008 (3)).

6. Data Archive

All of the raw and processed data from the KH-11-7 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

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- (6) ISO 25101 (2009 March 1st) Water quality — Determination of perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) — Method for unfiltered samples using solid phase extraction and liquid chromatography/mass spectrometry
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10.14. Density. (Tsurushima)

10.15. Chemical composition of atmospheric aerosol

1. Personnel

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Yuzuru NAKAGUCHI (on-land, Kinki University)

2. Introduction and objectives

Trace elements such as Fe, Cd, Ni, Cu, Zn and Co 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-11-07

cruise. The chemical composition and the origin of atmospheric aerosols are investigated by individual particle analysis with SEM-EDX and ICP-MS.

3. 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).

4. Analysis and method

Aerosol samples collected on the filters were preserved at 4 °C 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.

5. Data Archive

All of the raw and processed data from the KH-11-7 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

10.16. (Rei Ito, Hideki Minami)

10.17. Proxy-based reconstruction of water mass circulation in the Pacific: Fish teeth Nd isotopes and Cd/Ca of benthic foraminifera

1. Personnel

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Tomohiro Kodaira (Environmental Biology and Chemistry, Faculty of Science, University of Toyama)

2. Introduction and objectives

We have recently found that core-top fossil fish teeth Nd isotopes have a good correlation with dissolved phosphate content in the Pacific deep water (>2000 m depth).

The plot of Nd isotopes with phosphate represents a mixing envelope with southern-sourced (Lower Circumpolar Deep Water) and northern-sourced (North Pacific Deep Water) waters, and allows us to analyze basin-scale water mass circulation and water mass mixing in the Pacific (Horikawa et al., in press).

During this cruise, we obtained multiple core sediments from 3 sites on the Southern High of the Shatsky Rise. All three cores (18–30 cm long) are characterized by foram-bearing calcareous ooze, and the bottom of these sediment cores is expected to reach to the Last Glacial Maximum (LGM, 18–23 kyr ago) based on previous studies (Kawahata et al., 1999; Yamane, 2003). In this study, using the Shatsky Rise multiple core sediments and Pacific sediment samples we have, we will attempt to make time-sliced Nd isotope-phosphate (Cd/Ca-derived) plot, especially during the modern, the LGM and Heinrich periods.

For Nd isotopes, we will pick fossil fish teeth/debris from sediments of $>125\mu\text{m}$ fraction and measure their Nd isotopes, which have been shown to faithfully record bottom water values and used as a tracer that enable us to analyze the provenance of the water mass (Martin and Scher, 2004; Horikawa et al., in press). For phosphate, we will measure Cd/Ca of benthic foraminifer, regarded as a proxy of phosphate in bottom seawater. We expect that time-sliced Nd-phosphate plots can be used as a strict method for analyzing paleo-water mass structures and mixing in the Pacific.

3. Inventory information for the sampling

We obtained multiple core sediments from 3 sites (named TR-04MC, TR-05MC, and TR-06MC) on the Southern High of the Shatsky Rise. Detailed information on multi-corer sediments can be seen in Sec 8.2.5.

4. Analysis and method

We will pick fossil fish teeth/debris from sediments of $>125\mu\text{m}$ fraction and then physically clean the teeth/debris using ultrasonification in ultrapure water and methanol to remove sediment particles absorbed onto surfaces. These physically cleaned fish teeth/debris will be dissolved in a 1:1 mixture of optima grade concentrated HNO_3 and HCl in preparation for column chemistry. Bulk rare earth elements (REEs) are separated by a primary column with Mitsubishi resin and 1.7N HCl as an eluent. Nd is then isolated by passing the REEs aliquot through Ln-spec resin with 0.25N HCl as an eluent. Nd isotopes will be measured with VG54-30 TIMS and/or Neptune MC-ICP-MS.

Benthic foraminifera will be crushed first and then chemically cleaned according to “Boyle method”. The cleaned foraminifer samples will be dissolved in 2% optima grade HNO₃ with internal standards. Cd/Ca ratios of foraminifer aliquot will be determined by Element 2 SF-ICP-MS.

5. Anticipated results and work plan

To make time-sliced Nd isotope-phosphate (Cd/Ca-derived) plot during the LGM and Heinrich periods, we have gathered sediment samples widely distributed in the Pacific. We are planning to measure Nd isotopes and Cd/Ca-derived phosphate from at least 20 sites in the Pacific, and then make Nd-phosphate plots. Since the plot of core-top teeth Nd isotopes with dissolved phosphate produces a mixing envelope with southern-sourced (Lower Circumpolar Deep Water) and northern-sourced (North Pacific Deep Water) waters, we expect that proxy-based Nd isotope-phosphate plot will also be used for analyzing basin-scale water mass circulation and water mass mixing in the Pacific in the past.

6. Data Archive

All of the raw and processed data from the KH-11-7 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

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10.18. Reconstruction for glacial-deglacial change in the North Pacific deepwater properties

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The glacial Pacific Ocean had two water masses: well-ventilated and nutrient-depleted glacial North Pacific Intermediate Water (GNPIW) above ~2000 m and less-ventilated and nutrient-enriched deep water below ~2000 m (Keigwin, 1998; Matsumoto et al., 2002). GNPIW is a thicker and more deeply penetrating water mass than today's North Pacific Intermediate Water (NPIW). Major reorganization of ocean circulation occurred during Heinrich Event 1 (H1, 17,500 to 15,000 year B.P.) in the last deglacial period (McManus et al., 2004), which played an important role in global carbon cycle and climate change (Broecker and Barker, 2007). Our recent study suggested that deep water was formed in the North Pacific extending to a depth of ~2500 m during H1 (Okazaki et al., 2010). The main simulated pathway of deepwater spreading is along the western margin of the North Pacific, in a deep western boundary current analogous to the present one in the North Atlantic. However, our knowledge of paleo-deepwater properties, particularly in water deeper than 2000 m in the western North Pacific, is limited because of poor preservation of foraminiferal shells in sediment.

During KH11-7 Cruise of *R/V Hakuho-maru*, surface sediment cores were obtained from three sites with depth-transect ranging from 2300 m to 2900 m on the Shatsky Rise. These sediments were expected to reach last glacial period with abundant foraminiferal shells. Therefore, these cores have a great potential to reconstruct past deepwater properties by employing benthic foraminiferal stable carbon isotopes as commonly used nutrient proxy. I sliced the sediments at 0.5 cm intervals in order to reconstruct millennial scale deepwater changes during the last deglacial period. I plan to pick up benthic foraminiferal species after freeze dried and washing through 63 μm mesh screen on shore. I will measure stable carbon isotopes on selected several benthic foraminiferal species at core tops to confirm the relationship between seawater $\delta^{13}\text{C}$ and benthic foraminiferal $\delta^{13}\text{C}$. Then, I plan to downcore $\delta^{13}\text{C}$ analysis on selected benthic foraminiferal species to reconstruct deepwater nutrient concentration changes in the deep North Pacific during the last 20 kyrs.

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10.19. Spatial patterns of archaea and phytoplankton biomarkers in the Northwestern Pacific Ocean

1. Personnel

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Meixun (Max) Zhao (on-land, Ocean University of China)

2. Introduction and objectives

Recent studies have suggested that phytoplankton community structure in the open ocean is mostly controlled by productivity, with diatom dominating in high productivity areas and coccolithophorid dominating in low productivity areas. In addition, archaea have been suggested to play an important role in ocean carbon cycles but little is known about environmental controls on archaeal distribution in the ocean. The KH11-07 cruise covers a large productivity and environmental gradient in the Northwestern Pacific Ocean, and thus provides an excellent opportunity to further study the spatial distribution of archaea and phytoplankton and their relationship with ocean productivity and environment. Our aims include:

I: By analyzing the diatom, dinoflagellate and coccolithophorid biomarkers, to establish the relationship between primary productivities and phytoplankton community structures in the Northwestern Pacific Ocean.

II: To analyze archaeal biomarkers in the Northwestern Pacific Ocean, and to compare these results with those from marginal seas. To calibrate TEX₈₆ values against temperature for the application of the TEX₈₆ as paleothermometer in the Northwestern Pacific Ocean.

3. Inventory information for the sampling

1. Phytoplankton and archaeal biomarkers in particulates for the following:

1). Surface water particulates collected by using small pumps. The sample list as

below:

2). Particulates from DCM (depth of chlorophyll maximum), collected using CTD.

2. Phytoplankton and archaeal biomarkers, foraminiferal $\delta^{18}\text{O}$ and ^{14}C in sediments

Collect sediment samples using multicorer. The sampling list as below (Table 1):

Table 1 sampling list of particulates and sediments for archaea and phytoplankton biomarker analysis

| Official Stn. name | Alternative Stn. Name | Latitude | Longitude | Depth (m) | Chlorophyl-a Maximun Depth (m) | Surface POM | | Chl-a Maximun POM | | Multi-core | | |
|--------------------|-----------------------|-------------|--------------|-----------|--------------------------------|-------------|------------|-------------------|------------|------------|-------------|---------------|
| | | | | | | Sample | Volume (L) | Sample | Volume (L) | Sample | length (cm) | interval (cm) |
| TR01 | KE3 | 36°29.7377' | 143°02.0795' | 7653 | | √ | 330 | | | | | |
| TR02 | KE2 | 36°29.6974' | 145°00.1061' | 5446 | 30 | √ | 212 | √ | 61 | | | |
| TR03 | KE1 | 36°29.4301' | 150°00.4504' | 5864 | 85 | √ | 254 | √ | 72 | | | |
| TR04 | SHY3 | 32°00.2168' | 157°50.9280' | 2928 | 105 | √ | 456 | √ | 59 | √ | 27.5 | 0.5 |
| TR05 | SHY2 | 32°19.9088' | 157°51.0650' | 2616 | | √ | 414 | | | √ | 27 | 0.5 |
| TR06 | SHY1 | 32°33.4144' | 158°27.6619' | 2393 | | √ | 445 | | | √ | 17.5 | 0.5 |
| TR07 | GP10N4' | 29°59.9460' | 165°00.4896' | 5869 | 100 | √ | 715 | √ | 102 | | | |
| TR08 | GP10NS4' | 32°29.9605' | 165°00.1056' | 6193 | 75 | √ | 618 | √ | 111 | | | |
| TR09 | GP10NS4 | 34°59.9799' | 165°00.1512' | 5885 | 70 | √ | 528 | √ | 115 | | | |
| TR10 | GP10NS3 | 37°30.1646' | 165°00.0375' | 5321 | 60 | √ | 441 | √ | 118 | | | |
| TR11 | GP10N3 | 40°00.1562' | 165°00.2958' | 5449 | 30 | √ | 190 | √ | 115 | | | |
| TR12 | GP10NS2 | 42°30.2158' | 164°59.9757' | 5008 | 25 | √ | 160 | √ | 120 | | | |
| TR13 | GP10N2 | 44°59.5309' | 165°00.0828' | 5908 | 30 | √ | 400 | √ | 115 | | | |
| TR14 | GP10NS1 | 47°29.9172' | 164°59.8966' | 5890 | 60 | √ | 155 | √ | 115 | | | |
| TR15 | GP10N1(K1) | 50°59.9903' | 165°00.0205' | 4808 | 30 | √ | 188 | √ | 110 | | | |
| TR16 | K2 | 47°00.1117' | 160°02.7392' | 5222 | 30 | √ | 77 | √ | 117 | | | |
| TR17 | ES5 | 37°48.4489' | 143°52.3721' | 7039 | | √ | 269 | | | √ | 2.5 | 1.5 or 1 |
| TR18 | ES4 | 37°52.2230' | 143°34.4528' | 5237 | 48 | √ | 188 | √ | 30 | √ | 12 | 1 |
| TR19 | ES6 | 38°04.2588' | 143°27.6455' | 3957 | 22 | √ | 168 | √ | 47 | √ | 21 | 1 |
| TR21 | ES7 | 38°11.0878' | 143°31.1213' | 3936 | 28 | √ | 234 | √ | 61 | √ | 28 | 1 |
| TR23 | ES2 | 37°04.0407' | 142°14.8379' | 2124 | 32 | √ | 235 | √ | 72 | √ | 26 | 1 |
| TR25 | FS5 | 35°59.9032' | 141°19.9919' | 1186 | 28 | √ | 327 | √ | 61 | √ | 26 | 1 |

4. Analysis and method

Phytoplankton and archaeal biomarkers analysis

C₁₉ n-alkanol is added as internal standards to the freeze-dried sediment samples (~10 g) or POM filters, which are then extracted ultrasonically with a 3:1 mixture of dichloromethane and methanol four times. The combined extract is hydrolyzed in a KOH-MeOH solution and extracted centrifugally with hexane four times, then separated by silica gel chromatography into three fractions. The non-polarity fraction (mainly alkanes) is eluted by 8 ml hexane and the neutral lipid fraction is eluted by 12 ml 5% MeOH/dichloromethane (v/v) organic solvent, which contains phytoplankton and archaeal biomarkers.

Phytoplankton biomarkers are dried and derivatized with N,O-bis(trimethylsilyl)-trifluoroacetamide. A Thermo gas chromatograph-mass spectrometer (GCMS) is used for compound identification and an Agilent 6890N GC for quantification in both cases on an HP-1 capillary column (50 m × 0.32 μm × 0.17 μm) with hydrogen as carrier gas at a flow rate of 1.3 ml/minute.

Archaeal biomarkers are dried and analyzed by HPLC-MS.

Above analysis can only be carried on in the laboratory on land. During KH11-07 cruise, we are successful in finishing the sampling work.

5. Data Archive

All of the raw and processed data from the KH-11-7 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

10.20. Biogeochemical study of Fe(II) in the western North Pacific using an in-situ analyzer

1. Personnel

Shin Wakiyama, Hajime Obata (Marine Inorganic Chemistry Division, Ocean Research Institute, University of Tokyo)

Toshitaka Gamo (on land, Marine Inorganic Chemistry Division, Ocean Research Institute, University of Tokyo)

Kei Okamura (on land, Center for Advanced Marine Core Research, Kochi

University)

2. Introduction

Recently, the importance of iron on ocean primary production has been well known. Now the iron speciation is a main subject since the iron availability by phytoplankton depends on its speciation in seawater. Especially, Fe(II) is an important chemical species for iron acquisition by phytoplankton. However, the biogeochemical cycles of Fe(II) in the ocean are not well known yet because Fe(II) is easily oxidized in an oxic condition after sampling, which makes it difficult for us to determine Fe(II) in seawater. To solve these problems, we have developed a new method to determine Fe(II) in seawater using an in-situ chemical analyzer (GAMOS). During this cruise, we have investigated spatial variations of Fe(II) in the western North Pacific using the in-situ analyzer. We have also determined dissolved Fe(II) in seawater on board the ship by conventional luminol chemiluminescence method to compare the results by the in-situ analyzer.

3. Information for sampling

At the TR-7, 11, 13 and 15, we have deployed the GAMOS by using a titanium cable (No. 3 winch). We also collected seawater samples from the clean sampling system at the TR-7, 11, 13, 15 and 16.

4. Analytical methods

Conventional method

Seawater samples were collected by X-Niskin samplers installed on the CTD-CMS system. Samples were immediately filtered with 0.2 μ m cartridge filter (Acropak, Pall) in a "bubble". The seawater samples were injected to the flow analytical system (King and Lounsbury, 1995).

In-situ analytical method

The conventional luminol chemiluminescence method was adapted to an in-situ flow analytical system, GAMOS (Geochemical Anomalies Monitoring System; Okamura et al., 2001). Sample was taken into the system and mixed with luminol reagent by a peristaltic pump. The mixture was introduced to a photomultiplier in a pressure-compensated vessel, and the CL intensity was recorded in the system. The

device was lowered to a depth of 1000m, determining Fe(II) in seawater. After recovering the device onboard, we collected the Fe(II) data in the laboratory.

5. Results

At the TR-7, 13, 15 and 16, we have revealed vertical profiles of Fe(II) in seawater. At TR-7 and 15, we have also determined Fe(II) in seawater by using an in-situ analyzer successfully

6. Data Archive

All of the raw and processed data from the KH-11-7 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

10.21. Seabed disturbance above the seismogenic zone and tsunami sources area of the 2011 Tohoku-oki Earthquake along the East Japan margin of the Pacific

1. Personnel

Akira Takeuchi (University of Toyama)

Badalahu Bao (University of Toyama)

Yuko Furusawa (University of Toyama)

2. Introduction

The 11 March 2011 Tohoku District Taiheiyo-oki Earthquake (Tohoku-oki earthquake, hereafter) occurred on the mega thrust fault plane in the subduction zone of Pacific Plate beneath the Tohoku district of eastern Japan which belongs to North America Plate. The Tohoku-Oki Earthquake is one of repeated events which occur on the Japan Trench plate boundary off the eastern shore of northern Honshu. The moment magnitude (M_w) of this earthquake, 9.0, is one of five super-giant earthquakes occurred since AD 1900, although there is no written report of such a large earthquake in Japan since AD 1600. This event was large enough to generated 20-30 meter high tsunamis which have thoroughly washed away the coastal town and villages. We deeply express our special regret over the death and missing people reached about

twenty three thousand.

Several seismologists such as Ide *et al.* (2011) and Yagi (2011) claimed that the overriding plate, North America Plate, was thrown up or dynamically overshoot along the plate interface. Some subsea geodetic measurements before and after the giant event conducted by Japan Coast Guard and Tohoku University and depicted co-seismic dislocation by 24 and 31 m. Similarly, Fujiwara *et al.* (2011) compared the repeated 'before and after' swath bathymetry data on the same Multi-channelled seismic prospection lines acquired by JAMSTEC R/V Kairei KR99-08 and KR11-05 cruises.

These investigations leads a hypothesis that the lower portion performed the more remarkable disturbing phenomena and that the master décollement or the major backstop fault faulted at the time of the main shock rather than the upper spray faults did. Such a main shock was preceded by a foreshock sequence lasting two days. The largest of these was a M_w 7.3 earthquake on 9 March 2011 and the largest aftershock was a JMA magnitude M_{jma} 7.4 event on 7 April 2011. These large events might have caused severe disturbance on the landward trench slope due to surface rapture, strong vibration and translational displacement.

In order to solve the above important questions, we were included the Hakuho-maru cruise KH-11-07 to make a geomorphological and geological survey of the Tohoku-oki earthquake/tsunami source area. This cruise has conducted the 20 days investigation from Harumi, Tokyo Bay, on 16 July 2011 to Harumi on 4 August 2011.

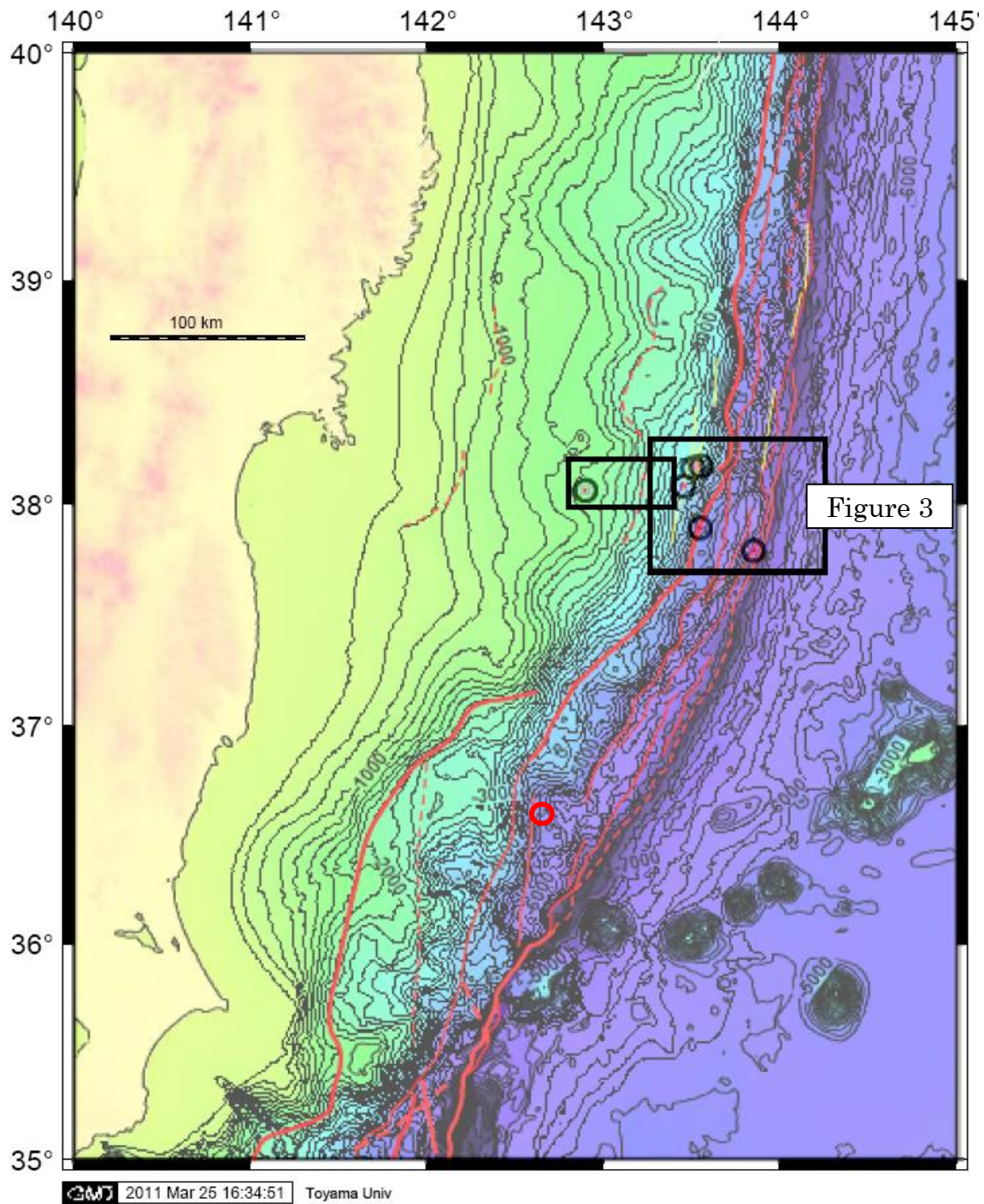


Figure 1. Index map for Earthquake Site during the Hakuho-maru cruise KH-11-07. Red lines indicate submarine active faults. Yellow circle denotes Site FS2.

3. Plans

3-1. Purposes and method of our research are as follows:

- (1) To detect geomorphological changes in bathymetric data before and after the giant earthquake, utilizing the multi-narrow beam echo sounder, SeaBeam 2120, equipped on the R/V Hakuho-maru.
- (2) To observe the seabed changes by means of the sub-bottom profiler, Bathy2000, equipped on the vessel.
- (3) To decipher and describe geological records of co-seismic events such as landslides and turbiditic mass movements utilizing both the mapping surveyor and the multiple core-sampler on this vessel.
- (4) To discuss comparative active tectonics, subductology and earthquake physics by integration of geophysics with material sciences related to lithosphere and its fault activity. Comparison with the both Pacific and Japan Sea sides of Honshu Archipelagoes is important to elucidate mechanism of earthquake generation in subduction zone.

3-2. System configuration of SeaBeam 2120

The Multi-narrow beam sounding system (MBES) mounted on R/V Hakuho-maru was a specially tuned model of SEABEAM 2120 series, utilizing 20 kHz of ultrasonic beams for highest resolution at around 4500 m in depth. Because the depth range of the observation surveys during KH-11-07 cruise was concentrated into 6000 m in the Pacific Basin and reached up to 7500 m in the Japan Trench, the swath width mode was set from the ordinary 120° mode to automatic 50 - 90° mode to eliminate noisy outer beams at depths larger than 4500 m.

This system operated at 0 dB, 90 degree auto-swath mode, where bathymetry data comprised 50 - 90 pings per beam, and average ping interval is 10 seconds. Cruising speed in the survey area 'Earthquake Station' was around 16 knots, where the depth resolution is theoretically estimated to be 70 - 80 m. Sound velocities of seawater were kept constant at the values used by the last cruise, which were calibrated with the references of previous measurements of XBT, XCDT and ARGO float for the sonic characteristics of seawater. The depth resolution of this MBES system was empirically checked more accurate than the above values by frequent multi-core samplings at bottom during the Cruise.

3-3. System configuration of Bathy2000

The BATHY-2000 system equipped on Hakuho-maru provides ordinary performance of bathymetric and sub-bottom survey capability from shallow waterways to full ocean depth ranging 2 - 12,000 m. The main part of this system is comprised of a 0-42 dB of 5-30 kW linear power transmitter and a 3.5 kHz transducer as well as 16 color, 1024x768 pixel display, 16 level grey shade thermal hardcopy. The other software for data storage and analyses runs simultaneously on a note PC, and we could download the digital data and electric copies of survey profiles.

During the KH-11-07 cruise the SBP system used to make profiles of surface sediments and geologic structure, and also to observe bottom condition for the multiple coring system.

4. Data

(1) Bathymetry: SEABEAM2120 Bathymetry data in MB44 format

Data period from 14 July-3 August, 2011

Processed data Map saved from the monitor display of 'Surveyor'

(2) Sub-bottom profiling: BATHY2000 Sub-Bottom Profiling data

Data period from 14 July-3 August, 2011

(3) Fluorescence meter on CTD system (for turbidity and chlorophyll-a):

(4) Lithology and stratigraphic information from Multiple core description:

TR17 through TR26

5. Results

On the basis of SeaBeam2100 and SBP Bathy2000 data, we made geomorphological investigation and selected the most adequate survey points for CTD cast, water sampling, and multi-coring, as shown in the following figures 2 and 3.

6. Brief description of Sampling Stations:

Site TR17 (ES5): Site ES5 is located on a syncline of fault-related folds in the first prism between the master décollement (plate detachment) and the backstop fault along the basal apron of landward trench slope. Since the multiple coring TR17-MC recovered no turbidite but smells ditch,

this prism was likely inactive during the Mw 9.0 event. It was regrettable that no other fault trace was available to be a target of coring because of larger inclination for multiple coring.

Site TR18 (ES4): Site ES4 is located on the major, low-angle spray fault, which forms the mid-slope terrace on the trench wall. Full of slope failures cover the middle trench slope and only a small part among landslides was pin-pointed out for sediment sampling. The multiple coring TR18-MC recovered a 2.5 cm thick turbidite on the core top.

Site TR19 (ES6): Sites ES6, ES7 and ES8 are located on the uppermost of trench slope, called as the trench slope break, where develop several tens kilometers long, parallel fissures, trending N-S through NNE-SSW. The multiple coring TR19-MC also recovered the above mentioned turbidite on the core top, which suggests a remarkable activity of the spray faults.

Site TR21 (ES8): On the SeaBeam bathymetric map of this cruise, a linear rift valley was clearly recognized at 3464 m water depth along a NNE trending narrow ridge, which is 150 m high in relative height and is correlated to the trench slope break. Other fissures or tension gashes in origin are also distributed west of the rift valley in this topographic map. The TR21 CTD cast was conducted along the crest of this ridge.

Site TR20 (ES7): This site is located about two miles west of the above site (ES8) and the situation is almost the same. Multiple coring TR20-MC has been successfully done.

Site TR22 (ES3): This site is just on the epicenter of the 11 March 2011 Mw9.0 Tohoku-oki Earthquake. No coring operation was designed.

Site TR24 (ES2): The site is located around the southern tip of the source area of the Tohoku-oki Earthquake, east off Fukushima Prefecture. The seabed is situated on the footwall of an active fault whose fault scarp, 40 m in relative height, is clearly distinguished at 2060 m water depth from the bathymetric map of this cruise.

7. Summary as a tentative conclusion

Our observations suggest that an additional deformation due to the backstop faulting associated with the fundamental displacement along the plate interface might explain the tsunami-genic nature of the trench slope as the active tectonic behavior along the axis of Japan Trench. Based on the spatial distribution of co-seismic turbidite we suggest that the larger disturbance was dominant in the lower half of trench slope. This may explain the large tsunami of the Tohoku-oki earthquake, but which fault excited the energetic disturbance of the trench slope is still unclear. It is a pity that no critical evidence was observed whether the master décollement did dislocate beneath the first fault scarp (Site ES5) along the trench axis.

Whatever the geomorphological and/or geological resolution to the above question, near-trench faulting would form the present geomorphology and geologic structures. A common subduction-related earthquake does not leave eternal deformation, but an unusually rare event of giant dislocation including the leading edge of overriding plate could explain the active tectonics and the unusually large earthquake and fatal tsunami.

8. Acknowledgment

We express many thanks to all the science party and crew onboard of KH-11-07 cruise.

10.21.2. A geophysical survey in the M9.0 Earthquake epicenter area off Tohoku Japan, Northwest Pacific Ocean.

(Badalahu Bao, Yuko Furusawa and Akira Takeuchi)

10.22. Helium isotope change related to the M9.0 earthquake

1. Personnel

Yuji SANO (on-land, University of Tokyo)

Naoto TAKAHATA (on-land, University of Tokyo)

2. Purpose

$^3\text{He}/^4\text{He}$ ratio is one of the most sensitive and conservative tracer in chemical oceanography because of wide range of the ratio (e.g., mantle derived gases of 1×10^{-5} while atmosphere of 1.4×10^{-6}), rapid mobility and chemical inertness of the isotopes. Sano et al. (1998) reported a significant change of $^3\text{He}/^4\text{He}$ ratio in groundwater after the 1995 Kobe Earthquake in Japan. They concluded that this change might be attributed to release of radiogenic helium as a result of micro-fracturing of rocks or mixing of different fluids. In order to study the coseismic and after shock impacts on the geochemical state of the main shock region of the 2011 M9.0 Tohoku-Oki Earthquake, we collected seawater samples with several depths at different sites around the epicenter.

3. Sampling method

Samples for helium isotope measurements were collected at each station around the epicenter with a CTD carousel system equipped with 10-L Niskin bottles. Seawater was transferred without exposure to the atmosphere from the Niskin bottles into containers of about 10 cm^3 made of copper tubing for storage.

4. On land experiment

The copper container with seawater sample is connected to a stainless steel high vacuum line and dissolved gases are extracted from the sample in vacuo. He and Ne in the exsolved gas are purified using hot titanium getters and charcoal traps held at liquid nitrogen temperature. The $^4\text{He}/^{20}\text{Ne}$ ratio is measured by an on-line quadrupole mass spectrometer. He is then separated from Ne using a cryogenic trap held at 40 K. The $^3\text{He}/^4\text{He}$ ratio is measured by a high precision noble gas mass spectrometer (Helix-SFT, GV Instrument). The observed $^3\text{He}/^4\text{He}$ ratios of the samples are calibrated against atmospheric helium collected in Tokyo, Japan. Experimental error of the $^3\text{He}/^4\text{He}$ ratio is less than 0.5% (1 σ), estimated by repeated measurements of standard air containing concentrations equivalent to those of the samples.

10.23. Distribution of dissolved methane. (Ururu Tsunogai)

10.24. Bacteria structure (Chiaki Kato)

**10.25. Cold seep geochemistry in pore water and bottom water off NE Japan.
(Kyohei Matsumoto, Jing Zhang)**

10.26. Mineral composition in surface sediments. (Harue Masuda)

10.27 The concentrations of artificial radionuclides in seawater, sediments and plankton around off Fukushima

1. Personnel

Tatsuo Aono (NIRS)

Jian Zheng (NIRS)

Kenji Oguma (AORI)

Hajime Obata (AORI)

Jing Zhang (Univ. of Toyama)

2. Introduction and objectives

The artificial radionuclides (^{134}Cs , ^{137}Cs , ^{90}Sr , and Pu isotopes etc.) were delivered to marine environment by fallout before the earthquake on March 11th. The large volume of pollution water include the high concentrations of radionuclides were flowed to ocean by the accident of Fukushima NPP. The purpose of this investigation is to determine the radionuclides concentrations in seawater, sediments and plankton, and to discuss the behaviors of radionuclides in marine environment.

3. Inventory information for the sampling

Seawater: TR-23, 24, 25 and 26

Sediments: TR-23, 24, 25 and 26

Plankton: TR-23, 26

10.28 Transport process of anthropogenic radionuclides in the region off Fukushima

1. Personnel

Shigeyoshi Otsuka (Japan Atomic Energy Agency)

Hisashi Narita (on-land, Tokai University)

2. Introduction and objectives

Due to the severe accident at Fukushima-Daiichi Nuclear Power Plant, significant amount of anthropogenic radionuclides were released to the marine/atmospheric environment. The radionuclides are still spreading on a global scale. It is expected that dissolvable radionuclides released in the surface seawater will be transported by the Kuroshio Current and reach to the North America in 3~5 years even though the extent is quite small.

Immediately after the accident, the Japanese Government and Tokyo Electric Power Co. started monitoring the concentration level of radionuclides in seawater at the vicinity of the accident site. However, data obtained from the monitoring activities are very limited and it is necessary to obtain more data with a higher quality.

In the Hakuho-Maru KH-11-07 cruise, we carried out (i) collection of seawater and sediment samples to investigate distributions of radionuclides released from the Fukushima-Daiichi NPP, and (ii) deployment of sediment traps to collect sinking particles in the region off Fukushima. Observations are outlined below.

3. Collection of seawater samples for measurement of ^{129}I (Otsuka)

Radioiodine is mainly produced by atomic fission of uranium and trans-uranium isotopes. Among 23 radioisotopes of iodine, ^{131}I (half life = 8.1d) and ^{133}I (half life = 20.8 h) are known as significant contributors to the health effect from nuclear accident and from open-air nuclear bomb testing during 1950s. Because of their short half-lives, however, it is difficult to assess their behavior and fate in the marine environment. Iodine-129 (^{129}I) with long half-life (16.7 Myr) is regarded as one of the most important radionuclides that should be assessed for its biogeochemical cycling on a global scale (e.g., Snyder et al., 2010). In fact, it is reported that significant amount of ^{129}I produced in European nuclear fuel reprocessing plants is accumulated in the North Pacific and its marginal sea (e.g., Suzuki et al., 2010). In this study, we investigate the distribution of ^{129}I in the surrounding region of the Fukushima-Daiichi NPP. By comparing previous data obtained from the neighboring region (Suzuki et al., unpublished data), the impact of the accident will be assessed.

In this cruise, seawater samples for ^{129}I measurement were collected at 4 stations; Stas. FS1, ES2, FS2 and FS5. Sampling was carried out with an interval between 100 and 500 m by a CTD-RMS system. Iodine in seawater samples is extracted and purified by solvent-extraction and is recovered as silver iodide (AgI). Subsequently, $^{129}\text{I}/^{127}\text{I}$ ratio in the AgI target is analyzed by an accelerator mass spectrometer (AMS). Concurrently with the $^{129}\text{I}/^{127}\text{I}$ measurement, concentration of stable iodine (^{127}I) in the sample is analyzed by ICP-mass spectrometry. Concentration of ^{129}I in seawater is then calculated from the $^{129}\text{I}/^{127}\text{I}$ ratio and ^{127}I concentration.

For surface seawater samples at Stas. FS1, FS3 and FS5, iodine species (iodide, iodate and organo-iodine) will also be measured by a modified method of Schwehr et al. (2005).

4. Sediment coring for measurement of anthropogenic radionuclides (Otosaka)

In order to observe concentration of anthropogenic radionuclides in seabed sediment in surrounding region of the Fukushima-Daiichi NPP, sediment coring using a multiple corer was carried out at Stas. FS1 and FS5. After transferred the sediment samples to a laboratory on land, we are scheduling the following analysis; (i) measurement of properties of the sediment (e.g., density and size distribution), (ii) analysis of anthropogenic/natural radionuclides using a HPGe spectrometer, (iii) measurement of major/trace elements, and (iv) ^{129}I measurement by accelerator mass spectrometry. Obtained data will be used as parameters of a simulation model to predict accumulation of the radionuclides into seabed.

5. Deployment of sediment trap (Otoska and Narita)

Mooring array equipped with a sediment trap (Fig.1) was deployed at Stas. FS1

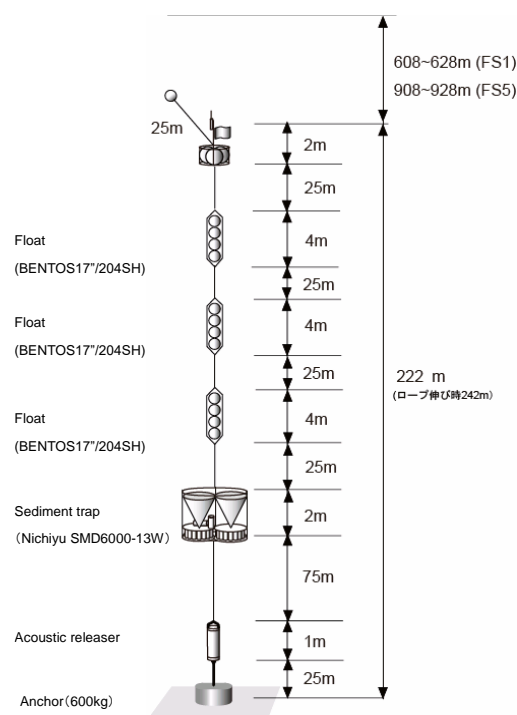


Fig.1 Schematic of mooring array deployed in this cruise

and FS5, respectively. These arrays are scheduled to be recovered in July 2012. Expected data, such as mass flux and elemental composition of sinking particles, will be compared with the previous data (e.g., Ootosaka and Noriki, 2005), and factors controlling transport of particulate materials in the regions will be investigated. In addition, fluxes of anthropogenic radionuclides originating from the Fukushima-Daiichi NPP are also estimated by a radiochemical analysis of sinking particles.

Since sediment trap is installed at a depth of 100m above the bottom, we are expecting that particles from the surface waters as well as those transported laterally from the continental shelf will be collected by the traps. If applicable isotopic/elemental proxies, such as $\Delta^{14}\text{C}$ (Ootosaka et al., 2008), are obtained, detailed transport processes of particulate radionuclides will be inferred.

6. Data Archive

All of the raw and processed data from the KH-11-7 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

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estuarine surface waters of Galveston Bay, Texas. *Limnology and Oceanography: Methods* 3, 326-337 (2005).

10.29 Distribution of radionuclides released from Fukushima NPP accident in northwest Pacific region

1. Personnel

Seiya Nagao, Mutusuo Inoue, Y Hamajima, Masayoshi Yamamoto (Low Level Radioactivity Laboratory, Institute of Nature and Environmental Technology, Kanazawa University)

2. Introduction and objectives

Nuclear accident at the Fukushima Daiichi Nuclear Power Plant (NPP) was occurred after the 2011 Tohoku Earthquake and Tsunami. About 370-630 PBq of radionuclides was released from the Fukushima Daiichi NPP, according to the estimation by Nuclear Safety Commission (NSC) of Japan and Nuclear and Industrial Safety Agency (NISA). To understand migration behavior of radionuclides released from the Fukushima NPP in northwest Pacific region, we measure radioactivities of ^{134}Cs and ^{137}Cs of seawater and sediment samples spatially.

3. Inventory information for the sampling

Seawater and sediment samples were summarized as follows.

Table 1 Locations of seawater and sediment samples collected during the KH-11-07 cruise.

| Stn. | Lat. | Long. | Sample |
|------|-----------|------------|--------------------|
| ES-2 | 37°04.00N | 142°15.00E | Seawater, Sediment |
| ES-3 | 38°04.00N | 142°54.00E | Seawater, Sediment |
| ES-5 | 37°47.00N | 143°54.00E | Seawater, Sediment |
| ES-6 | 38°04.00N | 143°28.00E | Seawater, Sediment |
| KE-1 | 36°30.00N | 150°00.00E | Seawater |
| KE-2 | 36°30.00N | 145°00.00E | Seawater |
| KE-3 | 36°30.00N | 145°00.00E | Seawater |

| | | | |
|--------|-----------|------------|--------------------|
| SHY-3 | 32°00.13N | 157°51.00E | Seawater, Sediment |
| GP10N2 | 45°00.00N | 165°00.00E | Seawater |
| GP10N3 | 46°00.00N | 165°00.00E | Seawater |
| GP10N4 | 32°30.00N | 165°00.00E | Seawater |

4. Analysis and method

Seawater samples will be analyzed for $^{134,137}\text{Cs}$ as follows. After adjustment to $\text{pH}<2$, ^{137}Cs isotopes are quantitatively separated from unfiltered water samples by coprecipitation with ammonium phosphomolybdate (AMP)/Cs by adding 0.66 g of CsCl and 10 g of AMP to a 20 L aliquot of water (Aoyama et al., 2000). Chemical procedures for the waters in 2009 are from Nakano et al. (2008). The γ -spectrometry is performed using coaxial- or planar-type Ge-detectors specially designed for low-background counting and equipped at Ogoya Underground Laboratory, Japan (Hamajima and Komura, 2004). The radioactivity of ^{134}Cs and ^{137}Cs are counted at the peaks of 605 and 796 keV, and 661 keV, respectively.

Sediment samples will be measured for ^{134}Cs and ^{137}Cs radioactivities using γ -spectrometry at Low Level Radioactivity Laboratory (LLRL) and Ogoya Underground Laboratory, and $^{239+240}\text{Pu}$ radioactivities using α -spectrometry at LLRL.

5. Anticipated results and work plan

We will obtain spatial distribution of ^{134}Cs and ^{137}Cs radioactivities in surface seawater in northwest Pacific region. We also obtain vertical distribution of ^{134}Cs , ^{137}Cs and $^{239+240}\text{Pu}$ radioactivities in bottom sediments from 141°E to 165°E. From the data set, we will evaluate migration behavior of ^{134}Cs , ^{137}Cs and $^{239+240}\text{Pu}$ in marine environment.

6. Data Archive

All of the raw and processed data from the KH-11-7 cruise will follow the General rules of Atmosphere and Ocean Research Institute (AORI), the University of Tokyo, and GEOTRACES Data Policy.

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10.30. Argo float deployment in the North Pacific

1. Personnel

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****:** Research Institute for Global Change

***:** Japan Agency for Marine-earth Science and Technology

2. Introduction and objectives

The objective of deployment is to clarify the structure and temporal/spatial variability of water masses in the North Pacific such as North Pacific Subtropical Mode Water (hereafter, STMW) and North Pacific Central Mode Water (hereafter, CMW) and their formation mechanism. To achieve the objective, profiling floats are launched to measure vertical profiles of temperature and salinity automatically every ten or five days. As the vertical resolution of the profiles is very fine, the structure and variability of the water mass can be displayed well. Therefore, the profile data from the floats will enable us to understand the variability and the formation mechanism of the water mass.

3. Inventory information for the sampling

In this cruise, 4 Argo floats were deployed. The Float S/N, ARGOS ID Number, launched date/ time, launched position observation cycle of the float are summarized in Table 10.30. 1. The deployments were accomplished by Dr. Horikawa and Mr. Matsumoto.

4. Analysis and method

The float equips one SBE41cp CTD sensor manufactured by Sea-Bird Electronics Inc to measure temperature, salinity and pressure from surface to 2000

dbar. The float usually drifts at a depth of 1000 dbar (called the parking depth), then it dives to a depth of 2000 dbar. During the ascent to the sea surface with increasing its volume in order to change its buoyancy, the float measures sea water temperature, salinity, and pressure. To send the measured data to the Argos data center via the ARGOS transmitting system in real time, the float stays at the sea surface for enough time, approximately 11 hours. Finally the float returns to the parking depth with decreasing volume. The cycle of the float moving repeats each 5 and 10 days for 3 or 4 years. The status of the float and the launch is shown in Table 10.30.2

5. Anticipated results and work plan

The floats were deployed near the formation region of STMW and near the distribution region of CMW in the North Pacific. It is important to detect and analyze the temporal variability of temperature and salinity of these mode waters because they affect the heat content due to their large volume in the subtropical North Pacific. Recent researches show the results described as follows: STMW formed in 2008 has three modes of core temperature. On the other hand, STMW formed in 2006 has only one mode of core temperature. The difference between the two years is attributed to the more variable state of the Kuroshio Extension in 2008, associated with stronger eddy activities in the STMW formation region, which enhance the eddy transport of STMW. The floats operating in this region are now decreasing. The monitoring characteristics of mode waters and clarifying mechanism of characteristics variability will make progress by the deployment of floats in KH-11-7 cruise.

6. Data Archive

The data will be measured automatically each observation cycle and can be obtained via internet promptly and freely. The real-time data are provided to meteorological organizations, research institutes, and universities via Global Data Assembly Center (GDAC: <http://www.usgodae.org/argo/argo.html>, <http://www.coriolis.eu.org/>) and Global Telecommunication System (GTS), and utilized for analysis and forecasts of the ocean conditions and the climate.

Table 10.30.1 Launching area and date/time









| | | | | |
|-------------------------------|---------------------------------|------------------------------|------------------------------|-------------------------------|
| Float S/N | 09013 | 09005 | 09007 | 09020 |
| ARGOS ID | 97908 | 97900 | 97902 | 97915 |
| Date and Time of Reset (UTC) | 2011/7/16 10:24 | 2011/7/18 21:40 | 2011/7/20 01:29 | 2011/8/2 16:16 |
| Date and Time of Launch (UTC) | 2011/7/16 10:52 | 2011/7/18 22:22 | 2011/7/20 01:59 | 2011/8/2 16:37 |
| Location of Launch | 34-59.880 [N] 140-19.483 [E] | 33-04.66 [N] 156-00.02[E] | 32-12.97 [N] 160-00.14[E] | 37-00.10 [N] 142-00.11 [E] |
| Observation Cycle | 5days | 10days | 10days | 5days |

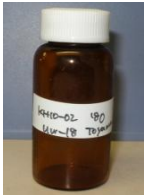







Table 10.30.2 Specification of launched float






| | |
|-------------------------|---|
| Float Type | Provor float manufactured by Nke. |
| CTD sensor | SBE41cp manufactured by Sea-Bird Electronics Inc. |
| Cycle | 5 or 10 days (approximately 11 hours at the sea surface) |
| ARGOS transmit interval | 30 sec |
| Target Parking Pressure | 1000 dbar |
| Sampling layers | 115 (2000,1950,1900,1850,1800,1750,1700,1650,1600,1550,1500,1450,1400,1350,1300,1250,1200,1150,1100,1050,1000,980,960,940,920,900,880,860,840,820,800,780,760,740,720,700,680,660,640,620,600,580,560,540,520,500,490,480,470,460,450,440,430,420,410,400,390,380,370,360,350,340,330,320,310,300,290,280,270,260,250,240,230,220,210,200,195,190,185,180,175,170,165,160,155,150,145,140,135,130,125,120,115,110,105,100,95,90,85,80,75,70,65,60,55,50,45,40,35,30,25,20,15,10,5,0) |

| | |
|--|---|
| | 05,100,95,90,85,80,75,70,65,60,55,50,45,40,35,30,25,20, 15,10,4 or surf, dbar) |
|--|---|

Sampling Bottles and sampling methods

| | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th |
|-------------------------------|---|---|---|--|---|---|---|---|
| photo |  |  |  |  |  |  |  |  |
| sample | DO | Density | He | pH | VOC | CH ₄ | Alkalinity | Salinity |
| group | Routine | AIST | AORI | Routine | Hokkaidou | Hokkaidou Univ. | Routine | Routine |
| rinse (times) | 3 (when wet) | 3 | - | 3 (when wet) | - | - | 3 (when wet) | 3 |
| overflow (times of bot. vol.) | 3 | 2 | | 2 | 3 | 3 | 2 | - |
| volume | 100 mL | 30 mL | | 100 mL | 100 mL | 100 mL | 250 ml | bottle neck |
| remark | measure w.temp | | Toyama takes | | cap wash | cap wash | | |

| | 9th | 10th | 11th | 12th | 13th | 14th | 15th | 16th |
|-------------------------------|---|---|---|--|---|---|---|---|
| photo |  |  |  |  |  |  |  |  |
| sample | 18O | Nutrient | REEs | Ba | PFOS | Chl-a | Chl-a | Pigment |
| group | Toyama Univ. | Routine | Toyama Univ. | Tokai Univ. | AIST | Routine | Toyama Univ. | Taiwan |
| rinse (times) | 3 | 3 | 3 | 3 | 0 | 3 | 3 | 3 |
| overflow (times of bot. vol.) | - | - | - | - | - | - | - | - |
| volume | bottle shoulder | 90% | bottle neck | full | 1 L | bottle neck | bottle neck | bottle neck |
| remark | | | Toyama takes | | don't touch O ring no tube | | | |

| | 17th | 18th | 19th | 20th | 21st | 22nd | 23rd | 24th |
|-------------------------------|---|---|---|--|---|------|------|------|
| photo |  |  |  |  |  | | | |
| sample | POM | 129 I | U, Pu, Cs | LV | Radio Isotope | | | |
| group | China | AORI | Hiro. Univ. | Hiro. Univ. | Kanazawa Univ. | | | |
| rinse (times) | 3 | 3 | 3 | 3 | 3 | | | |
| overflow (times of bot. vol.) | - | - | - | - | - | | | |
| volume | 50 L | bottle neck | 20 L | 20 L | 10 L | | | |
| remark | | | | 108 | | | | |

