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# *R/V Mirai Cruise Report*
# *MR13-06*

Arctic Ocean, Bering Sea, and North Pacific Ocean

Leg 1: 28th August to 7th October, 2013
Leg 2: 9th October to 21th October, 2013

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

Cruise Report ERRATA of the Nutrients part

| page | Error | Correction |
|---|---|---|
| 116 | potassium nitrate<br>CAS No. 7757-91-1 | potassium nitrate<br>CAS No. 7757-79-1 |
| 113 | 1N $H_2SO_4$ | 1M $H_2SO_4$ |

**Contents**

# 1. Cruise Summary

## 1.1. Overview of Observations

On the basis of our previous observations and theoretical considerations, we have come to realize that the Arctic Ocean plays an important role in global climate changes.

The objectives of this cruise are as follows:

a. To quantify on-going changes in ocean, atmosphere, and ecosystem, which are related to the recent Arctic warming and sea-ice reduction.
b. To clarify important processes and interactions among atmosphere, ocean, and ecosystem behind changes of the Arctic Ocean.
c. To collect data for understanding the effects of the Arctic Ocean changes on global climate.

In this research cruise, we conducted:

a. Fixed point observations with radiozonde, Doppler radar, general meteorological equipments, CTD (Conductivity, temperature, and depth sensors), XCTD (expendable CTD), seawater samplers, current profilers, turbulence ocean microstructure acquisition profiler, plankton nets, optical instruments, sea surface monitoring system, drifting buoys, and so on.
b. Wide-area observations with the metrological and oceanographic equipments described above.
c. Mooring observations to measure annual changes in seawater temperature, salinity, currents, dissolved oxygen, chlorophyll a, zooplankton (by acoustics), marine mammal (by acoustics), and sediments (by sediment traps).
d. Continuous observations of sea bottom topography, gravity, and magnetic fields along the cruise track, in addition to the continuous meteorological and oceanographic observations by general meteorological equipments and sea surface monitoring system, respectively.

This research cruise included the following publicly-offered studies:

- Studies on board

○ Sea-ice reduction in the western Arctic Ocean and its impact on the variation of biogenic particulate fluxes [JAMSTEC-RIGC]
○ Study on the response of lower trophic level ecosystem to environmental changes in the Arctic Ocean [Hokkaido University]
○ Study on the spatial variations of microbial community and DOM/POM and their controlling mechanism in the Canada Basin of the Arctic Ocean [Atmosphere and Ocean Research Institute, The University of Tokyo]
○ Study on the cycles of greenhouse gasses and their climatological responses in the Arctic region [Meteorological Research Institute]
○ Assessment of environmental impact on the efflux of chemical materials from the sea-ice due to its melt in the Arctic Ocean [National Institute of Advanced Industrial Science and Technology]

- Studies not on board

○ Maritime aerosol optical properties from measurements of ship-borne sky radiometer [Toyoma University]

○ Lidar observations of optical characteristics and vertical distribution of aerosols and clouds [National Institute for Environmental Studies]

○ Study on material cycles from wide-area observations of maritime gas and aerosol [JAMSTEC-RIGC]

○ Tectonics of the mid-Cretaceous Pacific Plate [Chiba University]

○ Standardization of marine geophysical data and its application to the ocean floor geodynamics studies [Ryukyu University]

## 1.2. Basic Information

| | |
|---|---|
| Name of Vessel | R/V Mirai<br>L x B x D 128.58m x 19.0m x 13.2m, Gross Tonnage 8,672 tons<br>Call Sign JNSR |
| Cruise Code | MR13-06 |
| Undertaking Institute | Japan Agency for Marine-Earth Science and Technology (JAMSTEC)<br>2-15 Natsushima-cho, Yokosuka 237-0061, Japan |
| Chief Scientists | Shigeto Nishino<br>Arctic Ocean Climate System Research Team,<br>Research Institute for Global Change (RIGC),<br>Japan Agency for Marine-Earth Science and Technology (JAMSTEC) |
| Cruise Periods | Leg 1: 28 August 2013 – 7 October 2013<br>Leg 2: 9 October 2013 – 21 October 2013 |
| Ports of Call | 28 August 2013, Dutch Harbor (leave port)<br>7 October 2013, Dutch Harbor (arrival in port)<br>9 October 2013, Dutch Harbor (leave port)<br>20 October 2013, Hachinohe (arrival in port)<br>21 October 2013, Sekinehama (arrival in port) |
| Research Areas | Arctic Ocean, Bering Sea, and North Pacific Ocean |

Research Activities

| | |
|---|---|
| Radiosonde | 319 stns |
| Mooring recoveries | 5 stns |
| Mooring deployments | 4 stns |
| TurboMAP | 7 stns /81 casts |
| SVP | 6 stns |
| XCTDs | 143 stns |
| CTD | 88 stns/213 casts |
| Water samplings | 79 stns/155 casts |
| Clean samplings | 11 stns/21 casts |
| Primary production | 10 stns/18 casts |
| Spectroradiometer (PRR) | 17 stns/ 33 casts |
| NORPAC nets | 34 stns/ 82 casts |
| Ring nets | 10 stns/62 casts |

| | |
|---|---|
| Closing PCP nets | 1 stn/72 casts |
| VMPS | 2 stns |

(Underway observations)
Doppler Radar
Dual polarization lidar
Optical Absorption Spectroscope/MAX-DOAS
Sky radio meter
Meteorological observation system
Sea surface water monitoring system
Total carbonate monitoring system
Greenhouse gases monitoring system (CRDS)
Satellite data observation system
PAR sensor
Air samplings
Sea surface water samplings
ADCP
Seabeam/Sub bottom profiler
Magnetometer
Gravity meter

Note:
With regard to some stationary observations marked by the double asterisk (**) in the MSR Application to the U.S., scientists originally intended to carry out them not only in the Arctic Ocean but also on the way to there and back to Japan, though it could be read that the stationary observations would be carried out only in the Arctic Ocean from the explanation of the Application.

Those research and observation items are Radiozonde observations (Section 2.1), meteorological samplings detecting $CO_2$, $CH_4$, CO (Section 2.5.1), whole airs (Section 2.5.2) and air contaminants (Section 4.13), and sea surface water samplings detecting water contaminants (Section 4.13) and radionuclides (Section 4.16).

Data and the research results obtained from those items, which are both expected and unexpected results such as detected contaminants and radionuclides, are also included in this report.

Those data and the results would be utilized for scientific researches and will be accordingly opened to the public unless otherwise indicated by the U.S. government.

## 1.3. Cruise Track

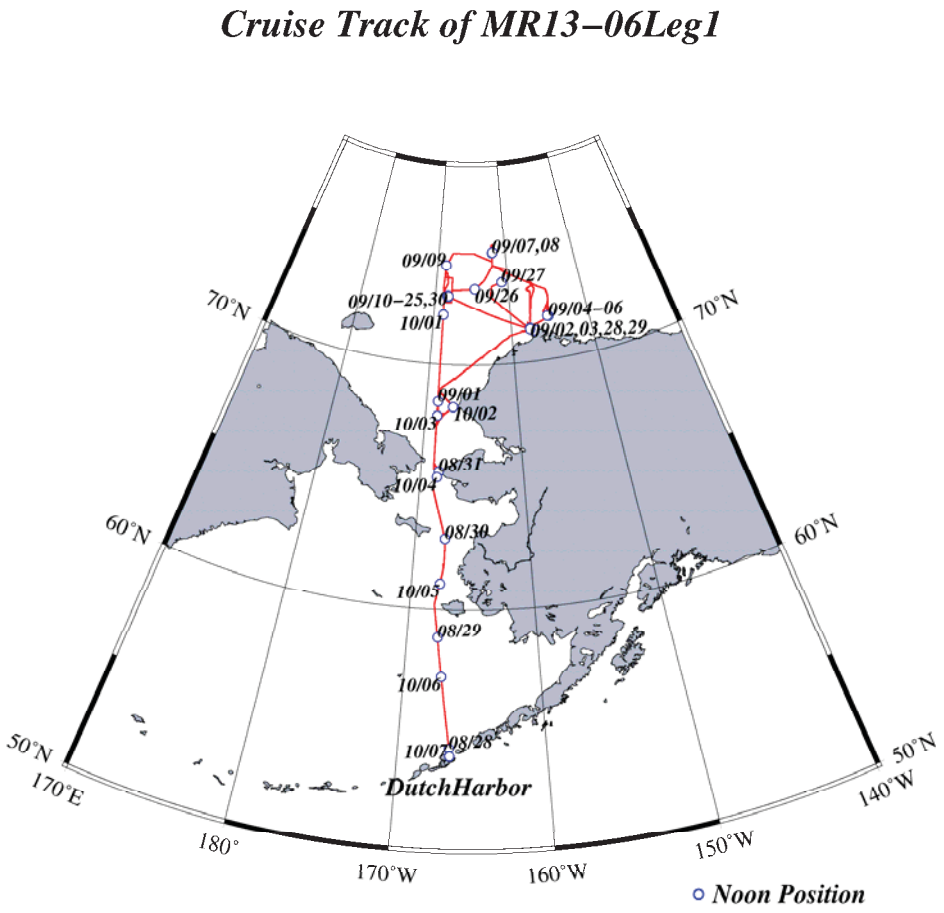


**Figure 1.3-1.** Research area and cruise track of MR13-06 Leg 1.

## *Cruise Track of MR13–06Leg2*

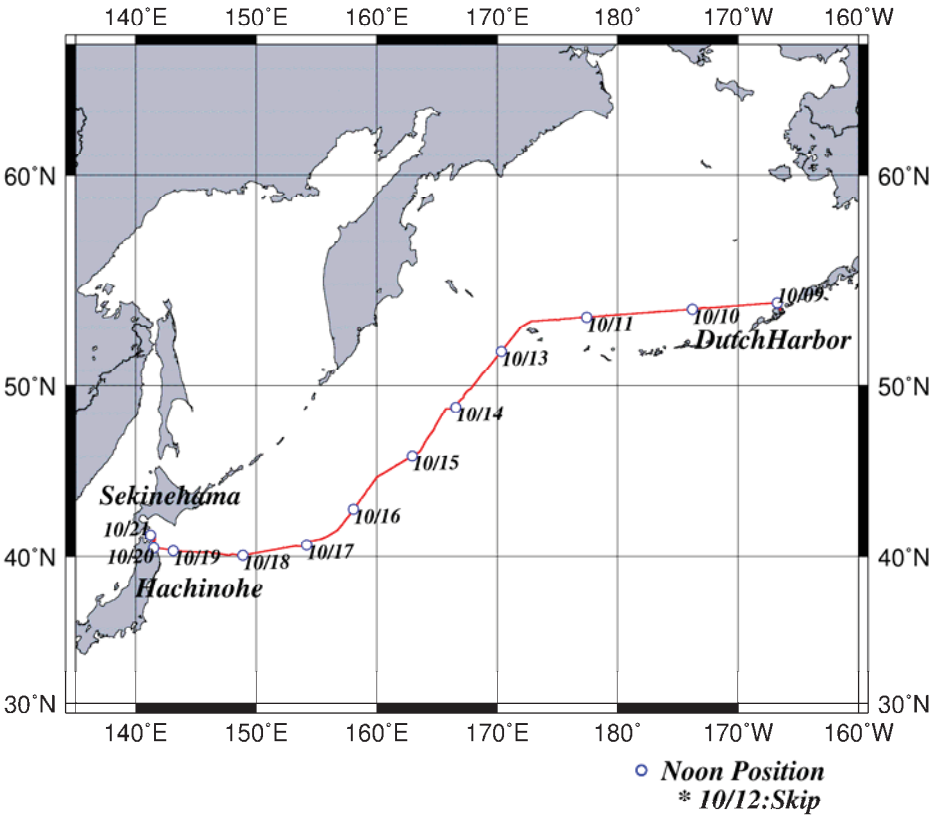


**Figure 1.3-2.** Research area and cruise track of MR13-06 Leg 2.

## 1.4. List of Participants

**Table 1.4-1.** List of participants (Leg 1)

| No. | Name | Organization | Position |
|---|---|---|---|
| 1 | Shigeto Nishino | JAMSTEC | Research Scientist |
| 2 | Jun Inoue | JAMSTEC/National Institute of Polar Research | Team Leader/Associate Professor |
| 3 | Kazuhiro Oshima | JAMSTEC | Research Scientist |
| 4 | Masatake Hori | JAMSTEC | Research Scientist |
| 5 | Yusuke Kawaguchi | JAMSTEC | Research Scientist |
| 6 | Kazutoshi Sato | JAMSTEC/The Graduate University for Advanced Studies | Graduate Student |
| 7 | Taku Mitsui | JAMSTEC/Nagasaki University | Graduate Student |
| 8 | Yo Tobase | JAMSTEC/Kyushu University | Graduate Student |
| 9 | Ana M. Aguilar-Islas | University of Alaska | Assistant Professor |
| 10 | David (Duke) Snider | Martech Polar Consulting Ltd | Ice Pilot |
| 11 | Jonaotaro Onodera | JAMSTEC | Research Scientist |
| 12 | Katsunori Kimoto | JAMSTEC | Research Scientist |
| 13 | Takahito Ikenoue | JAMSTEC/Kyushu University | Postdoctoral Scientist |
| 14 | Kohei Matsuno | National Institute of Polar Research | Postdoctoral Scientist |
| 15 | Amane Fujiwara | National Institute of Polar Research | Postdoctoral Scientist |
| 16 | Ryosuke Futsuki | Hokkaido University | Graduate Student |
| 17 | Mario Uchimiya | National Institute of Polar Research | Postdoctoral Scientist |
| 18 | Chiaki Motegi | Takuvik Joint International Laboratory | Postdoctoral Scientist |
| 19 | Naohiro Kosugi | Meteological Research Institute | Research Scientist |
| 20 | Kushi Kudo | Tokyo Institute of Technology | Graduate Student |
| 21 | Sachi Taniyasu | National Institute of Advanced Industrial Science and Technology (AIST) | Research Scientist |

| | | | |
|---|---|---|---|
| 22 | Soichiro Sueyoshi | Global Ocean Development Inc. | Technical Staff |
| 23 | Masanori Murakami | Global Ocean Development Inc. | Technical Staff |
| 24 | Katsuhisa Maeno | Global Ocean Development Inc. | Technical Staff |
| 25 | Koichi Inagaki | Global Ocean Development Inc. | Technical Staff |
| 26 | Kenichiro Sato | Marine Works Japan Ltd. | Technical Staff |
| 27 | Hirokatsu Uno | Marine Works Japan Ltd. | Technical Staff |
| 28 | Tatsuya Tanaka | Marine Works Japan Ltd. | Technical Staff |
| 29 | Shinsuke Toyoda | Marine Works Japan Ltd. | Technical Staff |
| 30 | Shungo Oshitani | Marine Works Japan Ltd. | Technical Staff |
| 31 | Rei Ito | Marine Works Japan Ltd. | Technical Staff |
| 32 | Minoru Kamata | Marine Works Japan Ltd. | Technical Staff |
| 33 | Yoshiko Ishikawa | Marine Works Japan Ltd. | Technical Staff |
| 34 | Masanori Enoki | Marine Works Japan Ltd. | Technical Staff |
| 35 | Tomonori Watai | Marine Works Japan Ltd. | Technical Staff |
| 36 | Makoto Takada | Marine Works Japan Ltd. | Technical Staff |
| 37 | Elena Hayashi | Marine Works Japan Ltd. | Technical Staff |
| 38 | Emi Deguchi | Marine Works Japan Ltd. | Technical Staff |
| 39 | Atsushi Ono | Marine Works Japan Ltd. | Technical Staff |
| 40 | Hideki Yamamoto | Marine Works Japan Ltd. | Technical Staff |
| 41 | Shinichiro Yokogawa | Marine Works Japan Ltd. | Technical Staff |
| 42 | Katsunori Sagishima | Marine Works Japan Ltd. | Technical Staff |
| 43 | Misato Kuwahara | Marine Works Japan Ltd. | Technical Staff |
| 44 | Masahiro Orui | Marine Works Japan Ltd. | Technical Staff |
| 45 | Kanako Yoshida | Marine Works Japan Ltd. | Technical Staff |
| 46 | Keitaro Matsumoto | Marine Works Japan Ltd. | Technical Staff |

**Table 1.4-2.** List of participants (Leg 2)

| No. | Name | Organization | Position |
|---|---|---|---|
| 1 | Shigeto Nishino | JAMSTEC | Research Scientist |
| 2 | Jun Inoue | JAMSTEC/National Institute of Polar Research | Team Leader/Associate Professor |
| 3 | Kazuhiro Oshima | JAMSTEC | Research Scientist |
| 4 | Kazutoshi Sato | JAMSTEC/The Graduate University for Advanced Studies | Graduate Student |
| 5 | Kohei Matsuno | National Institute of Polar Research | Postdoctoral Scientist |
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| 11 | Shungo Oshitani | Marine Works Japan Ltd. | Technical Staff |
| 12 | Minoru Kamata | Marine Works Japan Ltd. | Technical Staff |
| 13 | Masanori Enoki | Marine Works Japan Ltd. | Technical Staff |
| 14 | Tomonori Watai | Marine Works Japan Ltd. | Technical Staff |
| 15 | Kanako Yoshida | Marine Works Japan Ltd. | Technical Staff |
| 16 | Keitaro Matsumoto | Marine Works Japan Ltd. | Technical Staff |

# 2. Meteorology

## 2.1. GPS Radiosonde

(1) Personnel

| | |
|---|---|
| Jun Inoue | JAMSTEC/NIPR :Principal Investigator |
| Masatake Hori | JAMSTEC |
| Kazuhiro Oshima | JAMSTEC |
| Kazutoshi Sato | NIPR |
| Taku Mitsui | JAMSTEC/Nagasaki Univ. |
| Yo Tobase | JAMSTEC/Kyushu Univ. |
| Souichiro Sueyoshi | GODI |
| Katsuhisa Maeno | GODI |
| Masanori Murakami | GODI |
| Koichi Inagaki | GODI |
| Kazuho Yoshida | GODI |
| Ryo Ohyama | MIRAI Crew |

(2) Objectives

To understand the thermodynamic structure of the boundary layer, and migratory cyclones and anticyclones, a 3-hourly radiosonde observation was conducted over the Arctic Ocean from 1 September 2013 through 4 October 2013 which includes a stationary observation period during 11-26 September 2013 at the location of 72˚45'N, 168˚45'W. The dataset includes 12-hourly initial observations and 6-hourly post-observations conducted near the Bering Strait on 30-31 August 2013 and 4-6 October 2013 (it also includes 6-hourly observations in leg2, 9-18 October 2013). Obtained data will be used mainly for studies of clouds, validation of reanalysis data as well as satellite analysis, and data assimilation. This observation is also a part of a joint international observation period conducted on 11-24 September 2013.

(3) Parameters

Atmospheric soundings of temperature, humidity, and wind speed/direction.

(4) Instruments and Methods

Radiosonde observations were carried out from 30 August to 19 October 2013, by using GPS radiosonde (RS92-SGPD). We used software (DigiCORA III, ver.3.64), processor (SPS311), GPS antenna (GA20), UHF antenna (RB21) and balloon

launcher (ASAP) made by Vaisala Oyj. Prior to launch, humidity, air temperature, and pressure sensors were calibrated by using the calibrator system (GC25 and PTB330, Vaisala). In case the relative wind to the ship is not appropriate for the launch, the handy launch was selected.

(5) Station List

Table 2.1-1 summarizes the log of upper air soundings. All data were sent to the world meteorological community by the global telecommunication system (GTS) through the Japan Meteorological Agency immediately after each observation. Raw data was recorded as binary format during ascent. ASCII data was converted from raw data.

(6) Preliminary results

Location of 3-hourly radiosonde observations before and after the stationary observation period is shown in Figure 2.1-1. Before the stationary observation period, R/V Mirai operated in the coastal region of Alaska and near the sea-ice boundary. The northernmost location of observation is 74.86˚N on 8 September, where the SST was -0.8˚C and ice was visible. During this period, the anticyclone over the Beaufort Sea was strong, and radiosonde observation was primarily conducted under a strong pressure gradient along the outer rim of the anticyclone.

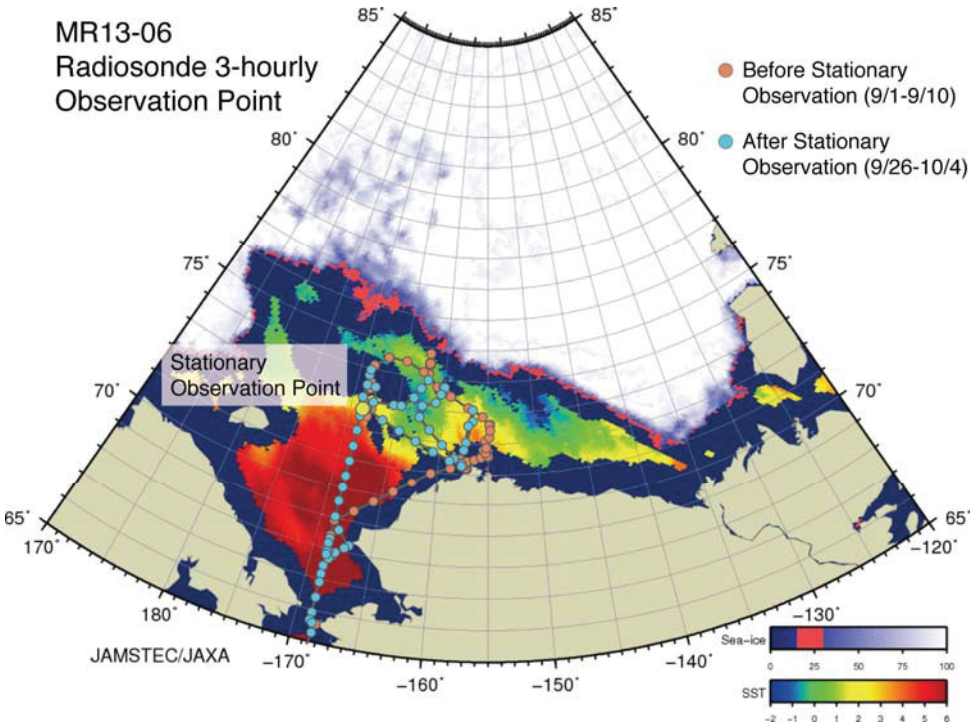


**Figure 2.1-1. Sounding stations during the cruise. Ice concentration and sea surface temperature derived from AMSR-2 sensor is shown by shadings.**

Time-height section of observed air temperature, wind and relative humidity during the stationary observation period of 11-26 September is given in Figure 2.1-2. The synoptic feature during this period is marked by a strong anticyclone that was prevalent in the north, which remained through the first half of the period. The last 5 days of the period is marked by small polar lows migrating northwestward from Alaska.

The period is characterized by two instances of strong surface wind during 14-15 September and 20-21 September. In the latter case, a dramatic change from northerly to southerly wind in the upper troposphere was observed during 18-19 September, which corresponds to an upper level cyclone vortex. The vortex was coincided with an intrusion of cold air into the middle to lower troposphere, lower tropopause height, and enhanced surface wind.

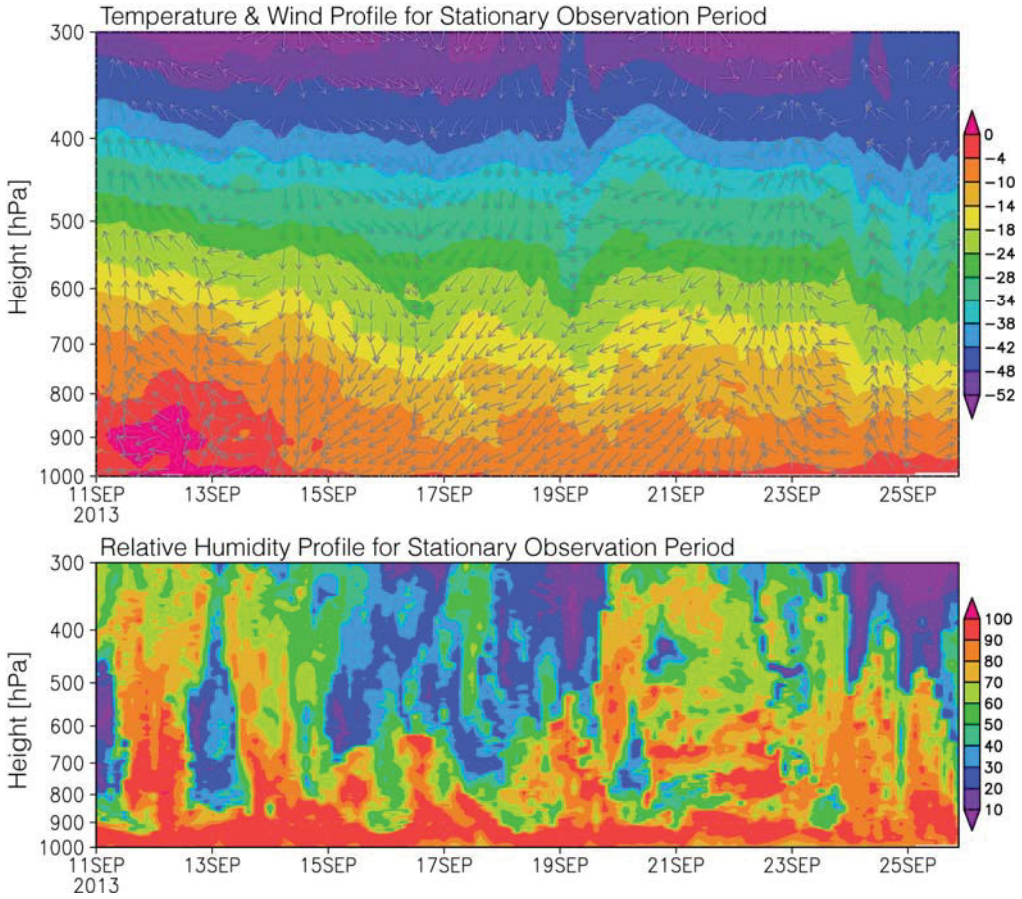


**Figure 2.1-2. Time-height cross section of air temperature (shade) and wind (vector) (top), and relative humidity (bottom) during the stationary observation period.**

After the stationary observation period, R/V Mirai briefly cruised near the sea-ice boundary and revisited the stationary observation point on 30 September. Small-scale migratory cyclones were observed during this period and frequent change in wind direction and humidity corresponding to cloud base height was visible.

(7) Data Archive

All datasets obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "R/V MIRAI Data Webpage" in JAMSTEC web site.

(8) Remarks

RS136 observation has no wind data, because of the trouble on receiving GPS signal.

**Table 2.1-1.** Launch log

| ID | Date | Latitude | Longitude | Psfc | Tsfc | RHsfc | WD | Wsp | SST | Max height | | Cloud | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | YYYYMMDDHH | degN | degE | hPa | degC | % | deg | m/s | degC | hPa | m | Amount | Type |
| RS001 | 2013083000 | 59.263 | −167.760 | 1014.5 | 7.8 | 77 | 348 | 6.7 | 8.117 | 34.6 | 23274 | 10 | St |
| RS002 | 2013083012 | 61.168 | −167.611 | 1015.3 | 7.1 | 67 | 176 | 1.0 | 9.452 | 168.7 | 13021 | − | − |
| RS003 | 2013083100 | 63.073 | −167.468 | 1013.7 | 8.4 | 74 | 151 | 4.4 | 9.502 | 36.4 | 22941 | 10 | Sc |
| RS004 | 2013083112 | 64.871 | −168.644 | 1010.9 | 6.9 | 85 | 51 | 6.6 | 5.694 | 50.7 | 20767 | − | − |
| RS005 | 2013090100 | 65.665 | −168.261 | 1010.6 | 7.4 | 67 | 53 | 8.6 | 10.251 | 38.3 | 22579 | 0 | St, Sc |
| RS006 | 2013090103 | 66.010 | −168.747 | 1011.0 | 7.3 | 64 | 47 | 7.7 | 8.435 | 66.0 | 19033 | 4 | St, Sc |
| RS007 | 2013090106 | 66.507 | −168.755 | 1012.0 | 6.5 | 68 | 47 | 9.8 | 9.650 | 38.8 | 22490 | 2 | St, Sc |
| RS008 | 2013090109 | 67.003 | −168.745 | 1012.1 | 5.1 | 67 | 50 | 8.1 | 7.937 | 37.2 | 22750 | 2 | St, Sc |
| RS009 | 2013090112 | 67.501 | −168.749 | 1011.9 | 5.3 | 79 | 50 | 6.1 | 5.953 | 70.0 | 18609 | 0 | − |
| RS010 | 2013090115 | 67.902 | −168.198 | 1011.6 | 5.4 | 74 | 53 | 7.0 | 5.322 | 38.0 | 22579 | 1 | Sc |
| RS011 | 2013090118 | 68.003 | −168.781 | 1010.7 | 5.3 | 78 | 46 | 6.6 | 5.095 | 33.0 | 23499 | 1 | Sc |
| RS012 | 2013090121 | 68.165 | −168.784 | 1010.2 | 5.7 | 73 | 59 | 6.3 | 6.644 | 35.4 | 23032 | 1 | Sc |
| RS013 | 2013090200 | 68.517 | −168.745 | 1009.2 | 5.8 | 75 | 60 | 5.6 | 7.791 | 33.4 | 23419 | 4 | Cu |
| RS014 | 2013090203 | 69.004 | −168.753 | 1008.7 | 4.5 | 83 | 72 | 9.3 | 6.548 | 36.6 | 22829 | 8 | Sc |
| RS015 | 2013090206 | 69.417 | −167.218 | 1007.9 | 5.1 | 79 | 55 | 9.0 | 7.739 | 44.1 | 21592 | 5 | Ci, Sc, St |
| RS016 | 2013090209 | 69.837 | −165.632 | 1007.1 | 4.2 | 80 | 65 | 10.6 | 7.462 | 48.7 | 20946 | 4 | Ci, Sc |
| RS017 | 2013090212 | 70.260 | −164.009 | 1006.9 | 3.3 | 84 | 81 | 11.8 | 5.582 | 37.8 | 22581 | 3〜4 | Sc |
| RS018 | 2013090215 | 70.662 | −162.359 | 1007.0 | 2.7 | 91 | 89 | 10.1 | 4.820 | 54.4 | 20190 | 10 | St |
| RS019 | 2013090218 | 71.038 | −160.677 | 1009.0 | 0.5 | 83 | 72 | 11.0 | 1.589 | 40.4 | 22128 | 7 | St, Sc |
| RS020 | 2013090221 | 71.257 | −158.776 | 1007.7 | 0.2 | 86 | 76 | 8.3 | 2.341 | 36.5 | 22793 | 5 | Sc |
| RS021 | 2013090300 | 71.341 | −157.612 | 1007.8 | 0.2 | 85 | 81 | 11.3 | 2.614 | 53.1 | 20351 | 10 | Sc, St |
| RS022 | 2013090303 | 71.327 | −157.679 | 1005.6 | 0.6 | 96 | 74 | 11.8 | 2.627 | 97.4 | 16393 | 10 | St |
| RS023 | 2013090306 | 71.343 | −157.610 | 1004.4 | 0.7 | 86 | 80 | 14.5 | 2.877 | 580.5 | 4310 | 10 | St |
| RS024 | 2013090309 | 71.588 | −157.858 | 1003.9 | 1.2 | 83 | 77 | 11.9 | 3.453 | 43.9 | 21609 | 9 | St, Sc |
| RS025 | 2013090312 | 71.312 | −157.294 | 1001.5 | 1.4 | 85 | 62 | 16.1 | 2.151 | 41.2 | 22026 | 10 | St,Sc |
| RS026 | 2013090315 | 71.562 | −157.807 | 1001.8 | 0.8 | 84 | 65 | 16.0 | 3.253 | 39.3 | 22317 | 10 | St, Sc |
| RS027 | 2013090318 | 71.449 | −157.605 | 1000.1 | 1.1 | 86 | 65 | 14.9 | 1.957 | 389.2 | 7222 | 10 | St |
| RS028 | 2013090321 | 71.260 | −157.128 | 999.0 | 1.2 | 87 | 68 | 11.7 | 2.442 | 42.2 | 21870 | 10 | St |
| RS029 | 2013090400 | 71.273 | −157.119 | 998.6 | 1.2 | 89 | 71 | 13.0 | 2.506 | 33.5 | 23351 | 10 | St |
| RS030 | 2013090403 | 71.281 | −157.258 | 998.2 | 1.1 | 90 | 68 | 12.9 | 2.638 | 37.3 | 22647 | 10 | St |
| RS031 | 2013090406 | 71.378 | −157.457 | 998.6 | 0.8 | 91 | 62 | 10.7 | 2.374 | 54.2 | 20210 | 10 | St |
| RS032 | 2013090409 | 71.423 | −157.561 | 999.1 | 0.8 | 91 | 52 | 11.6 | 3.005 | 42.0 | 21878 | 10 | St |
| RS033 | 2013090412 | 71.495 | −157.140 | 999.4 | 0.4 | 95 | 47 | 11.8 | 3.008 | 37.0 | 22699 | 10 | St |
| RS034 | 2013090415 | 71.546 | −156.361 | 999.7 | 0.2 | 95 | 56 | 11.2 | 2.955 | 34.2 | 23202 | 10 | St, Sc |
| RS035 | 2013090418 | 71.628 | −155.702 | 999.6 | 0.7 | 85 | 57 | 11.0 | 2.928 | 85.1 | 17232 | 7 | Sc, Ci |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RS036 | 2013090421 | 71.652 | −154.939 | 1000.8 | 0.4 | 92 | 47 | 9.9 | 2.760 | 39.7 | 22240 | 10 | St |
| RS037 | 2013090500 | 71.737 | −155.112 | 1002.1 | 0.6 | 91 | 47 | 10.7 | 3.196 | 39.5 | 22293 | 9 | St |
| RS038 | 2013090503 | 71.861 | −155.443 | 1003.3 | −0.8 | 90 | 42 | 11.5 | 3.218 | 39.1 | 22335 | 9 | Ci,Sc,St |
| RS039 | 2013090506 | 72.154 | −155.228 | 1004.7 | −1.5 | 92 | 48 | 10.5 | 2.860 | 37.1 | 22668 | 10 | St |
| RS040 | 2013090509 | 72.677 | −154.797 | 1006.7 | −2.4 | 90 | 31 | 8.6 | −0.120 | 50.7 | 20637 | 10 | St |
| RS041 | 2013090512 | 72.673 | −154.826 | 1007.6 | −2.1 | 90 | 27 | 5.2 | 0.322 | 46.0 | 21257 | 10 | St |
| RS042 | 2013090515 | 72.285 | −154.883 | 1007.2 | −1.1 | 90 | 58 | 5.7 | 2.812 | 41.5 | 21937 | 10 | St |
| RS043 | 2013090518 | 71.839 | −154.997 | 1007.3 | 0.0 | 87 | 89 | 6.2 | 3.073 | 50.3 | 20675 | 10 | Sc |
| RS044 | 2013090521 | 71.670 | −155.007 | 1008.1 | −0.1 | 87 | 93 | 5.0 | 2.946 | 30.1 | 24038 | 9 | St |
| RS045 | 2013090600 | 71.771 | −155.284 | 1008.6 | 0.1 | 86 | 110 | 6.9 | 3.072 | 37.6 | 22586 | 10 | St |
| RS046 | 2013090603 | 71.733 | −155.118 | 1008.6 | 0.4 | 92 | 98 | 7.8 | 2.985 | 42.1 | 21855 | 10 | St |
| RS047 | 2013090606 | 71.746 | −155.163 | 1008.6 | 1.5 | 90 | 103 | 9.7 | 3.144 | 47.5 | 21061 | 10 | Sc, St |
| RS048 | 2013090609 | 71.787 | −155.292 | 1009.1 | 1.5 | 96 | 104 | 9.8 | 3.064 | 42.5 | 21789 | 10 | St |
| RS049 | 2013090612 | 71.743 | −155.181 | 1009.0 | 1.6 | 96 | 100 | 8.8 | 3.071 | 37.7 | 22573 | 10 | St |
| RS050 | 2013090615 | 71.870 | −155.495 | 1008.7 | 1.5 | 99 | 82 | 10.2 | 3.102 | 40.7 | 22071 | 10 | St |
| RS051 | 2013090618 | 71.688 | −155.022 | 1008.3 | 1.8 | 99 | 111 | 6.0 | 2.395 | 43.4 | 21647 | 10 | St |
| RS052 | 2013090621 | 71.684 | −155.025 | 1008.3 | 2.3 | 99 | 128 | 5.5 | 2.854 | 29.6 | 24144 | 9 | St, As |
| RS053 | 2013090700 | 71.776 | −155.289 | 1008.0 | 3.0 | 95 | 127 | 5.3 | 3.070 | 36.5 | 22781 | 7 | Sc, Ac |
| RS054 | 2013090703 | 71.940 | −155.213 | 1007.6 | 3.3 | 97 | 112 | 5.0 | 2.987 | 43.3 | 21676 | 4 | St,Ac |
| RS055 | 2013090706 | 72.501 | −154.800 | 1008.3 | 1.0 | 100 | 103 | 8.1 | 1.890 | 43.4 | 21657 | 10 | St |
| RS056 | 2013090709 | 72.929 | −155.566 | 1008.9 | 0.1 | 99 | 98 | 9.1 | 0.615 | 35.7 | 22907 | 10 | St |
| RS057 | 2013090712 | 73.204 | −157.221 | 1009.1 | 0.3 | 99 | 94 | 12.4 | 1.661 | 37.6 | 22539 | 10 | St |
| RS058 | 2013090715 | 73.527 | −159.164 | 1009.4 | 0.0 | 100 | 99 | 11.6 | 0.281 | 63.7 | 18994 | 10 | St |
| RS059 | 2013090718 | 73.818 | −160.879 | 1009.5 | −0.1 | 100 | 110 | 12.5 | 1.574 | 32.6 | 23449 | 10 | St |
| RS060 | 2013090721 | 74.211 | −162.007 | 1011.2 | −0.6 | 94 | 87 | 10.8 | 1.318 | 37.8 | 22502 | 10 | St |
| RS061 | 2013090800 | 74.505 | −161.982 | 1011.0 | −1.1 | 95 | 98 | 10.9 | 0.235 | 44.5 | 21447 | 10 | St |
| RS062 | 2013090803 | 74.860 | −161.973 | 1010.7 | −1.4 | 96 | 95 | 8.5 | −0.810 | 35.5 | 22900 | 10 | St |
| RS063 | 2013090806 | 74.533 | −161.929 | 1009.4 | 0.2 | 99 | 130 | 9.7 | 0.328 | 31.0 | 23776 | 10 | St |
| RS064 | 2013090809 | 74.549 | −161.906 | 1009.7 | 0.6 | 100 | 180 | 6.7 | 0.310 | 47.6 | 20988 | 10 | St |
| RS065 | 2013090812 | 74.500 | −161.992 | 1009.8 | −0.2 | 100 | 168 | 7.6 | 0.443 | 42.6 | 21700 | 10 | St |
| RS066 | 2013090815 | 74.508 | −161.972 | 1009.2 | 0.6 | 97 | 158 | 7.8 | 0.431 | 41.2 | 21907 | 10 | St |
| RS067 | 2013090818 | 74.518 | −161.849 | 1009.6 | 0.6 | 99 | 169 | 7.8 | 0.434 | 40.5 | 22020 | 10 | St |
| RS068 | 2013090821 | 74.557 | −161.973 | 1009.9 | 0.4 | 98 | 184 | 5.8 | 0.559 | 31.9 | 23581 | 10 | St |
| RS069 | 2013090900 | 74.529 | −161.922 | 1010.1 | 0.3 | 100 | 178 | 7.0 | 0.450 | 34.4 | 23086 | 10 | St |
| RS070 | 2013090903 | 74.538 | −161.969 | 1010.3 | 0.8 | 97 | 186 | 7.1 | 0.500 | 34.8 | 23005 | 10 | St |
| RS071 | 2013090906 | 74.541 | −161.960 | 1010.9 | 0.3 | 98 | 165 | 8.9 | 0.523 | 39.9 | 22116 | 10 | St |
| RS072 | 2013090909 | 74.192 | −162.001 | 1011.0 | 0.4 | 90 | 160 | 6.3 | 1.770 | 44.5 | 21408 | 10 | St |
| RS073 | 2013090912 | 74.241 | −162.612 | 1010.9 | 0.1 | 94 | 173 | 5.9 | 1.059 | 40.4 | 22031 | 3 | St |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RS074 | 2013090915 | 74.500 | −164.751 | 1010.3 | −0.5 | 94 | 179 | 5.9 | −0.020 | 39.2 | 22226 | 10 | St |
| RS075 | 2013090918 | 74.500 | −166.982 | 1009.6 | −0.8 | 96 | 155 | 6.8 | −0.310 | 49.7 | 20666 | 10 | St, Sc |
| RS076 | 2013090921 | 74.156 | −168.439 | 1008.9 | −1.2 | 99 | 131 | 8.2 | −0.320 | 39.9 | 22099 | 9 | St |
| RS077 | 2013091000 | 74.000 | −168.742 | 1008.5 | −1.4 | 99 | 120 | 9.5 | −0.050 | 37.9 | 22438 | 10 | St |
| RS078 | 2013091003 | 73.628 | −168.446 | 1007.6 | −0.9 | 99 | 111 | 7.4 | −0.980 | 41.0 | 21930 | 10 | St |
| RS079 | 2013091006 | 73.408 | −168.348 | 1006.8 | −0.9 | 99 | 96 | 7.6 | −0.960 | 91.2 | 16711 | 10 | St |
| RS080 | 2013091009 | 73.000 | −168.749 | 1005.8 | 0.9 | 95 | 126 | 7.4 | 1.657 | 39.2 | 22234 | 10 | St |
| RS081 | 2013091012 | 72.751 | −168.748 | 1005.2 | 0.9 | 98 | 130 | 7.1 | 2.471 | 40.7 | 21987 | 10 | St |
| RS082 | 2013091015 | 72.502 | −168.034 | 1004.6 | 0.1 | 95 | 118 | 6.7 | 3.362 | 33.9 | 23171 | 10 | St |
| RS083 | 2013091018 | 72.767 | −167.741 | 1004.7 | 0.2 | 96 | 114 | 6.8 | 3.311 | 35.4 | 22879 | 10 | St |
| RS084 | 2013091021 | 72.790 | −168.171 | 1004.4 | 0.2 | 88 | 110 | 6.0 | 3.082 | 37.0 | 22604 | 10 | St,Sc |
| RS085 | 2013091100 | 72.759 | −168.326 | 1004.0 | 0.3 | 87 | 111 | 6.4 | 3.106 | 48.7 | 20831 | 9 | St, Sc |
| RS086 | 2013091103 | 72.760 | −168.252 | 1003.5 | 0.6 | 96 | 91 | 6.2 | 3.150 | 40.7 | 21989 | 9 | St,Sc,Ci |
| RS087 | 2013091106 | 72.760 | −168.241 | 1003.2 | 0.7 | 89 | 81 | 7.6 | 3.117 | 41.2 | 21915 | 10 | St,Sc,Ci |
| RS088 | 2013091109 | 72.742 | −168.249 | 1003.6 | 0.1 | 93 | 81 | 4.1 | 3.168 | 38.4 | 22376 | 10 | St, Sc |
| RS089 | 2013091112 | 72.735 | −168.269 | 1003.2 | 0.4 | 98 | 77 | 4.9 | 3.154 | 39.7 | 22162 | 10 | St |
| RS090 | 2013091115 | 72.751 | −168.243 | 1002.7 | 1.1 | 99 | 63 | 6.3 | 3.138 | 51.3 | 20478 | 10 | St |
| RS091 | 2013091118 | 72.753 | −168.266 | 1002.3 | 0.8 | 100 | 69 | 5.6 | 3.139 | 35.9 | 22810 | 9 | St, Ac |
| RS092 | 2013091121 | 72.750 | −168.280 | 1002.2 | 1.3 | 96 | 71 | 7.4 | 3.109 | 39.9 | 22127 | 9 | St, As |
| RS093 | 2013091200 | 72.735 | −168.275 | 1001.6 | 1.4 | 97 | 69 | 8.5 | 3.114 | 35.0 | 22992 | 10 | St |
| RS094 | 2013091203 | 72.767 | −168.251 | 1000.4 | 1.2 | 97 | 55 | 11.0 | 3.142 | 39.1 | 22279 | 10 | St |
| RS095 | 2013091206 | 72.755 | −168.293 | 999.3 | 1.8 | 98 | 81 | 11.2 | 3.133 | 43.3 | 21608 | 10 | St |
| RS096 | 2013091209 | 72.735 | −168.249 | 999.8 | 1.8 | 100 | 149 | 6.2 | 3.137 | 34.9 | 23007 | 10 | St |
| RS097 | 2013091212 | 72.761 | −168.223 | 1001.2 | 2.7 | 98 | 186 | 4.9 | 3.271 | 65.2 | 18916 | 10 | St |
| RS098 | 2013091215 | 72.752 | −168.224 | 1002.5 | 2.9 | 89 | 195 | 6.5 | 3.079 | 54.4 | 20102 | 10 | St |
| RS099 | 2013091218 | 72.754 | −168.213 | 1003.9 | 2.1 | 93 | 206 | 6.9 | 3.169 | 43.6 | 21537 | 9 | St, Ci |
| RS100 | 2013091221 | 72.752 | −168.279 | 1005.4 | 2.2 | 92 | 206 | 3.8 | 3.167 | 61.6 | 19300 | 10 | St |
| RS101 | 2013091300 | 72.771 | −168.346 | 1005.9 | 2.7 | 90 | 242 | 1.6 | 3.153 | 44.5 | 21425 | 10 | St |
| RS102 | 2013091303 | 72.752 | −168.251 | 1005.5 | 2.6 | 84 | 14 | 1.4 | 3.306 | 37.5 | 22539 | 9 | St |
| RS103 | 2013091306 | 72.746 | −168.280 | 1005.0 | 2.0 | 96 | 59 | 3.9 | 3.196 | 37.6 | 22535 | 10 | St |
| RS104 | 2013091309 | 72.743 | −168.260 | 1005.1 | 1.6 | 99 | 55 | 3.6 | 3.289 | 39.1 | 22282 | 10 | St |
| RS105 | 2013091312 | 72.742 | −168.260 | 1005.0 | 2.0 | 95 | 71 | 5.8 | 3.263 | 36.4 | 22745 | 10 | St |
| RS106 | 2013091315 | 72.749 | −168.224 | 1004.6 | 1.8 | 99 | 45 | 8.2 | 3.241 | 41.9 | 21821 | 10 | St |
| RS107 | 2013091318 | 72.750 | −168.259 | 1005.1 | 1.5 | 97 | 49 | 8.0 | 3.252 | 39.6 | 22184 | 10 | St |
| RS108 | 2013091321 | 72.750 | −168.298 | 1006.0 | 1.6 | 97 | 42 | 6.9 | 3.242 | 40.0 | 22120 | 10 | St |
| RS109 | 2013091400 | 72.755 | −168.255 | 1006.8 | 1.0 | 97 | 24 | 9.3 | 3.228 | 35.5 | 22918 | 10 | St |
| RS110 | 2013091403 | 72.759 | −168.251 | 1008.0 | 0.3 | 93 | 28 | 9.4 | 3.201 | 41.1 | 21975 | 10 | St |
| RS111 | 2013091406 | 72.742 | −168.276 | 1009.3 | −0.4 | 84 | 28 | 10.5 | 3.180 | 41.9 | 21828 | 10 | St |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RS112 | 2013091409 | 72.742 | −168.252 | 1010.9 | −1.2 | 83 | 31 | 10.9 | 3.206 | 43.9 | 21537 | 10 | St |
| RS113 | 2013091412 | 72.743 | −168.282 | 1012.6 | −2.1 | 88 | 21 | 14.0 | 3.175 | 44.6 | 21428 | 10 | St |
| RS114 | 2013091415 | 72.750 | −168.255 | 1013.9 | −1.2 | 90 | 23 | 10.2 | 3.097 | 40.8 | 21998 | 10 | St |
| RS115 | 2013091418 | 72.745 | −168.281 | 1015.8 | −1.1 | 88 | 17 | 10.5 | 3.099 | 53.6 | 20227 | 10 | St |
| RS116 | 2013091421 | 72.761 | −168.310 | 1018.3 | −0.8 | 82 | 42 | 14.0 | 2.876 | 42.2 | 21779 | 10 | St, Sc |
| RS117 | 2013091500 | 72.772 | −168.291 | 1020.4 | −1.0 | 89 | 45 | 10.7 | 2.814 | 36.3 | 22776 | 10 | St |
| RS118 | 2013091503 | 72.763 | −168.251 | 1022.2 | −1.5 | 89 | 47 | 9.4 | 2.780 | 40.2 | 22100 | 10 | St |
| RS119 | 2013091506 | 72.736 | −168.261 | 1024.0 | −0.9 | 83 | 60 | 9.0 | 2.923 | 43.0 | 21658 | 10 | St |
| RS120 | 2013091509 | 72.730 | −168.254 | 1026.0 | −1.4 | 78 | 63 | 7.9 | 2.707 | 37.1 | 22632 | 10 | St,? |
| RS121 | 2013091512 | 72.756 | −168.313 | 1027.1 | −1.3 | 77 | 59 | 9.6 | 2.720 | 40.9 | 21986 | 10 | St |
| RS122 | 2013091515 | 72.749 | −168.224 | 1027.5 | −2.3 | 85 | 42 | 6.7 | 2.889 | 42.7 | 21711 | 10 | St |
| RS123 | 2013091518 | 72.747 | −168.273 | 1028.4 | −2.6 | 84 | 61 | 7.2 | 2.849 | 47.8 | 20971 | 10 | Sc, St |
| RS124 | 2013091521 | 72.751 | −168.297 | 1028.8 | −2.6 | 88 | 49 | 7.4 | 2.670 | 47.6 | 21011 | 10 | Sc |
| RS125 | 2013091600 | 72.753 | −168.277 | 1028.9 | −2.7 | 86 | 71 | 8.2 | 2.734 | 39.0 | 22300 | 9 | Sc, St |
| RS126 | 2013091603 | 72.766 | −168.250 | 1028.7 | −2.7 | 86 | 39 | 6.5 | 2.667 | 38.1 | 22455 | 10 | St |
| RS127 | 2013091606 | 72.750 | −168.299 | 1028.5 | −2.3 | 85 | 71 | 8.0 | 2.772 | 40.6 | 22040 | 10 | St |
| RS128 | 2013091609 | 72.736 | −168.260 | 1028.8 | −2.0 | 84 | 75 | 6.6 | 2.650 | 45.4 | 21305 | 10 | St |
| RS129 | 2013091612 | 72.762 | −168.276 | 1028.7 | −1.4 | 79 | 52 | 4.7 | 2.628 | 41.5 | 21880 | 10 | St |
| RS130 | 2013091615 | 72.741 | −168.219 | 1028.1 | −1.6 | 80 | 72 | 6.3 | 2.627 | 48.5 | 20858 | 10 | St |
| RS131 | 2013091618 | 72.744 | −168.275 | 1028.3 | −1.3 | 86 | 114 | 9.1 | 2.662 | 42.9 | 21632 | 10 | St |
| RS132 | 2013091621 | 72.751 | −168.280 | 1028.4 | −0.9 | 69 | 75 | 6.9 | 2.609 | 43.6 | 21526 | 10 | St, As |
| RS133 | 2013091700 | 72.776 | −168.318 | 1028.1 | −1.2 | 77 | 75 | 7.2 | 2.615 | 40.9 | 21956 | 10 | Sc, St, Ci |
| RS134 | 2013091703 | 72.767 | −168.250 | 1027.6 | −1.5 | 70 | 44 | 7.5 | 2.625 | 41.7 | 21823 | 10 | Sc |
| RS135 | 2013091706 | 72.755 | −168.275 | 1027.3 | −1.5 | 72 | 48 | 8.0 | 2.826 | 41.6 | 21833 | 10 | Sc,St |
| RS136 | 2013091709 | 72.748 | −168.248 | 1026.8 | −1.5 | 74 | 55 | 4.5 | 2.812 | 66.8 | 18758 | 10 | St |
| RS137 | 2013091712 | 72.764 | −168.271 | 1026.2 | −1.4 | 78 | 42 | 7.3 | 2.733 | 42.1 | 21754 | 10 | St |
| RS138 | 2013091715 | 72.750 | −168.210 | 1025.4 | −1.0 | 63 | 42 | 9.9 | 2.878 | 48.9 | 20763 | 10 | St |
| RS139 | 2013091718 | 72.745 | −168.257 | 1025.9 | −1.6 | 72 | 36 | 11.7 | 2.896 | 42.7 | 21649 | 10 | Sc |
| RS140 | 2013091721 | 72.750 | −168.303 | 1025.7 | −2.9 | 76 | 47 | 9.0 | 2.889 | 42.9 | 21622 | 10 | Sc |
| RS141 | 2013091800 | 72.760 | −168.289 | 1025.7 | −2.6 | 79 | 71 | 10.4 | 2.868 | 40.9 | 21938 | 10 | Sc |
| RS142 | 2013091803 | 72.765 | −168.250 | 1025.6 | −2.1 | 78 | 42 | 10.3 | 2.794 | 36.9 | 22600 | 10 | Sc |
| RS143 | 2013091806 | 72.758 | −168.280 | 1025.6 | −2.6 | 85 | 61 | 10.4 | 2.707 | 42.2 | 21722 | 10 | Sc,St |
| RS144 | 2013091809 | 72.740 | −168.288 | 1025.5 | −2.7 | 90 | 35 | 6.3 | 2.799 | 38.1 | 22373 | 10 | St |
| RS145 | 2013091812 | 72.743 | −168.304 | 1024.5 | −2.6 | 90 | 65 | 6.9 | 2.711 | 36.5 | 22645 | 10 | St |
| RS146 | 2013091815 | 72.756 | −168.200 | 1023.7 | −2.7 | 88 | 58 | 6.2 | 2.561 | 37.7 | 22413 | 10 | St |
| RS147 | 2013091818 | 72.747 | −168.276 | 1022.5 | −2.8 | 87 | 41 | 8.3 | 2.671 | 40.4 | 21973 | 10 | Sc |
| RS148 | 2013091821 | 72.749 | −168.293 | 1021.6 | −3.4 | 84 | 42 | 8.3 | 2.661 | 41.3 | 21816 | 10 | Sc |
| RS149 | 2013091900 | 72.745 | −168.296 | 1020.6 | −2.8 | 89 | 55 | 10.0 | 2.512 | 43.4 | 21510 | 10 | Sc |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RS150 | 2013091903 | 72.766 | −168.251 | 1020.5 | −2.4 | 85 | 41 | 9.0 | 2.624 | 41.1 | 21912 | 10 | Sc |
| RS151 | 2013091906 | 72.756 | −168.284 | 1019.4 | −2.4 | 84 | 53 | 9.4 | 2.610 | 42.8 | 21591 | 10 | SC,St |
| RS152 | 2013091909 | 72.734 | −168.252 | 1018.7 | −2.2 | 82 | 48 | 11.5 | 2.601 | 60.4 | 19353 | 10 | St |
| RS153 | 2013091912 | 72.747 | −168.311 | 1018.1 | −1.9 | 82 | 45 | 12.7 | 2.592 | 33.0 | 23212 | 10 | Sc |
| RS154 | 2013091915 | 72.749 | −168.211 | 1017.6 | −1.9 | 83 | 44 | 10.8 | 2.556 | 54.0 | 20053 | 10 | St |
| RS155 | 2013091918 | 72.750 | −168.275 | 1017.2 | −2.7 | 87 | 27 | 11.7 | 2.584 | 39.5 | 22061 | 10 | Sc |
| RS156 | 2013091921 | 72.766 | −168.289 | 1016.8 | −3.4 | 89 | 43 | 9.7 | 2.518 | 39.7 | 22022 | 10 | Sc |
| RS157 | 2013092000 | 72.754 | −168.295 | 1016.2 | −2.8 | 89 | 39 | 12.4 | 2.485 | 40.8 | 21858 | 10 | Sc |
| RS158 | 2013092003 | 72.763 | −168.244 | 1015.3 | −3.3 | 84 | 34 | 13.1 | 2.450 | 35.6 | 22723 | 10 | St,Sc |
| RS159 | 2013092006 | 72.751 | −168.288 | 1014.7 | −2.3 | 86 | 41 | 13.2 | 2.390 | 38.5 | 22207 | 10 | St,Sc |
| RS160 | 2013092009 | 72.774 | −168.216 | 1013.9 | −2.2 | 81 | 48 | 13.6 | 2.337 | 45.2 | 21176 | 10 | St,Sc |
| RS161 | 2013092012 | 72.755 | −168.254 | 1012.5 | −2.5 | 84 | 34 | 14.1 | 2.297 | 53.8 | 20039 | 10 | St |
| RS162 | 2013092015 | 72.758 | −168.186 | 1011.4 | −2.0 | 85 | 35 | 14.0 | 2.075 | 35.4 | 22705 | 10 | St |
| RS163 | 2013092018 | 72.762 | −168.249 | 1010.0 | −1.6 | 83 | 33 | 14.2 | 2.007 | 39.5 | 22003 | 10 | Sc |
| RS164 | 2013092021 | 72.749 | −168.239 | 1008.6 | −2.0 | 84 | 45 | 11.7 | 2.067 | 47.4 | 20839 | 10 | Sc |
| RS165 | 2013092100 | 72.764 | −168.285 | 1007.3 | −1.9 | 85 | 50 | 15.7 | 2.030 | 47.8 | 20774 | 9 | Sc, Ac |
| RS166 | 2013092103 | 72.780 | −168.250 | 1006.2 | −2.6 | 89 | 35 | 11.6 | 2.137 | 36.5 | 22484 | 10 | St,Sc |
| RS167 | 2013092106 | 72.766 | −168.237 | 1005.6 | −2.3 | 81 | 22 | 13.2 | 2.052 | 65.3 | 18723 | 10 | Sc,St,Ac |
| RS168 | 2013092109 | 72.773 | −168.217 | 1004.3 | −1.8 | 70 | 36 | 9.3 | 2.085 | 39.3 | 21993 | 10 | St |
| RS169 | 2013092112 | 72.779 | −168.254 | 1003.5 | −2.4 | 77 | 34 | 11.6 | 2.130 | 41.4 | 21661 | 9 | St |
| RS170 | 2013092115 | 72.758 | −168.179 | 1003.0 | −2.7 | 81 | 19 | 10.9 | 2.061 | 47.6 | 20734 | 10 | St |
| RS171 | 2013092118 | 72.742 | −168.284 | 1002.0 | −2.1 | 72 | 6 | 10.0 | 2.036 | 32.5 | 23192 | 10 | Sc |
| RS172 | 2013092121 | 72.750 | −168.296 | 1001.5 | −2.6 | 79 | 7 | 6.9 | 1.942 | 41.6 | 20941 | 10 | Sc |
| RS173 | 2013092200 | 72.740 | −168.215 | 1001.2 | −2.6 | 78 | 23 | 5.4 | 1.834 | 48.9 | 20562 | 10 | Sc |
| RS174 | 2013092203 | 72.765 | −168.249 | 1000.4 | −2.8 | 82 | 6 | 7.4 | 1.945 | 50.8 | 20317 | 10 | Sc,Ci |
| RS175 | 2013092206 | 72.747 | −168.278 | 999.8 | −3.0 | 90 | 359 | 7.1 | 1.824 | 37.4 | 22281 | 10 | Sc,St |
| RS176 | 2013092209 | 72.735 | −168.250 | 998.8 | −2.6 | 89 | 7 | 4.8 | 1.984 | 29.7 | 23756 | 10 | St? |
| RS177 | 2013092212 | 72.737 | −168.251 | 998.0 | −2.5 | 87 | 33 | 4.2 | 1.605 | 57.2 | 19532 | 10 | St? |
| RS178 | 2013092215 | 72.749 | −168.249 | 997.3 | −2.1 | 81 | 63 | 3.3 | 1.865 | 141.1 | 13600 | 10 | Sc |
| RS179 | 2013092218 | 72.751 | −168.265 | 997.0 | −2.2 | 83 | 100 | 3.4 | 1.536 | 40.8 | 21709 | 10 | Sc |
| RS180 | 2013092221 | 72.750 | −168.309 | 996.8 | −1.4 | 77 | 156 | 4.1 | 1.568 | 36.3 | 22458 | 9 | Sc |
| RS181 | 2013092300 | 72.754 | −168.238 | 997.0 | −1.2 | 75 | 164 | 5.9 | 1.714 | 33.7 | 22934 | 9 | Sc, Ac |
| RS182 | 2013092303 | 72.772 | −168.251 | 997.5 | −1.2 | 77 | 132 | 7.2 | 1.795 | 46.7 | 20838 | 3 | Sc,Ac,Ci |
| RS183 | 2013092306 | 72.755 | −168.246 | 997.7 | −1.4 | 77 | 133 | 7.2 | 1.799 | 40.8 | 21714 | 6 | Sc,Ac |
| RS184 | 2013092309 | 72.732 | −168.257 | 998.2 | −1.8 | 77 | 121 | 8.3 | 1.804 | 38.8 | 22044 | 9 | Sc |
| RS185 | 2013092312 | 72.746 | −168.267 | 999.0 | −2.8 | 83 | 130 | 8.6 | 1.690 | 34.0 | 22879 | 10 | St |
| RS186 | 2013092315 | 72.750 | −168.192 | 999.1 | −3.2 | 85 | 99 | 8.9 | 1.683 | 53.2 | 20015 | 9 | St |
| RS187 | 2013092318 | 72.751 | −168.266 | 998.5 | −2.6 | 86 | 96 | 8.2 | 1.628 | 39.1 | 22026 | 10 | St |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RS188 | 2013092321 | 72.750 | −168.310 | 998.1 | −2.4 | 84 | 73 | 7.1 | 1.750 | 35.9 | 22563 | 10 | Sc,St |
| RS189 | 2013092400 | 72.756 | −168.225 | 997.5 | −2.5 | 90 | 68 | 5.2 | 1.588 | 34.1 | 22905 | 10 | St |
| RS190 | 2013092403 | 72.773 | −168.251 | 997.1 | −2.1 | 92 | 104 | 2.0 | 1.603 | 41.0 | 21740 | 7 | Sc,Ci |
| RS191 | 2013092406 | 72.755 | −168.223 | 996.8 | −1.8 | 82 | 181 | 6.0 | 1.619 | 75.5 | 17773 | 10 | Sc,Ci |
| RS192 | 2013092409 | 72.733 | −168.242 | 997.4 | −0.6 | 89 | 154 | 8.0 | 1.655 | 37.6 | 22282 | 10 | St,Sc |
| RS193 | 2013092412 | 72.757 | −168.197 | 997.3 | 0.2 | 89 | 152 | 11.0 | 2.016 | 45.5 | 21077 | 3 | Sc,Ci |
| RS194 | 2013092415 | 72.751 | −168.156 | 997.3 | 0.3 | 87 | 158 | 9.5 | 1.595 | 50.8 | 20359 | 10 | St |
| RS195 | 2013092418 | 72.756 | −168.243 | 997.1 | 0.3 | 85 | 170 | 3.0 | 1.581 | 39.4 | 22020 | 8 | St, Cu, Ci |
| RS196 | 2013092421 | 72.752 | −168.291 | 997.2 | −0.4 | 85 | 173 | 7.4 | 1.627 | 36.7 | 22475 | 5 | Sc, Cu, Cs |
| RS197 | 2013092500 | 72.765 | −168.245 | 997.2 | −0.7 | 84 | 160 | 10.3 | 1.588 | 42.0 | 21626 | 8 | Cu, St, Ci |
| RS198 | 2013092503 | 72.776 | −168.249 | 996.7 | −1.4 | 93 | 122 | 3.3 | 1.588 | 41.5 | 21712 | 10 | Sc |
| RS199 | 2013092506 | 72.759 | −168.265 | 994.5 | 0.2 | 88 | 114 | 10.7 | 1.589 | 45.0 | 21190 | 10 | St,Sc |
| RS200 | 2013092509 | 72.725 | −168.249 | 994.0 | −0.7 | 86 | 257 | 8.8 | 1.992 | 39.5 | 22026 | 10? | Sc,Ac |
| RS201 | 2013092512 | 72.745 | −168.208 | 993.8 | −1.2 | 94 | 230 | 14.9 | 1.958 | 40.4 | 21881 | 10 | Sc? |
| RS202 | 2013092515 | 72.759 | −168.918 | 993.6 | −0.7 | 79 | 205 | 13.5 | 2.051 | 45.7 | 21075 | 6 | Sc |
| RS203 | 2013092518 | 72.737 | −168.187 | 993.9 | −0.9 | 92 | 281 | 10.1 | 2.077 | 39.1 | 22104 | 8 | Sc, Ci |
| RS204 | 2013092521 | 72.749 | −168.294 | 994.8 | −0.9 | 82 | 272 | 9.1 | 2.003 | 43.5 | 21416 | 6 | Sc, Cu |
| RS205 | 2013092600 | 72.753 | −168.231 | 995.5 | −1.5 | 85 | 276 | 8.0 | 2.084 | 47.1 | 20906 | 8 | Sc |
| RS206 | 2013092603 | 73.092 | −168.906 | 995.4 | −1.8 | 84 | 289 | 7.1 | 0.866 | 50.1 | 20499 | 7 | Sc |
| RS207 | 2013092606 | 73.812 | −168.781 | 994.6 | −3.6 | 91 | 277 | 8.8 | −0.990 | 54.8 | 19899 | 8 | Sc |
| RS208 | 2013092609 | 74.006 | −168.764 | 995.1 | −3.3 | 84 | 251 | 7.1 | −1.030 | 40.3 | 21905 | 9 | Sc |
| RS209 | 2013092612 | 73.501 | −168.757 | 996.2 | −3.6 | 86 | 288 | 3.9 | −0.860 | 46.6 | 20962 | 10 | Sc? |
| RS210 | 2013092615 | 73.493 | −167.760 | 996.4 | −3.5 | 83 | 263 | 5.5 | −1.020 | 47.6 | 20814 | 10 | Sc |
| RS211 | 2013092618 | 73.001 | −167.637 | 996.8 | −2.1 | 88 | 331 | 2.3 | 0.622 | 45.7 | 21093 | 9 | Sc |
| RS212 | 2013092621 | 73.042 | −165.446 | 997.1 | −1.6 | 75 | 238 | 4.4 | −0.140 | 46.2 | 21029 | 8 | St, Sc |
| RS213 | 2013092700 | 73.064 | −164.609 | 997.5 | −1.4 | 64 | 242 | 3.1 | −0.570 | 40.0 | 21977 | 8 | Ac, Sc |
| RS214 | 2013092703 | 73.383 | −163.298 | 997.6 | −1.6 | 80 | 180 | 5.1 | −0.420 | 39.0 | 22152 | 6 | Sc,Ci,As |
| RS215 | 2013092706 | 73.694 | −162.653 | 997.3 | −1.3 | 84 | 161 | 3.9 | −0.500 | 45.1 | 21190 | 8 | Sc,Ci,Ac |
| RS216 | 2013092709 | 74.002 | −161.989 | 997.5 | −0.5 | 91 | 180 | 6.5 | 0.150 | 41.4 | 21767 | 8 | Sc,Ci,As |
| RS217 | 2013092712 | 73.821 | −160.189 | 998.2 | −0.1 | 91 | 180 | 8.2 | 0.290 | 37.2 | 22465 | 10 | St? |
| RS218 | 2013092715 | 73.804 | −159.983 | 998.8 | 0.0 | 81 | 202 | 10.4 | 0.239 | 54.1 | 20016 | 10 | Sc |
| RS219 | 2013092718 | 73.807 | −159.973 | 999.6 | −0.2 | 78 | 187 | 10.3 | −0.330 | 46.3 | 21052 | 4 | Ac, Sc, Cu |
| RS220 | 2013092721 | 73.593 | −160.341 | 1000.0 | 0.1 | 70 | 173 | 11.1 | 0.791 | 53.6 | 20116 | 6 | Ac, As, Sc |
| RS221 | 2013092800 | 73.303 | −160.839 | 1000.5 | −0.2 | 78 | 179 | 9.5 | 0.693 | 44.5 | 21351 | 8 | Ac, Sc |
| RS222 | 2013092803 | 73.150 | −162.319 | 999.8 | −0.4 | 83 | 173 | 8.2 | 0.887 | 56.2 | 19821 | 9 | Sc,As |
| RS223 | 2013092806 | 72.780 | −162.458 | 1000.4 | −1.5 | 92 | 294 | 6.7 | −0.220 | 37.7 | 22447 | 9 | unknown |
| RS224 | 2013092809 | 72.407 | −161.280 | 1001.2 | −0.8 | 92 | 215 | 5.5 | 0.179 | 40.1 | 22047 | 10? | Sc, Ci |
| RS225 | 2013092812 | 71.972 | −159.790 | 1002.0 | −1.4 | 89 | 312 | 1.7 | 0.145 | 42.0 | 21746 | 2 | Ac |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RS226 | 2013092815 | 71.559 | −158.446 | 1002.0 | −0.6 | 85 | 338 | 8.1 | 0.764 | 40.2 | 22024 | 10 | Sc |
| RS227 | 2013092818 | 71.328 | −157.661 | 1002.3 | −0.5 | 91 | 13 | 6.1 | 0.638 | 74.3 | 17968 | 10 | Sc, St |
| RS228 | 2013092821 | 71.331 | −157.669 | 1003.3 | −1.2 | 94 | 358 | 10.0 | 0.795 | 92.2 | 16516 | 10 | St, Sc |
| RS229 | 2013092900 | 71.406 | −157.626 | 1004.7 | −1.4 | 76 | 347 | 10.8 | 0.943 | 47.0 | 20977 | 10 | Sc, St |
| RS230 | 2013092903 | 72.086 | −157.279 | 1006.0 | −1.7 | 64 | 6 | 8.1 | 0.369 | 47.4 | 20915 | 9 | Ac,Ci |
| RS231 | 2013092906 | 72.781 | −156.653 | 1007.0 | −2.2 | 64 | 9 | 6.4 | 0.042 | 42.4 | 21641 | 10? | Sc? |
| RS232 | 2013092909 | 73.136 | −156.689 | 1008.1 | −2.3 | 61 | 313 | 2.5 | 0.251 | 39.0 | 22175 | 10 | unknown |
| RS233 | 2013092912 | 72.625 | −157.147 | 1009.7 | −2.0 | 57 | 305 | 2.1 | 0.012 | 41.7 | 21740 | 10 | unknown |
| RS234 | 2013092915 | 71.850 | −157.461 | 1011.0 | −1.7 | 61 | 3 | 3.8 | 0.611 | 46.1 | 21079 | 10 | unknown |
| RS235 | 2013092918 | 71.327 | −157.658 | 1012.3 | −1.7 | 53 | 27 | 3.2 | 1.165 | 49.4 | 20630 | 10 | Sc |
| RS236 | 2013092921 | 71.329 | −157.648 | 1013.4 | −1.6 | 58 | 0 | 0.8 | 0.729 | 34.0 | 23074 | 10 | Sc,As |
| RS237 | 2013093000 | 71.330 | −157.632 | 1014.2 | −1.3 | 59 | 278 | 0.3 | 0.776 | 45.1 | 21224 | 9 | Sc |
| RS238 | 2013093003 | 71.492 | −158.850 | 1014.8 | −1.7 | 62 | 186 | 0.4 | 0.726 | 47.0 | 20942 | 2 | Sc,Ci,As |
| RS239 | 2013093006 | 71.740 | −160.646 | 1014.6 | −0.9 | 69 | 215 | 3.5 | 0.242 | 64.0 | 18905 | 2 | Sc,Ac |
| RS240 | 2013093009 | 71.994 | −162.539 | 1014.5 | −1.3 | 92 | 184 | 5.5 | −0.080 | 38.4 | 22243 | 10 | unknown |
| RS241 | 2013093012 | 72.251 | −164.413 | 1014.4 | −0.9 | 80 | 241 | 3.4 | 0.034 | 38.2 | 22261 | 1 | unknown |
| RS242 | 2013093015 | 72.494 | −166.295 | 1016.2 | −1.9 | 85 | 10 | 4.2 | 0.189 | 39.4 | 22043 | 9 | unknown |
| RS243 | 2013093018 | 72.737 | −168.152 | 1017.0 | −1.9 | 79 | 80 | 2.8 | −0.370 | 182.1 | 11957 | 10 | St |
| RS244 | 2013093021 | 72.750 | −168.304 | 1018.1 | −1.3 | 78 | 147 | 5.6 | −0.370 | 39.1 | 22084 | 6 | St, Sc, Cs |
| RS245 | 2013100100 | 72.752 | −168.250 | 1018.8 | −1.2 | 79 | 134 | 6.4 | −0.300 | 44.9 | 21188 | 8 | Sc, St |
| RS246 | 2013100103 | 72.775 | −168.251 | 1019.5 | −1.3 | 83 | 122 | 7.4 | −0.220 | 37.0 | 22435 | 8 | Sc,Ci |
| RS247 | 2013100106 | 72.743 | −168.259 | 1020.0 | −1.7 | 96 | 92 | 10.8 | −0.050 | 40.3 | 21856 | 10 | Sc |
| RS248 | 2013100109 | 72.734 | −168.244 | 1020.5 | −0.8 | 80 | 141 | 8.0 | 0.945 | 41.6 | 21663 | 7 | unknown |
| RS249 | 2013100112 | 72.757 | −168.223 | 1020.9 | −1.1 | 82 | 163 | 7.2 | 1.032 | 39.1 | 22056 | 1 | unknown |
| RS250 | 2013100115 | 72.750 | −168.178 | 1021.3 | −0.7 | 84 | 164 | 5.7 | 0.897 | 41.5 | 21653 | 2 | unknown |
| RS251 | 2013100118 | 72.755 | −168.266 | 1021.2 | −1.3 | 79 | 135 | 8.4 | 0.989 | 42.4 | 21498 | 9 | Sc |
| RS252 | 2013100121 | 72.484 | −168.745 | 1020.8 | 0.0 | 70 | 151 | 8.5 | 1.760 | 45.2 | 21093 | 4 | Sc |
| RS253 | 2013100200 | 72.003 | −168.741 | 1020.3 | −0.2 | 69 | 150 | 7.9 | 2.167 | 43.7 | 21324 | 8 | Sc |
| RS254 | 2013100203 | 71.501 | −168.747 | 1019.3 | −0.9 | 84 | 137 | 8.3 | 2.810 | 43.6 | 21331 | 9 | Sc,As |
| RS255 | 2013100206 | 70.999 | −168.751 | 1017.9 | −0.1 | 82 | 124 | 11.4 | 2.628 | 38.5 | 22128 | 10 | Sc |
| RS256 | 2013100209 | 70.500 | −168.751 | 1016.9 | 0.2 | 69 | 139 | 8.1 | 2.957 | 31.3 | 23486 | 10 | unknown |
| RS257 | 2013100212 | 70.089 | −168.750 | 1015.9 | −0.3 | 76 | 129 | 10.4 | 2.601 | 42.5 | 21501 | 10 | unknown |
| RS258 | 2013100215 | 69.644 | −168.750 | 1014.9 | −0.7 | 85 | 91 | 6.9 | 2.755 | 37.8 | 22260 | 10 | unknown |
| RS259 | 2013100218 | 69.132 | −168.752 | 1014.5 | −0.2 | 78 | 241 | 0.5 | 3.932 | 38.0 | 22242 | 10 | St, Sc |
| RS260 | 2013100221 | 68.728 | −168.111 | 1014.5 | 0.1 | 70 | 124 | 1.1 | 4.056 | 40.7 | 21808 | 9 | Sc, St |
| RS261 | 2013100300 | 68.302 | −167.046 | 1014.4 | −0.2 | 77 | 79 | 2.0 | 4.614 | 123.6 | 14580 | 10 | St |
| RS262 | 2013100303 | 68.203 | −167.330 | 1014.3 | 0.3 | 75 | 27 | 2.3 | 4.307 | 64.4 | 18836 | 10 | Sc,St |
| RS263 | 2013100306 | 68.002 | −168.003 | 1014.3 | 0.9 | 82 | 306 | 4.0 | 2.610 | 62.7 | 19023 | 10 | unknown |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RS264 | 2013100309 | 67.765 | −168.465 | 1014.6 | 0.4 | 78 | 323 | 3.3 | 2.169 | 42.8 | 21499 | 10? | St |
| RS265 | 2013100312 | 68.020 | −168.586 | 1014.2 | 0.8 | 85 | 300 | 3.9 | 2.281 | 34.8 | 22817 | 10 | unknown |
| RS266 | 2013100315 | 68.422 | −168.723 | 1013.2 | 1.3 | 94 | 349 | 4.9 | 4.235 | 66.4 | 18627 | 10 | St, fog |
| RS267 | 2013100318 | 68.258 | −168.752 | 1012.7 | 1.3 | 83 | 22 | 2.2 | 3.051 | 41.3 | 21713 | 10 | Sc |
| RS268 | 2013100321 | 68.000 | −168.752 | 1012.7 | 1.1 | 87 | 10 | 2.8 | 2.139 | 44.1 | 21298 | 8 | As, St |
| RS269 | 2013100400 | 67.893 | −168.748 | 1012.5 | 1.2 | 92 | 6 | 3.2 | 1.567 | 35.7 | 22668 | 10 | St |
| RS270 | 2013100403 | 67.530 | −168.749 | 1012.0 | 1.1 | 87 | 19 | 5.2 | 2.877 | 47.4 | 20819 | 10 | St |
| RS271 | 2013100406 | 67.250 | −168.751 | 1012.0 | 1.3 | 82 | 0 | 9.4 | 3.822 | 36.8 | 22469 | 2 | St,Sc |
| RS272 | 2013100409 | 67.000 | −168.758 | 1012.3 | 1.2 | 86 | 354 | 11.9 | 4.019 | 32.5 | 23295 | 10 | St |
| RS273 | 2013100412 | 66.501 | −168.760 | 1012.5 | 0.9 | 89 | 346 | 8.2 | 4.558 | 44.2 | 21319 | 8 | unknown |
| RS274 | 2013100415 | 66.022 | −168.749 | 1012.8 | 0.7 | 86 | 328 | 9.3 | 1.760 | 42.8 | 21524 | 9 | unknown |
| RS275 | 2013100418 | 65.781 | −168.756 | 1012.4 | 0.5 | 82 | 337 | 8.5 | 1.692 | 60.2 | 19363 | 4 | Sc, Cu |
| RS276 | 2013100421 | 65.702 | −168.524 | 1011.9 | 0.5 | 82 | 340 | 4.0 | 2.087 | 40.0 | 21982 | 2 | As, St |
| RS277 | 2013100500 | 65.386 | −168.422 | 1010.0 | 0.8 | 82 | 93 | 1.7 | 2.610 | 48.0 | 20841 | 2 | Sc, Ci |
| RS278 | 2013100506 | 64.078 | −168.098 | 1003.5 | 1.4 | 80 | 136 | 10.3 | 4.129 | 75.4 | 17995 | 9 | Sc |
| RS279 | 2013100512 | 62.833 | −167.335 | 993.7 | 2.5 | 88 | 126 | 13.6 | 3.506 | 38.1 | 22332 | 10 | unknown |
| RS280 | 2013100518 | 61.886 | −167.357 | 984.6 | 6.3 | 100 | 188 | 7.6 | 5.858 | 43.1 | 21557 | 10 | St |
| RS281 | 2013100600 | 60.871 | −167.736 | 987.8 | 7.3 | 86 | 232 | 10.8 | 7.958 | 117.6 | 14993 | 10 | St |
| RS282 | 2013100606 | 59.874 | −167.916 | 993.0 | 7.2 | 85 | 219 | 12.4 | 7.838 | 34.3 | 23033 | 2 | Sc |
| RS283 | 2013100612 | 58.870 | −167.653 | 995.9 | 6.6 | 91 | 204 | 13.9 | 7.438 | 41.3 | 21811 | 9? | unknown |
| RS284 | 2013100618 | 57.885 | −167.404 | 995.9 | 6.5 | 94 | 209 | 12.2 | 5.096 | 128.0 | 14438 | 10 | St |
| RS285 | 2013100700 | 56.822 | −167.150 | 1000.3 | 7.9 | 94 | 241 | 13.1 | 11.800 | 59.6 | 19441 | 7 | Ac, Sc |
| RS286 | 2013100706 | 55.786 | −166.901 | 1003.2 | 7.8 | 94 | 216 | 9.8 | 13.000 | 35.1 | 22873 | 10 | unknown |
| RS287 | 2013101000 | 54.214 | −167.514 | 999.4 | 7.8 | 97 | 188 | 13.6 | 6.845 | 34.9 | 22915 | 10 | St, Ns |
| RS288 | 2013101006 | 54.144 | −169.027 | 996.2 | 7.9 | 91 | 217 | 13.5 | 7.611 | 39.1 | 22187 | 10 | St |
| RS289 | 2013101012 | 54.066 | −170.791 | 995.7 | 7.9 | 91 | 238 | 11.0 | 8.029 | 44.8 | 21285 | 2 | unknown |
| RS290 | 2013101018 | 53.993 | −172.613 | 997.0 | 7.9 | 84 | 260 | 13.5 | 8.410 | 37.4 | 22425 | 8 | Sc |
| RS291 | 2013101100 | 53.909 | −174.487 | 997.5 | 7.8 | 75 | 242 | 11.5 | 8.198 | 34.1 | 23014 | 8 | Sc, ,As |
| RS292 | 2013101106 | 53.825 | −176.502 | 993.2 | 7.1 | 75 | 198 | 6.3 | 8.342 | 40.9 | 21827 | 7 | St, Sc |
| RS293 | 2013101112 | 53.732 | −178.610 | 989.1 | 7.5 | 83 | 269 | 9.3 | 8.554 | 43.0 | 21495 | 4? | unknown |
| RS294 | 2013101118 | 53.636 | 179.238 | 989.4 | 6.2 | 76 | 334 | 13.9 | 8.525 | 33.8 | 23041 | 4 | Sc |
| RS295 | 2013101200 | 53.535 | 176.994 | 994.1 | 7.0 | 80 | 313 | 13.1 | 9.160 | 44.2 | 21311 | 6 | Sc, Cu, As, |
| RS296 | 2013101206 | 53.466 | 175.259 | 1004.2 | 7.3 | 73 | 339 | 14.7 | 9.389 | 37.9 | 22323 | 6 | Sc, Nb, Ac |
| RS297 | 2013101212 | 53.382 | 173.486 | 1011.5 | 6.7 | 68 | 331 | 9.8 | 9.188 | 34.6 | 22915 | 2? | unknown |
| RS298 | 2013101218 | 52.896 | 171.738 | 1013.7 | 6.1 | 57 | 291 | 5.7 | 9.492 | 31.3 | 23584 | 3 | Sc |
| RS299 | 2013101300 | 51.732 | 170.205 | 1011.7 | 6.8 | 68 | 161 | 9.3 | 8.905 | 41.7 | 21808 | 10? | As, Sc |
| RS300 | 2013101306 | 50.710 | 168.919 | 995.6 | 8.7 | 97 | 130 | 14.5 | 9.337 | 621.1 | 3868 | 10 | St |
| RS301 | 2013101312 | 49.823 | 167.794 | 982.5 | 10.8 | 100 | 199 | 15.0 | 9.018 | 47.0 | 21077 | 10? | unknown |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RS302 | 2013101318 | 49.201 | 166.880 | 984.4 | 9.9 | 88 | 242 | 16.3 | 9.459 | 35.8 | 22784 | 10? | unknown |
| RS303 | 2013101400 | 48.865 | 166.586 | 986.3 | 9.6 | 78 | 246 | 17.0 | 9.240 | 49.4 | 20729 | 3 | St, Sc, Ac |
| RS304 | 2013101406 | 48.597 | 165.571 | 990.1 | 8.4 | 84 | 301 | 8.8 | 9.555 | 45.8 | 21204 | 9 | Sc |
| RS305 | 2013101412 | 47.734 | 164.828 | 999.7 | 8.3 | 71 | 326 | 15.1 | 9.512 | 43.2 | 21584 | 4 | unknown |
| RS306 | 2013101418 | 46.892 | 164.010 | 1008.2 | 8.3 | 75 | 306 | 7.9 | 10.904 | 35.1 | 22858 | 10? | unknown |
| RS307 | 2013101500 | 46.155 | 163.070 | 1017.3 | 9.1 | 72 | 282 | 12.4 | 10.801 | 35.5 | 22790 | 5 | Sc, Cu, Ci |
| RS308 | 2013101506 | 45.601 | 161.745 | 1022.2 | 9.3 | 66 | 263 | 10.4 | 12.516 | 45.6 | 21214 | 9 | Sc, Ac |
| RS309 | 2013101512 | 45.033 | 160.393 | 1022.4 | 11.8 | 85 | 205 | 11.5 | 10.701 | 33.3 | 23235 | 10 | unknown |
| RS310 | 2013101518 | 44.225 | 159.362 | 1021.0 | 13.6 | 85 | 192 | 12.5 | 13.099 | 48.6 | 20855 | 9? | St? |
| RS311 | 2013101600 | 43.080 | 158.226 | 1019.7 | 16.0 | 90 | 178 | 13.6 | 15.787 | 27.5 | 24468 | 9 | Ac, As, Cs |
| RS312 | 2013101606 | 42.003 | 157.151 | 1010.8 | 18.8 | 88 | 176 | 13.4 | 16.765 | 35.7 | 22847 | 10 | Ac, As, Ci |
| RS313 | 2013101706 | 40.647 | 153.402 | 1018.3 | 12.3 | 66 | 323 | 11.4 | 16.009 | 32.0 | 23539 | 6 | Cu |
| RS314 | 2013101712 | 40.525 | 152.275 | 1023.3 | 12.0 | 55 | 316 | 8.4 | 19.285 | 35.0 | 22973 | 1 | Cu |
| RS315 | 2013101718 | 40.340 | 150.877 | 1024.7 | 13.0 | 58 | 273 | 6.7 | 17.665 | 35.6 | 22796 | 3 | Cu, Sc |
| RS316 | 2013101800 | 40.134 | 149.436 | 1027.3 | 13.1 | 69 | 284 | 6.8 | 16.481 | 32.6 | 23366 | 5 | Cu, As, Ac, |
| RS317 | 2013101806 | 40.131 | 148.133 | 1027.7 | 12.6 | 57 | 322 | 4.8 | 14.690 | 41.3 | 21879 | 1 | As |
| RS318 | 2013101812 | 40.192 | 146.521 | 1029.4 | 13.7 | 55 | 343 | 4.2 | 14.068 | 36.3 | 22670 | 6 | Ac, As |
| RS319 | 2013101818 | 40.264 | 145.125 | 1028.9 | 13.9 | 63 | 6 | 6.2 | 18.917 | 34.0 | 23048 | 3 | AC?, Sc? |

## 2.2. Doppler Radar

(1) Personnel

| | |
|---|---|
| Jun Inoue | JAMSTEC/NIPR :Principal Investigator |
| Masatake Hori | JAMSTEC |
| Kazuhiro Oshima | JAMSTEC |
| Kazutoshi Sato | NIPR |
| Taku Mitsui | JAMSTEC/Nagasaki Univ. |
| Yo Tobase | JAMSTEC/Kyushu Univ. |
| Souichiro Sueyoshi | GODI |
| Katsuhisa Maeno | GODI |
| Masanori Murakami | GODI |
| Koichi Inagaki | GODI |
| Kazuho Yoshida | GODI |
| Ryo Ohyama | MIRAI Crew |

(2) Objective

Low level clouds over the Arctic Ocean which usually dominate during summer have a key role for sea/ice surface heat budget. In addition to this, cyclones which modify the sea-ice distributions are substantially important to understand the air-ice-sea interaction. To grasp the broad precipitation system over the Arctic Ocean, three dimensional radar echo structure and wind fields of rain/snow clouds was obtained by C-band Doppler radar observation.

(3) Parameters

C-band Doppler radar observed three dimensional radar echo structure and wind fields of rain/snow cloud.

(4) Instruments and Methods

The specifications of R/V MIRAI shipboard Doppler radar (RC-52B, Mitsubishi Electric Co. Ltd., Japan) are as follows.

| | |
|---|---|
| Frequency: | 5290MHz (C-band) |
| Beam Width: | better than 1.5 degrees |
| Transmit Power: | 250kW (Peak Power) |
| Signal Processor: | RVP-7 (Vaisala Inc. Sigmet Product Line, U.S.A) |

Inertial Navigation Unit: PHINS (Ixsea SAS, France)
Application Software: IRIS/Open Ver.8.12.4
(Vaisala Inc. Sigmet Product Line, U.S.A)

Measured parameters are Radar reflectivity factor (dBZ), Doppler velocity (m/s), and velocity width (m/s). We checked transmitted frequency, mean output power and pulse repetition frequency (PRF) every day. The transmit pulse width and the receiver performance were checked before and after the observation.

(5) Observation log

The observation was performed throughout in the MR13-06 cruise. During the observation, the volume scan consisting of 21 PPIs was conducted every 10 minutes. Meanwhile, a surveillance PPI scan was performed every 30 minutes. The parameters for above scans are listed in Table 2.2-1.

Observertion Period

Leg1: 5:00UTC 29 Aug. 2013 – 15:00UTC 7 Oct. 2013

Leg2: 19:40 UTC 9 Oct. 2013 – 00:00UTC 18 Oct. 2013

(6) Preliminary results

During the latter half of the stationary observation at (72.75N, 168.25W), two polar lows passed over the ship on 23 and 24 September 2013. The Doppler radar picked up almost center of the lows. After that the two polar lows were merged and developed to a larger cyclone on 25 September (Figure 2.2-1). Rapid changes in wind speed and wind direction occurred in the period. We were able to confirm the horizontal structure and temporal variation of those lows by NOAA satellite images as well. In addition, we often observed stratus clouds and cloud cells with snowfall (Figure 2.2-2) during the cruise. Echo top of those clouds were below 1 km and about 2-5 km height, respectively.

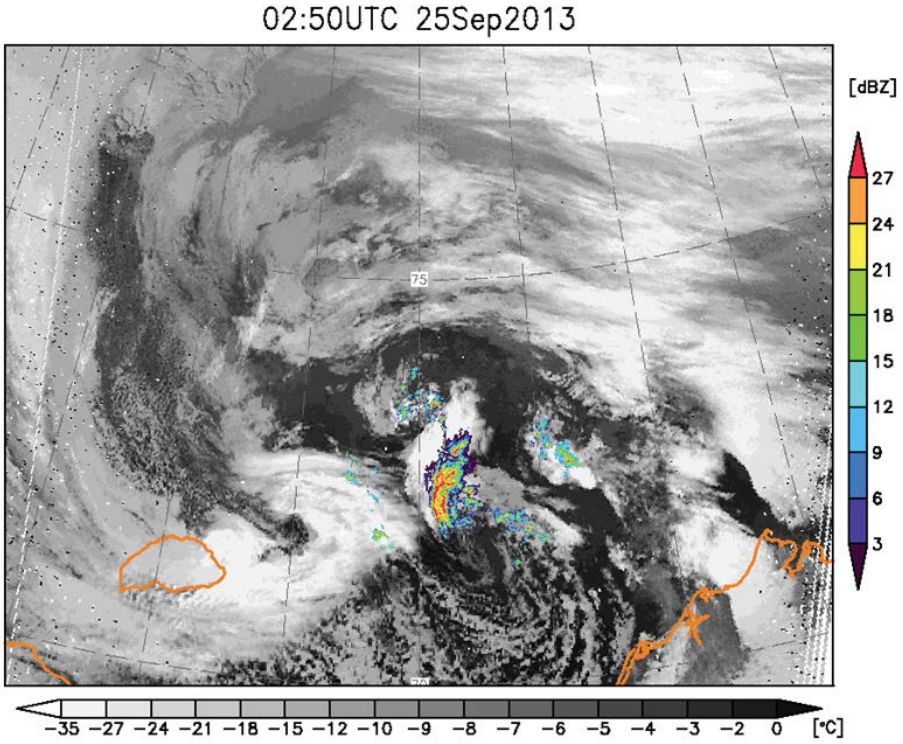


**Figure 2.2-1.** NOAA/AVHRR infrared image overlaid with the radar reflectivity on 02:50UTC 25 September 2013.

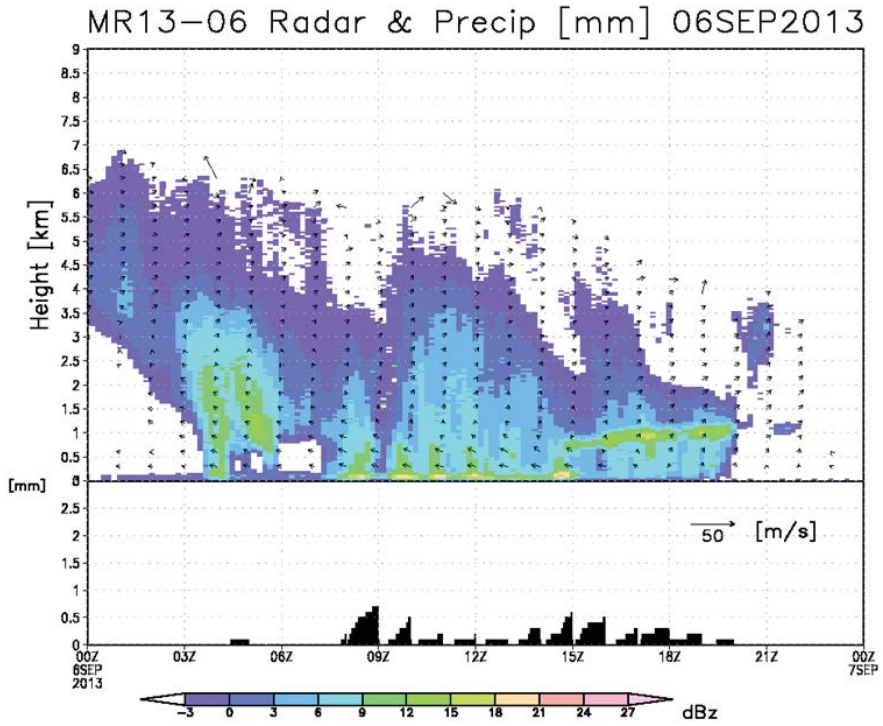


**Figure 2.2-2.** Top: Time-height cross section of radar reflectivity (shade) and VAD wind (vector). Bottom: Time series of rainfall (bar) on 6 September 2013.

(7) Data Archive

The raw data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC.

(8) Remark

1. Transmit power of 2.0 μs pulse was reduced as following periods, due to transmitter trouble.

   [Transmit power : 225kW] 00:59 UTC 19 Sep. 2013 – 06:59 UTC 5 Oct. 2013
   [Transmit power : 200kW] 19:40 UTC 9 Oct. 2013 – 00:00 UTC 18 Oct. 2013

2. Following periods, Surveillance PPI observation was suspended.
   07:29 UTC 5 Oct. 2013 – 15:00 UTC 7 Oct. 2013

3. Following periods, observation data was missing
   Surveillance PPI:
   05:59 UTC 12 Sep. 2013 – 04:29 UTC 15 Sep. 2013 (Recordig media trouble)
   21:29 UTC 18 Sep. 2013 – 22:29 UTC 18 Sep. 2013 (Transmitter overload)
   23:29 UTC 18 Sep. 2013 – 00:29 UTC 19 Sep. 2013 (Transmitter overload)
   06:29 UTC 5 Oct. 2013 – 06:59 UTC 5 Oct. 2013 (Transmitter overload)
   19:59 UTC 9 Oct. 2013 – 20:29 UTC 9 Oct. 2013 (AFC* trouble)
   Volume scan:
   21:30 UTC 18 Sep. 2013 – 22:40 UTC 18 Sep. 2013 (Transmitter overload)
   23:30 UTC 18 Sep. 2013 (Transmitter overload)
   06:30 UTC 5 Oct. 2013 – 07:10 UTC 5 Oct. 2013 (Transmitter overload)
   19:40 UTC 9 Oct. 2013 – 20:40 UTC 59Oct. 2013 (AFC trouble)
   20:50 UTC 13 Oct. 2013 (Modulator overload)
   * AFC: Automatic Frequency Controller

**Table 2.2-1.** Selected parameters of C-band Doppler radar

| | Surveillance PPI | Volume scan | RHI |
|---|---|---|---|
| Pulse width | 2.0 [μs] | 0.5 [μs] | |
| Scan speed | 18 [deg/sec] | | Automatic |
| PRF | 260 [Hz] | 900/720 [Hz] | |
| Sweep integration | 32 samples | 40 samples | |
| Ray spacing | about 1.0 [deg] | | |
| Bin spacing | 250 [m] | | |
| Elevations | 0.5 | 0.5, 1.0, 1.5, 2.1, 2.8, 3.5, 4.3, 5.1, 5.9, 6.8, 7.6, 8.5, 9.4, 10.4, 11.5, 12.7, 14.0, 15.5, 16.8, 18.8, 21.3 | 0.0 to 60.0 |
| Azimuths | Full Circle | | Optional |
| Range | 300 [km] | 160 [km] | |
| Software Filters | No filter | Dual-PRF velocity unfolding | |
| Gain control | Fixed | | |

## 2.3. Surface Meteorological Observations

(1) Personnel

| | |
|---|---|
| Jun Inoue | JAMSTEC/NIPR: PI |
| Masatake Hori | JAMSTEC |
| Kazuhiro Oshima | JAMSTEC |
| Kazutoshi Sato | NIPR |
| Taku Mitsui | JAMSTEC/Nagasaki Univ |
| Yo Tobase | JAMSTEC/Kyushu Univ |
| Souichiro Sueyoshi | GODI |
| Katsuhisa Maeno | GODI |
| Kazuho Yoshida | GODI |
| Masanori Murakami | GODI |
| Koichi Inagaki | GODI |
| Ryo Ohyama | MIRAI Crew |

(2) Objective

Surface meteorological parameters are observed as a basic dataset of the meteorology. These parameters bring us the information about the temporal variation of the meteorological condition surrounding the ship.

(3) Instruments and Methods

Surface meteorological parameters were observed throughout the MR13-06 cruise. We used two systems for the observation, during this cruise.

i) MIRAI Surface Meteorological observation (SMet) system

Instruments of SMet system are listed in Table.2.3-1 and measured parameters are listed in Table.2.3-2. Data were collected and processed by KOAC-7800 weather data processor made by Koshin-Denki, Japan. The data set consists of 6-second averaged data.

ii) Shipboard Oceanographic and Atmospheric Radiation (SOAR) system

SOAR system designed by BNL (Brookhaven National Laboratory, USA) consists of major three parts.

a) Portable Radiation Package (PRP) designed by BNL - short and long wave downward radiation.
b) Zeno Meteorological (Zeno/Met) system designed by BNL - wind, air temperature, relative humidity, pressure, and rainfall measurement.
c) Photosynthetically Available Radiation (PAR) sensor manufactured by Biospherical Instruments Inc. (USA) - PAR measurement.
d) Scientific Computer System (SCS) developed by NOAA (National Oceanic and Atmospheric Administration, USA) - centralized data acquisition and logging of all data sets.

SCS recorded PRP data every 6 seconds, while Zeno/Met data every 10 seconds. Instruments and their locations are listed in Table.2.3-3 and measured parameters are listed in Table.2.3-4.

For the quality control as post processing, we checked the following sensors, before and after the cruise.

i) Young Rain gauge (SMet and SOAR)

Inspect of the linearity of output value from the rain gauge sensor to change Input value by adding fixed quantity of test water.

ii. Barometer (SMet and SOAR)

Comparison with the portable barometer value, PTB220CASE, VAISALA.

iii. Thermometer (air temperature and relative humidity) (SMet and SOAR)

Comparison with the portable thermometer value, HMP41/45, VAISALA.

(4) Preliminary results

Figure 2.3-1 and Figure 2.3-2 show the time series of the following parameters;

Wind (SOAR)
Air temperature (SMet)
Relative humidity (SMet)
Precipitation (SOAR, ORG)
Short/long wave radiation (SOAR)
Pressure (SMet)
Sea surface temperature (SMet)
Significant wave height (SMet)

(5) Data archives

These meteorological data will be submitted to the Data Management Group (DMG) of JAMSTEC just after the cruise.

(6) Remarks

i) SST (Sea Surface Temperature) data were available in the following periods.

06:00UTC 28 Aug. 2013 - 22:05UTC 06 Oct. 2013
19:00UTC 09 Oct. 2013 - 07:00UTC 19 Oct. 2013

ii) At the following time, increasing of SMet capacitive rain gauge data were invalid due to test transmitting for MF/HF or VHF radio.

17:21UTC 02 Sep. 2013
21:27UTC 26 Sep. 2013
00:43UTC 19 Oct. 2013
21:48UTC 19 Oct. 2013

iii) In the following period, FRSR data acquisition was suspended to prevent damage to the shadow-band from freezing.
23:16UTC 2 Sep. 2013 - 00:30UTC 05 Oct. 2013

iv) At the following time, air temperature, dew-point temperature and relative humidity data of SMet include invalid data.
23:44UTC 06 Oct. 2013 (Starboard side)
01:56UTC 07 Oct. 2013 (Port side)

**Table.2.3-1.** Instruments and installations of MIRAI Surface Meteorological observation system

| Sensors | Type | Manufacturer | Location (altitude from surface) |
|---|---|---|---|
| Anemometer | KE-500 | Koshin Denki, Japan | foremast (24 m) |
| Tair/RH | HMP155 | Vaisala, Finland | compass deck (21 m) |
| | | | starboard and port side |
| | with 43408 Gill aspirated radiation shield | | R.M. Young, USA |
| Thermometer (SST) | RFN1-0 | Koshin Denki, Japan | 4th deck (-1m, inlet -5m) |
| Barometer | Model-370 | Setra System, USA | captain deck (13 m) |
| | | | weather observation room |
| Rain gauge | 50202 | R. M. Young, USA | compass deck (19 m) |
| Optical rain gauge | ORG-815DS | Osi, USA | compass deck (19 m) |
| Radiometer (short wave) | MS-802 | Eiko Seiki, Japan | radar mast (28 m) |
| Radiometer (long wave) | MS-202 | Eiko Seiki, Japan | radar mast (28 m) |
| Wave height meter | WM-2 | Tsurumi-seiki, Japan | bow (10 m) |
| | | | port side stern (8 m) |

**Table.2.3-2.** Parameters of MIRAI Surface Meteorological observation system

| Parameter | | Units | Remarks |
|---|---|---|---|
| 1 | Latitude | degree | |
| 2 | Longitude | degree | |
| 3 | Ship's speed | knot | MIRAI log, DS-30 Furuno |
| 4 | Ship's heading | degree | MIRAI gyro, TG6000, Tokimec |
| 5 | Relative wind speed | m/s | 6sec./10min. averaged |
| 6 | Relative wind direction | degree | 6sec./10min. averaged |
| 7 | True wind speed | m/s | 6sec./10min. averaged |
| 8 | True wind direction | degree | 6sec./10min. averaged |
| 9 | Barometric pressure | hPa | adjusted to sea surface level |
| | | | 6sec. averaged |
| 10 | Air temperature (starboard) | degC | 6sec. averaged |
| 11 | Air temperature (port side) | degC | 6sec. averaged |
| 12 | Dewpoint temperature (starboard) | degC | 6sec. averaged |
| 13 | Dewpoint temperature (side) | degC | 6sec. averaged |
| 14 | Relative humidity (starboard) | % | 6sec. averaged |

| | | | |
|---|---|---|---|
| 15 | Relative humidity (port side) | % | 6sec. averaged |
| 16 | Sea surface temperature | degC | 6sec. averaged |
| 17 | Rain rate (optical rain gauge) | mm/hr | hourly accumulation |
| 18 | Rain rate (capacitive rain gauge) | mm/hr | hourly accumulation |
| 19 | Down welling shortwave radiation | W/m$^2$ | 6sec. averaged |
| 20 | Down welling infra-red radiation | W/m$^2$ | 6sec. averaged |
| 21 | Significant wave height (bow) | m | hourly |
| 22 | Significant wave height (aft) | m | hourly |
| 23 | Significant wave period (bow) | second | hourly |
| 24 | Significant wave period (aft) | second | hourly |

**Table.2.3-3.** Instruments and installation locations of SOAR system

| Sensors (Zeno/Met) | Type | Manufacturer | Location (altitude from surface) |
|---|---|---|---|
| Anemometer | 05106 | R.M. Young, USA | foremast (25 m) |
| Tair/RH | HMP45A | Vaisala, Finland | foremast (23 m) |
| | with 43408 Gill aspirated radiation shield | | R.M. Young, USA |
| Barometer | 61302V | R.M. Young, USA | foremast (23 m) |
| | with 61002 Gill pressure port | | R.M. Young, USA |
| Rain gauge | 50202 | R.M. Young, USA | foremast (24 m) |
| Optical rain gauge | ORG-815DA | Osi, USA | foremast (24 m) |

| Sensors (PRP) | Type | Manufacturer | Location (altitude from surface) |
|---|---|---|---|
| Radiometer (short wave) | PSP | Epply Labs, USA | foremast (25 m) |
| Radiometer (long wave) | PIR | Epply Labs, USA | foremast (25 m) |
| Fast rotating shadowband radiometer | | Yankee, USA | foremast (25 m) |

| Sensor (PAR) | Type | Manufacturer | Location (altitude from surface) |
|---|---|---|---|
| PAR sensor | PUV-510 | Biospherical Instruments Inc., USA | Navigation deck (18m) |

**Table.2.3-4.** Parameters of SOAR system

| Parameter | | Units | Remarks |
|---|---|---|---|
| 1 | Latitude | degree | |
| 2 | Longitude | degree | |
| 3 | SOG | knot | |
| 4 | COG | degree | |
| 5 | Relative wind speed | m/s | |
| 6 | Relative wind direction | degree | |
| 7 | Barometric pressure | hPa | |
| 8 | Air temperature | degC | |
| 9 | Relative humidity | % | |
| 10 | Rain rate (optical rain gauge) | mm/hr | |
| 11 | Precipitation (capacitive rain gauge) | mm | reset at 50 mm |

| | | |
|---|---|---|
| 12 | Down welling shortwave radiation | $W/m^2$ |
| 13 | Down welling infra-red radiation | $W/m^2$ |
| 14 | Defuse irradiance | $W/m^2$ |

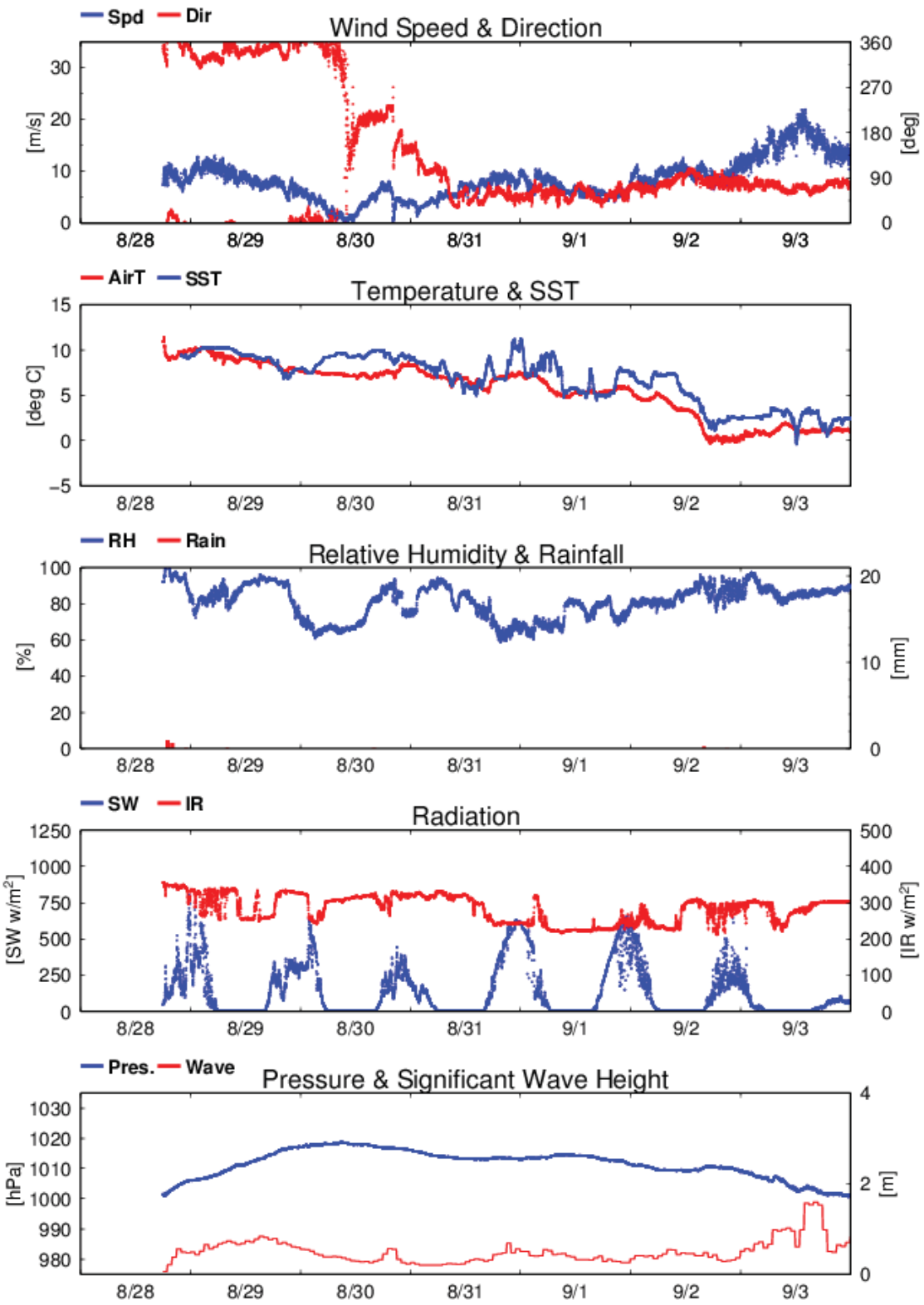


**Figure 2.3-1.** Time series of surface meteorological parameters during the MR13-06 Leg1.

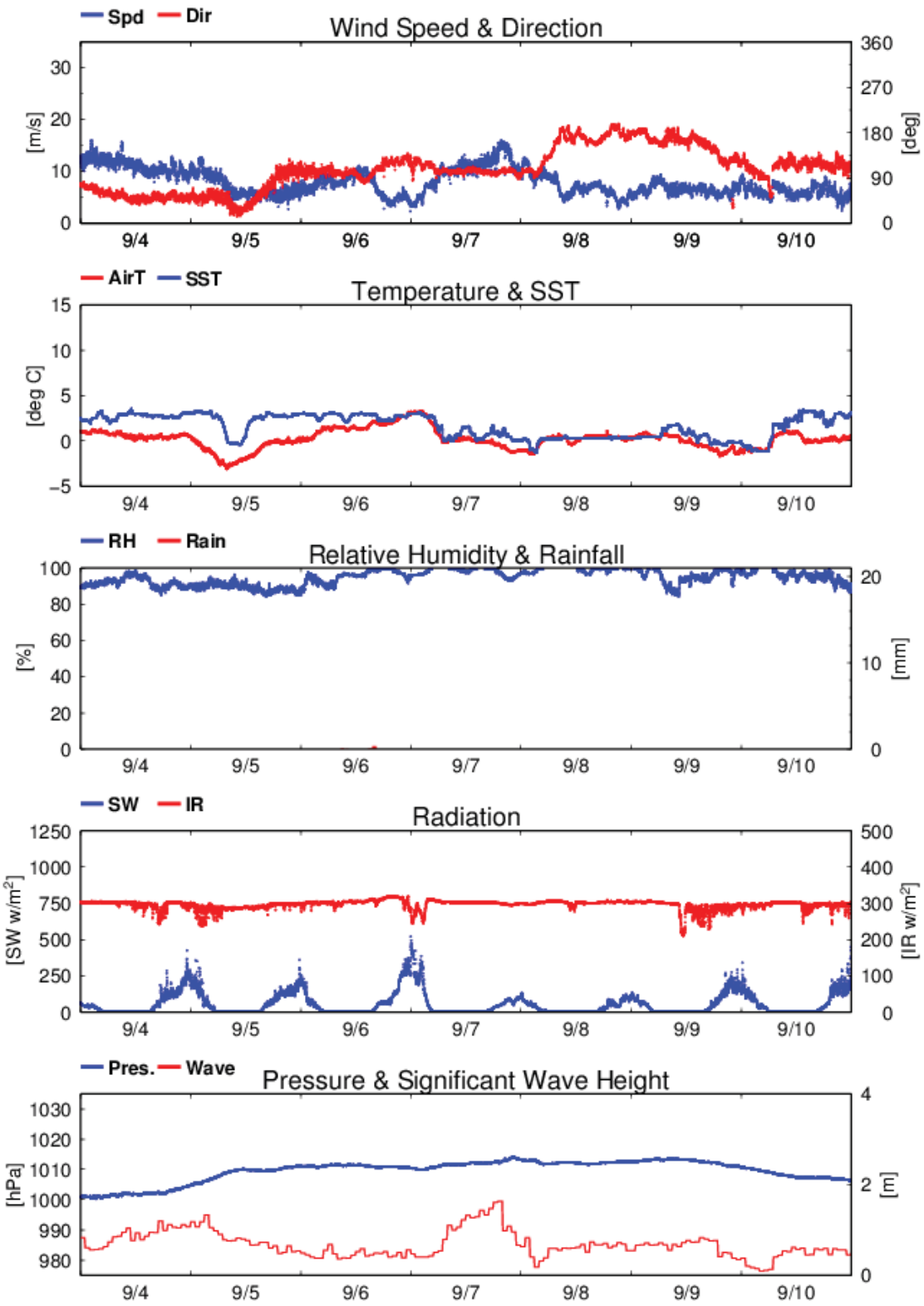


**Figure 2.3-1.** (Continued).

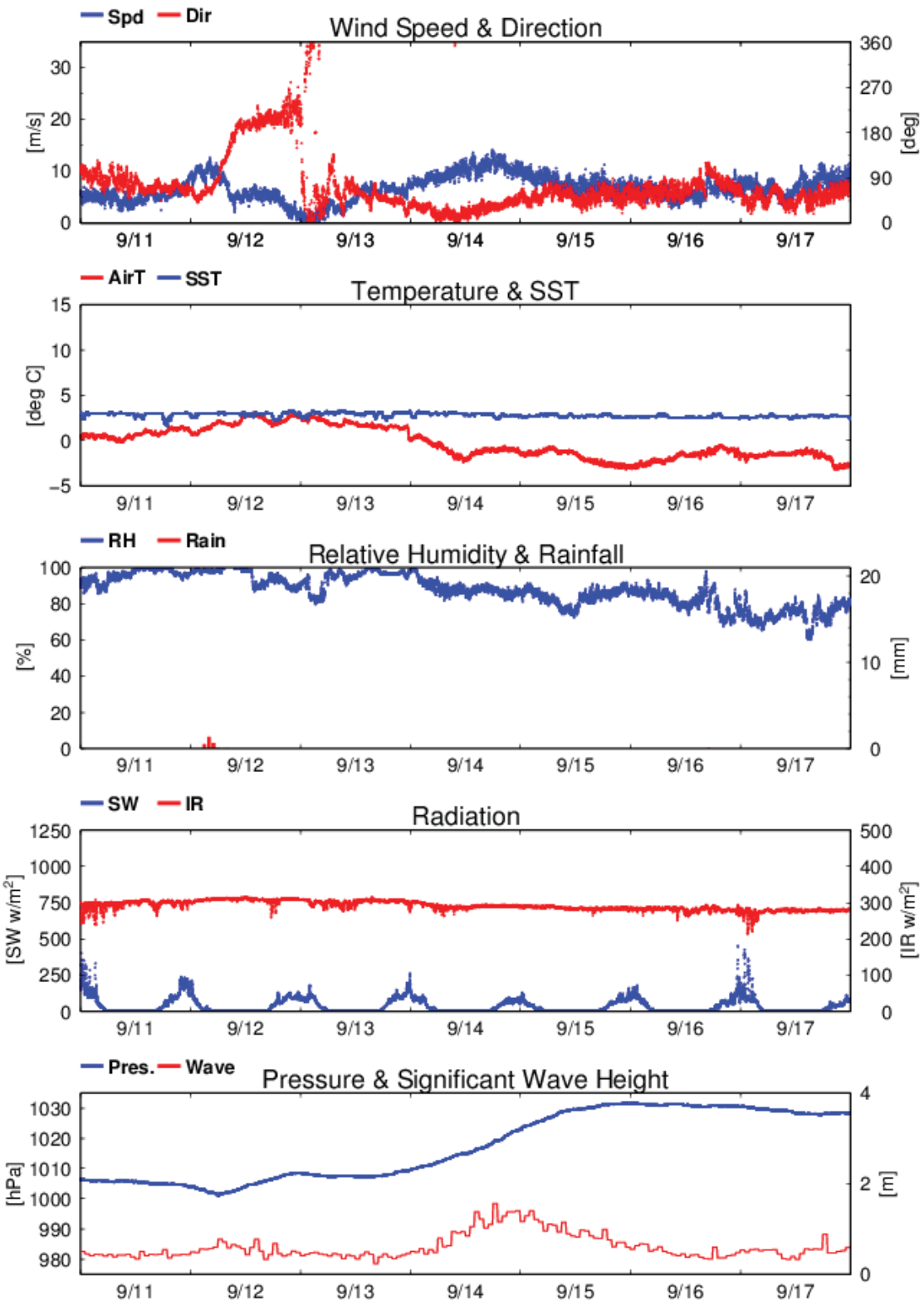


**Figure 2.3-1.** (Continued).

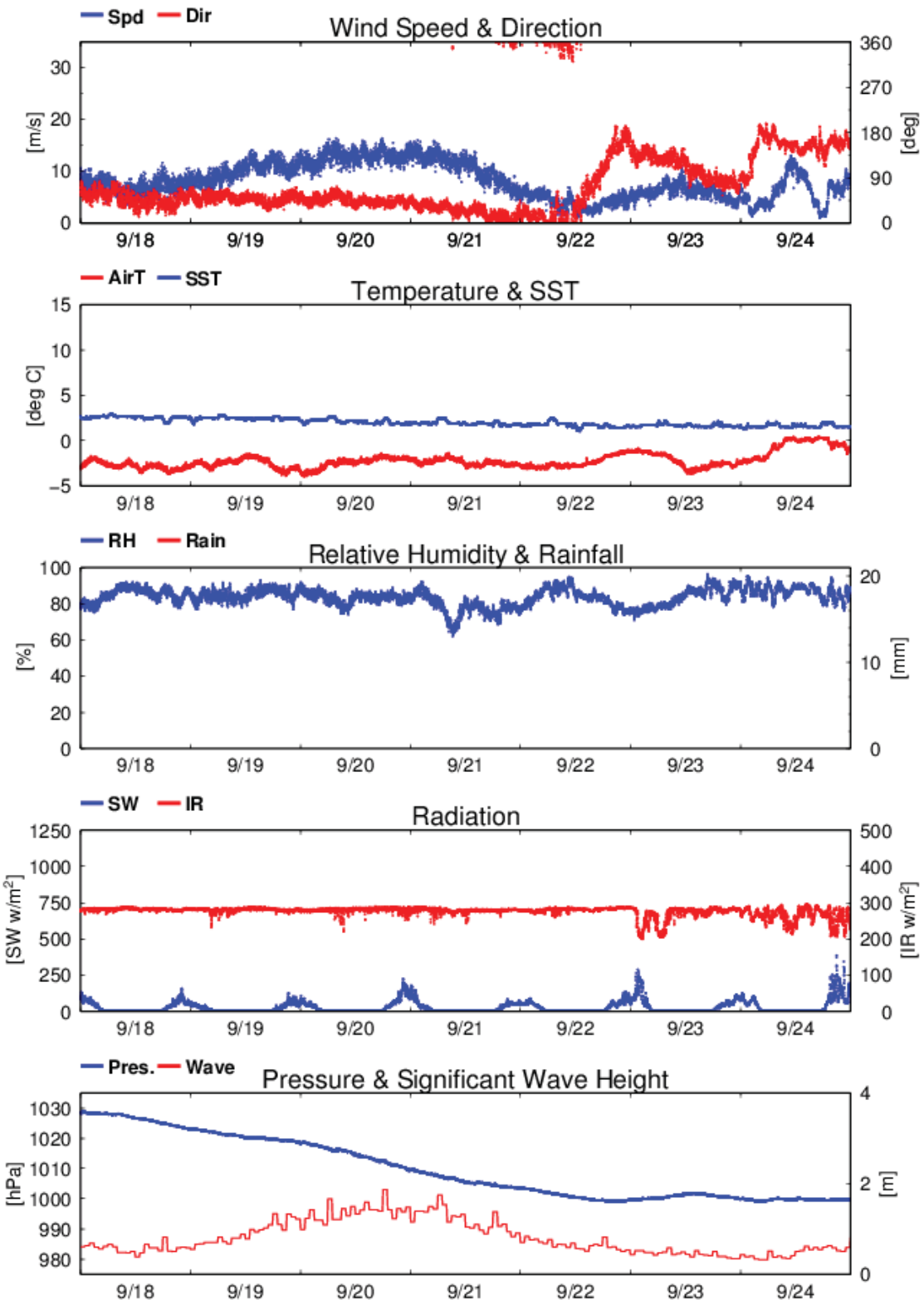


**Figure 2.3-1.** (Continued).

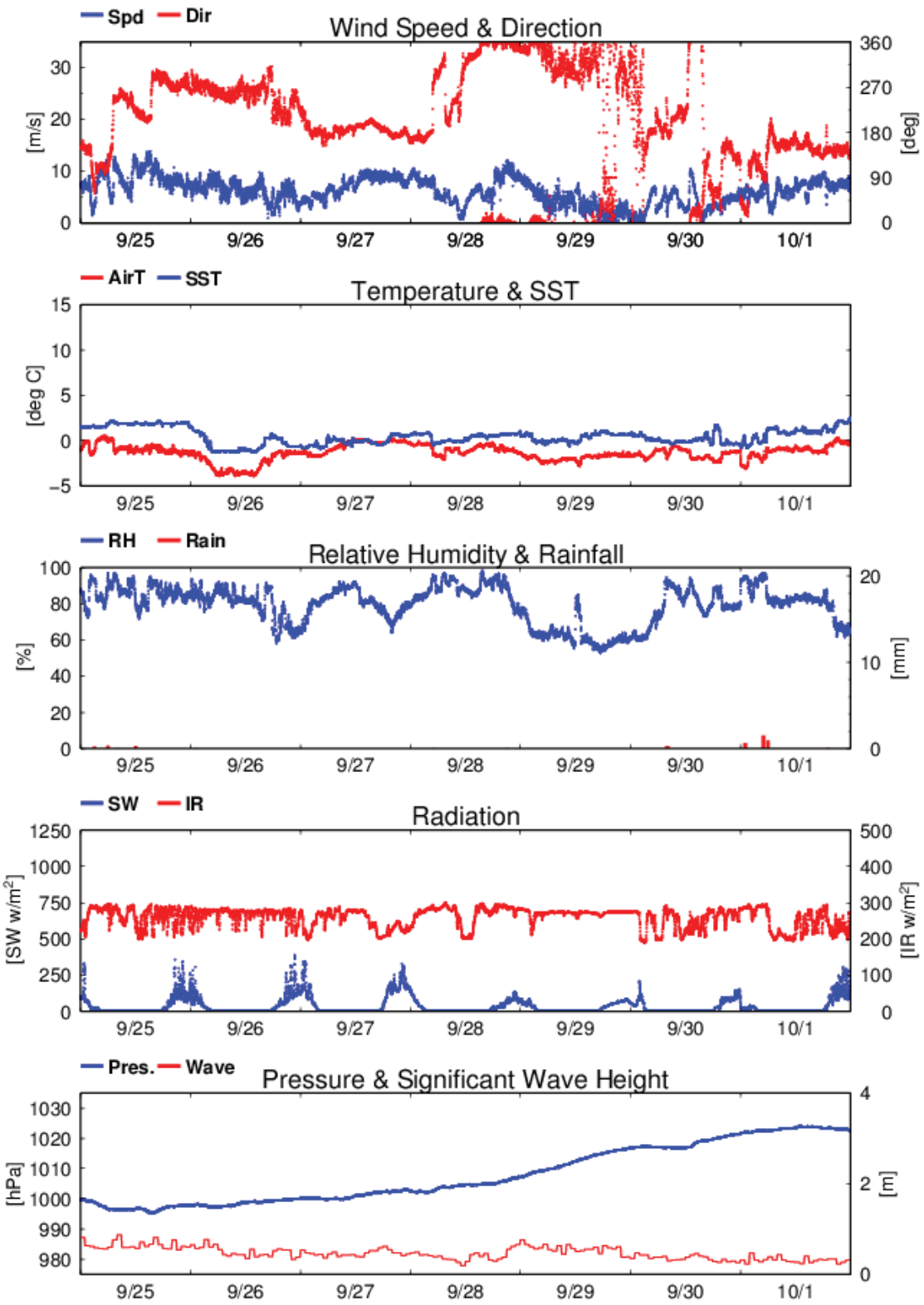


**Figure 2.3-1.** (Continued).

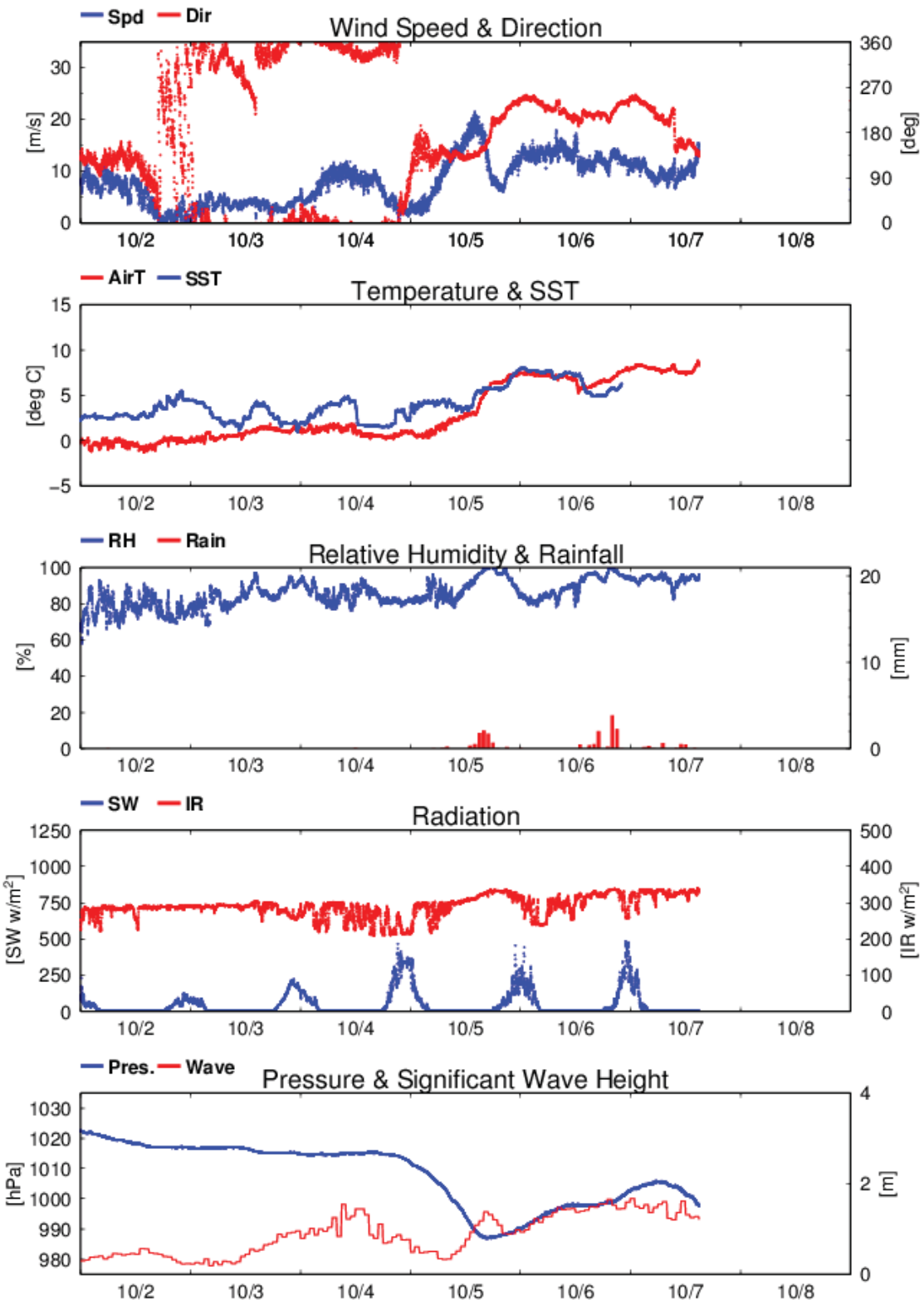


**Figure 2.3-1.** (Continued).

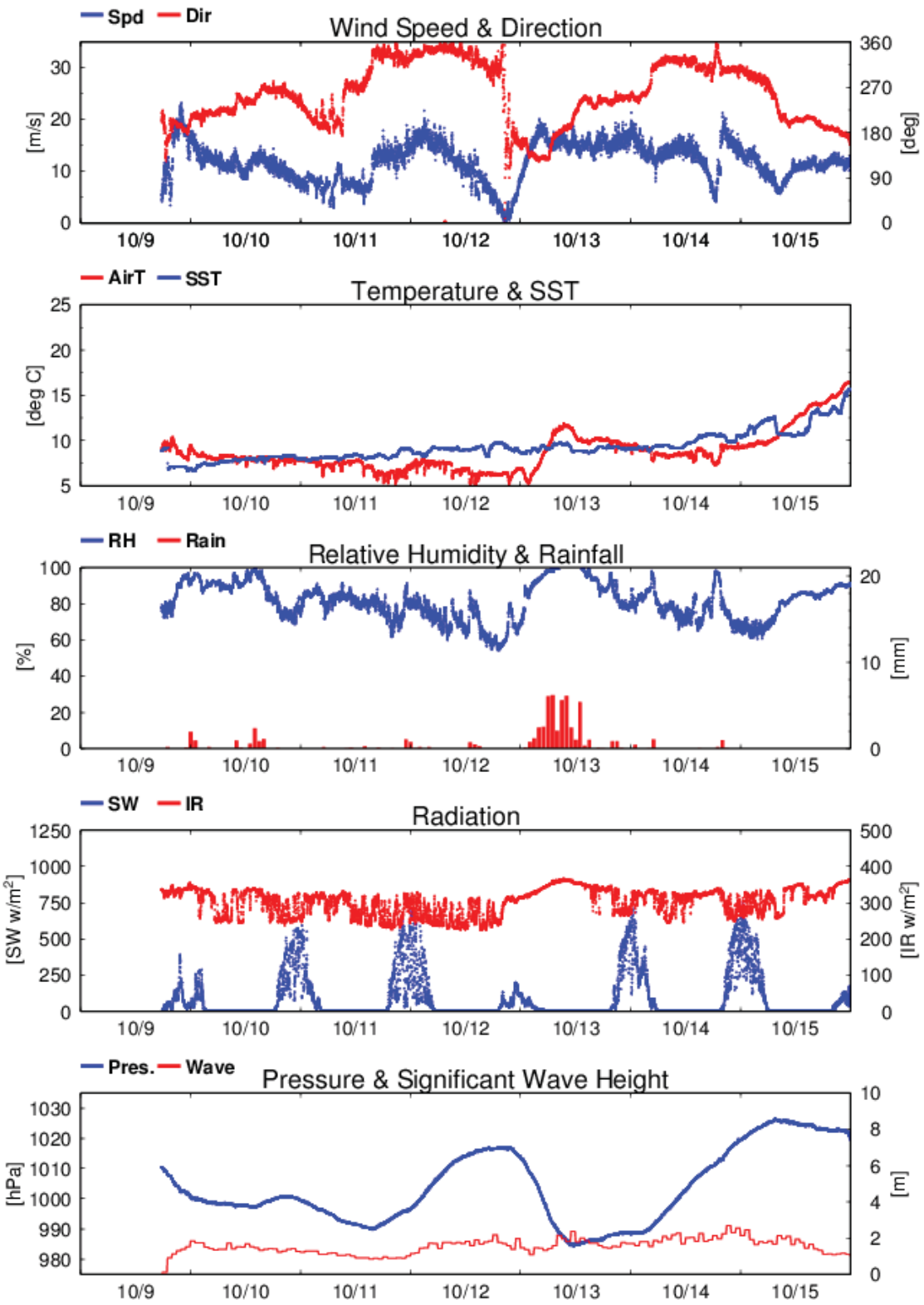


**Figure 2.3-2.** Time series of surface meteorological parameters during the MR13-06 Leg2.

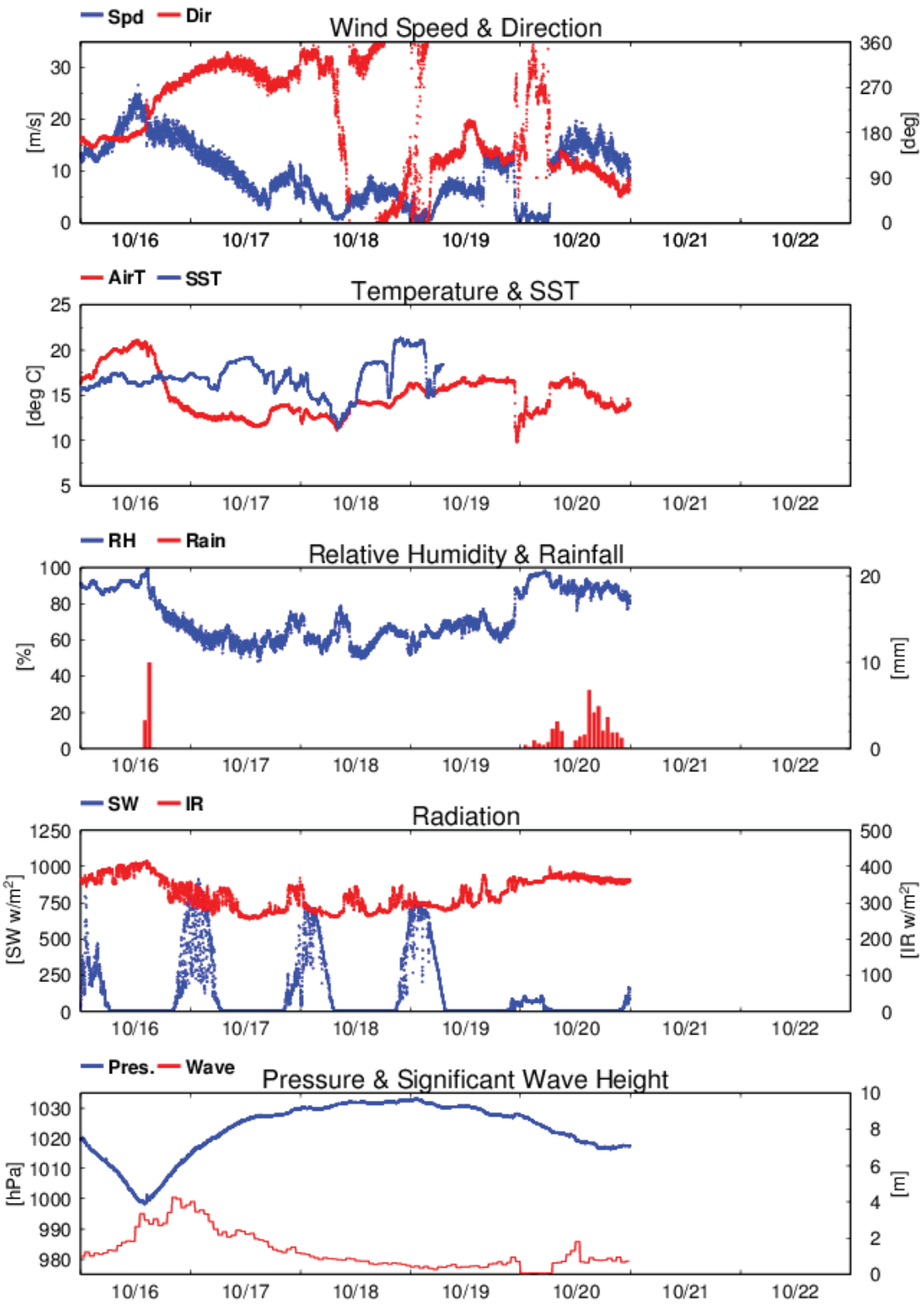


**Figure 2.3-2.** (Continued).

## 2.4. Ceilometer

(1) Personnel

| | |
|---|---|
| Jun Inoue | JAMSTEC/NIPR: PI |
| Masatake Hori | JAMSTEC |
| Kazuhiro Oshima | JAMSTEC |
| Kazutoshi Sato | NIPR |
| Taku Mitsui | JAMSTEC/Nagasaki Univ |
| Yo Tobase | JAMSTEC/Kyushu Univ |
| Souichiro Sueyoshi | GODI |
| Katsuhisa Maeno | GODI |
| Kazuho Yoshida | GODI |
| Masanori Murakami | GODI |
| Koichi Inagaki | GODI |
| Ryo Ohyama | MIRAI Crew |

(2) Objective

The information of cloud base height and the liquid water amount around cloud base is important to understand the process on formation of the cloud. As one of the methods to measure them, the ceilometer observation was carried out.

(3) Parameters

1. Cloud base height [m].
2. Backscatter profile, sensitivity and range normalized at 10 m resolution.
3. Estimated cloud amount [oktas] and height [m]; Sky Condition Algorithm.

(4) Instruments and Methods

We measured cloud base height and backscatter profile using ceilometer (CL51, VAISALA, Finland) throughout the MR13-06 cruise.

Major parameters for the measurement configuration are as follows;

| | |
|---|---|
| Laser source: | Indium Gallium Arsenide (InGaAs) Diode Laser |
| Transmitting center wavelength: | 910±10 nm at 25 degC |
| Transmitting average power: | 19.5 mW |
| Repetition rate: | 6.5 kHz |
| Detector: | Silicon avalanche photodiode (APD) |
| Measurement range: | 0 ~ 15 km |
| | 0 ~ 13 km (Cloud detection) |
| Resolution: | 10 meter in full range |
| Sampling rate: | 36 sec |
| Sky Condition | 0, 1, 3, 5, 7, 8 oktas (9: Vertical Visibility) |
| | (0: Sky Clear, 1: Few, 3: Scattered, 5-7: Broken, 8: Overcast) |

On the archive dataset, cloud base height and backscatter profile are recorded

with the resolution of 10 m.

(5) Preliminary results

Figure 2.4-1 shows the time series of cloud-base heights derived from the ceilometer (black line) during this clue. In most of periods, although the cloud base height was below 500m, it sometimes exceeded 500m.

Figure 2.4-2 shows frequency distribution of the cloud-base heights detected by the ceilometer. The highest frequency of occurrence of lowest cloud base was in the lowest 500 m of the atmosphere. The frequency of cloud-base heights below the 500 m level was about 70%.

(6) Data archives

The raw data obtained during this cruise will be submitted to the Data Management Group (DMG) in JAMSTEC.

(7) Remarks

1. Window cleaning;

00:55UTC 29 Aug. 2013
20:41UTC 05 Sep. 2013
22:55UTC 14 Sep. 2013
20:52UTC 24 Sep. 2013
22:46UTC 01 Oct. 2013
00:15UTC 09 Oct. 2013
01:17UTC 18 Oct. 2013

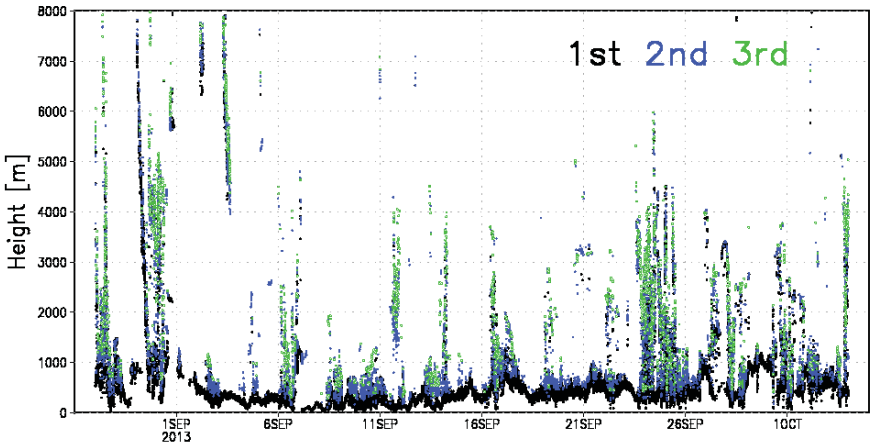


**Figure 2.4-1.** The time series of cloud-base heights throughout the MR13-06 cruise.

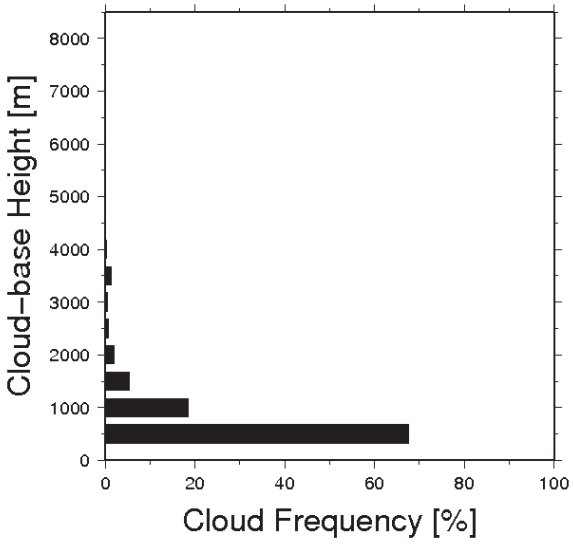


**Figure 2.4-2.** Frequency distribution of the cloud-base height (km) detected by a ceilometer throughout the MR13-06 cruise.

## 2.5. Greenhouse Gasses

### 2.5.1. Shipboard Measurements

(1) Personal

| | |
|---|---|
| Shuji Aoki | Tohoku University: Principal Investigator |
| Naohiro Kosugi | Meteorological Research Institute / JMA |
| Yasunori Tohjima | National Institute for Environmental Studies |
| Junji Matsushita | National Institute of Polar Research |

(2) Objective

In arctic region, there are a lot of vulnerable carbon pools, which have the potential to become strong sources of $CO_2$ and $CH_4$ release into the atmosphere when the destabilization occurs through climate change. Therefore, it is important to understand the current situation of the greenhouse gas emissions around the arctic region. The purpose of present study is to observe the atmospheric $CO_2$ and $CH_4$ mixing ratios during the cruse, detect the enhanced mixing ratios associated with the regional emissions, and estimate the distribution of the regional emission sources. The atmospheric CO mixing ratios, which are also observed at the same time, can be used as an indicator of the anthropogenic emissions associated with the combustion processes.

(3) Parameters

Mixing ratio of atmospheric $CO_2$, $CH_4$, and CO.

(4) Instruments and Methods

Atmospheric $CO_2$, $CH_4$, and CO mixing ratios were measured by a wavelength-scanned cavity ring-down spectrometer (WS-CRDS, Picarro, G2401). An air intake, capped with an inverted stainless steel beaker covered with stainless steel mesh, was placed on the right-side of the upper deck. A diaphragm pump (GAST, MOA-P108) was used to draw in the outside air at a flow rate of ~10 L $min^{-1}$. Water vapor in the sample air was removed to a dew pint of about 2°C and about -35°C by passing it through a thermoelectric dehumidifier (KELK, DH-109) and a Nafion drier (PERMA PURE, PD-50T-24), respectively. Then, the dried sample air was introduced into the WS-CRDS at a flow rate of 100 ml $min^{-1}$. The WS-CRDS were automatically calibrated every 24 hour by introducing 3 standard airs with known $CO_2$, $CH_4$ and CO mixing ratios. The analytical precisions for $CO_2$, $CH_4$, and CO mixing ratios are about 0.02 ppm,

0.3 ppb and 3 ppb, respectively.

(5) Observation log

The shipboard measurements were conducted during the entire cruse.

(6) Preliminary results

Temporal changes in the atmospheric $CO_2$, $CH_4$, and CO mixing ratios observed during MR13-06 cruise (August 28-October 6, 2013) are plotted in Figure 2.5.1-1. The geographical distributions of the observed $CH_4$ are also depicted in Figure 2.5.1-2. Relatively elevated $CH_4$ concentrations were observed along the North Slope of Alaska, which is consistent with previous measurements during MR12-E03 cruise.

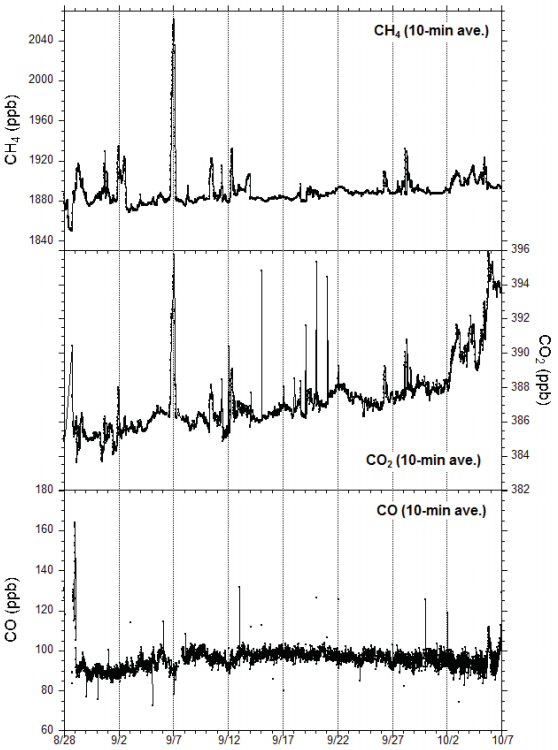


**Figure 2.5.1-1.** Time series of the atmospheric $CH_4$, $CO_2$, and CO concentrations observed during MR13-06 cruise.

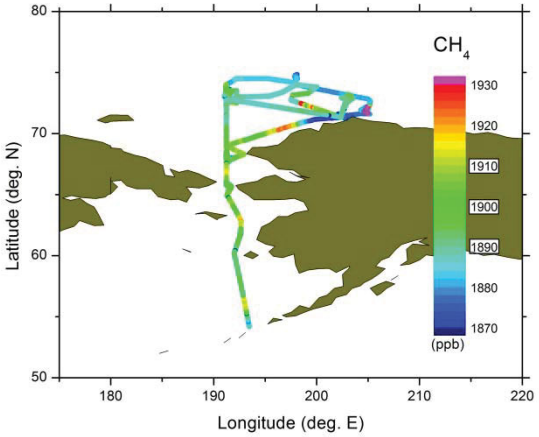


**Figure 2.5.2-2.** Geographical distribution of the atmospheric $CH_4$ concentrations observed during MR13-06 cruise.

(7) Data archives

The data of the atmospheric CO2, CH4 and CO mixing ratios with time (UTC) will be submitted to the Data Management Group (DMG) of JAMSTEC.

## 2.5.2. Whole Air Sampling

(1) Personal

| | |
|---|---|
| Shuji Aoki | Tohoku University: Principal Investigator |
| Shigeyuki Ishidoya | National Institute of Advanced Industrial Science and Technology (AIST) |
| Shinji Morimoto | Tohoku University |
| Naohiro Kosugi | Meteorological Research Institute / JMA |

(2) Objective

In order to clarify space variations and air-sea exchanges of the greenhouse gases at northern high latitude, air samples were corrected into 40 stainless-steel flasks in the Arctic Ocean. The collected air samples will be analyzed for the concentrations of $CO_2$, $O_2$, Ar, $CH_4$, CO, $N_2O$ and $SF_6$ and the isotopic ratios of $CO_2$ and $CH_4$.

(3) Parameters

Atmospheric $CO_2$ concentration, $O_2/N_2$ ratio ($O_2$ concentration), $Ar/N_2$ ratio (Ar concentration), $CH_4$ concentration, CO concentration, $N_2O$ concentration, $SF_6$ concentartion, $\delta^{13}C$ of $CO_2$, $\delta^{18}O$ of $CO_2$, $\delta^{13}C$ of $CH_4$ and $\delta D$ of $CH_4$.

(4) Instruments and Methods

The air sampling equipment consisted of an air intake, a piston pump (GAST LOA), a water trap, solenoid valves (CKD), an ethanol bath as refrigerant, a flow meter and an immersion cooler (EYELA ECS-80). Ambient air was pumped using a piston pump from an air intake and dried cryogenically, and filled into a 1 L stainless-steel flask at a pressure of 0.45 MPa.

(5) Observation log

Here are lists of collected sample

| Sample number | Date (UTC) | Time (UTC) | Position Lat. | Lon. |
|---|---|---|---|---|
| MR13-06_Flask_Gas_A01 | 2013/08/29 | 03:11 | 55-26N | 166-49W |
| MR13-06_Flask_Gas_A02 | 2013/08/30 | 03:56 | 59-59N | 167-57W |
| MR13-06_Flask_Gas_A03 | 2013/08/31 | 04:02 | 63-49N | 167-56W |
| MR13-06_Flask_Gas_A04 | 2013/09/01 | 05:11 | 66-30N | 168-45W |
| MR13-06_Flask_Gas_A05 | 2013/09/02 | 00:33 | 68-45N | 168-45W |

| | | | | |
|---|---|---|---|---|
| MR13-06_Flask_Gas_A06 | 2013/09/03 | 06:47 | 71-27N | 157-43W |
| MR13-06_Flask_Gas_A07 | 2013/09/04 | 05:05 | 71-22N | 157-25W |
| MR13-06_Flask_Gas_A08 | 2013/09/05 | 03:42 | 71-57N | 155-40W |
| MR13-06_Flask_Gas_A09 | 2013/09/06 | 07:35 | 71-52N | 155-29W |
| MR13-06_Flask_Gas_A10 | 2013/09/07 | 02:38 | 72-01N | 155-08W |
| MR13-06_Flask_Gas_A11 | 2013/09/08 | 01:00 | 74-36N | 162-01W |
| MR13-06_Flask_Gas_A12 | 2013/09/09 | 08:01 | 74-14N | 162-00W |
| MR13-06_Flask_Gas_A13 | 2013/09/10 | 00:54 | 73-48N | 168-47W |
| MR13-06_Flask_Gas_A14 | 2013/09/11 | 05:53 | 72-43N | 168-15W |
| MR13-06_Flask_Gas_A15 | 2013/09/12 | 06:12 | 72-40N | 168-15W |
| MR13-06_Flask_Gas_A16 | 2013/09/13 | 06:12 | 72-40N | 168-15W |
| MR13-06_Flask_Gas_A17 | 2013/09/14 | 06:31 | 72-36N | 168-15W |
| MR13-06_Flask_Gas_A18 | 2013/09/15 | 00:20 | 72-52N | 168-15W |
| MR13-06_Flask_Gas_A19 | 2013/09/16 | 00:17 | 72-51N | 168-15W |
| MR13-06_Flask_Gas_A20 | 2013/09/17 | 00:16 | 72-51N | 168-15W |
| MR13-06_Flask_Gas_A21 | 2013/09/18 | 00:15 | 72-52N | 168-15W |
| MR13-06_Flask_Gas_A22 | 2013/09/19 | 00:17 | 72-51N | 168-15W |
| MR13-06_Flask_Gas_A23 | 2013/09/20 | 00:16 | 72-49N | 168-13W |
| MR13-06_Flask_Gas_A24 | 2013/09/21 | 00:16 | 72-50N | 168-15W |
| MR13-06_Flask_Gas_A25 | 2013/09/22 | 05:57 | 72-43N | 168-15W |
| MR13-06_Flask_Gas_A26 | 2013/09/23 | 05:56 | 72-43N | 168-15W |
| MR13-06_Flask_Gas_A27 | 2013/09/24 | 00:18 | 72-51N | 168-15W |
| MR13-06_Flask_Gas_A28 | 2013/09/25 | 05:56 | 72-44N | 168-15W |
| MR13-06_Flask_Gas_A29 | 2013/09/26 | 05:38 | 73-48N | 168-47W |
| MR13-06_Flask_Gas_A30 | 2013/09/27 | 10:14 | 73-54N | 160-59W |
| MR13-06_Flask_Gas_A31 | 2013/09/28 | 10:15 | 72-08N | 160-23W |
| MR13-06_Flask_Gas_A32 | 2013/09/29 | 01:37 | 71-54N | 157-22W |
| MR13-06_Flask_Gas_A33 | 2013/09/30 | 00:53 | 71-22N | 157-59W |
| MR13-06_Flask_Gas_A34 | 2013/10/01 | 05:58 | 72-42N | 168-15W |
| MR13-06_Flask_Gas_A35 | 2013/10/02 | 00:55 | 71-44N | 168-45W |
| MR13-06_Flask_Gas_A36 | 2013/10/03 | 10:59 | 67-68N | 168-34W |
| MR13-06_Flask_Gas_A37 | 2013/10/04 | 14:51 | 66-00N | 168-45W |
| MR13-06_Flask_Gas_A38 | 2013/10/05 | 01:34 | 64-55N | 168-39W |
| MR13-06_Flask_Gas_A39 | 2013/10/06 | 02:45 | 60-19N | 167-57W |
| MR13-06_Flask_Gas_A40 | 2013/10/06 | 20:12 | 57-23N | 167-17W |

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC home page.

## 2.6. Sky Radiometer

(1) Personnel

Kazuma Aoki (University of Toyama) Principal Investigator / not onboard
Tadahiro Hayasaka (Tohoku University) Co-worker / not onboard
Sky radiometer operation was supported by Global Ocean Development Inc.

(2) Objective

Objective of this observation is to study distribution and optical characteristics of marine aerosols by using a ship-borne sky radiometer (POM-01 MKII: PREDE Co. Ltd., Japan). Furthermore, collections of the data for calibration and validation to the remote sensing data were performed simultaneously.

(3) Parameters

- Aerosol optical thickness at five wavelengths (400, 500, 675, 870 and 1020 nm)
- Ångström exponent
- Single scattering albedo at five wavelengths
- Size distribution of volume (0.01 μm – 20 μm)
- # GPS provides the position with longitude and latitude and heading direction of the vessel, and azimuth and elevation angle of the sun. Horizon sensor provides rolling and pitching angles.

(4) Instruments and Methods

The sky radiometer measures the direct solar irradiance and the solar aureole radiance distribution with seven interference filters (0.34, 0.4, 0.5, 0.675, 0.87, 0.94, and 1.02 μm). Analysis of these data was performed by SKYRAD.pack version 4.2 developed by Nakajima *et al.* 1996.

(5) Data archives

Aerosol optical data are to be archived at University of Toyama (K.Aoki, SKYNET/SKY: http://skyrad.sci.u-toyama.ac.jp/) after the quality check and will be submitted to JAMSTEC.

## 2.7. Tropospheric Aerosol and Gas Observations

(1) Personnel

Yugo KANAYA (JAMSTEC RIGC) Principal Investigator / not on board
Fumikazu TAKETANI (JAMSTEC RIGC, not on board)
Takuma MIYAKAWA (JAMSTEC RIGC, not on board)
Hisahiro TAKASHIMA (JAMSTEC RIGC, not on board)
Xiaole PAN (JAMSTEC RIGC, not on board)
Yuichi KOMAZAKI (JAMSTEC RIGC, not on board)
Operation was supported by Global Ocean Development Inc.

(2) Objective

- To clarify transport processes of atmospheric pollutants from the Asian continent to the ocean
- To investigate processes of biogeochemical cycles between the atmosphere and the ocean
- To advance validation of satellite observations of atmospheric composition

(3) Parameters

1. NO2 vertical column densities and profiles,
2. Aerosol optical depth and vertical profile of extinction coefficient at 476 nm
3. Black carbon mass concentrations and size distribution
4. Ozone and carbon monoxide mixing ratios

(4) Instruments and Methods

1. MAX-DOAS

Multi-Axis Differential Optical Absorption Spectroscopy (MAX-DOAS), a passive remote sensing technique measuring spectra of scattered visible and ultraviolet (UV) solar radiation, was used for atmospheric aerosol and gas profile measurements. Our MAX-DOAS instrument consists of two main parts: an outdoor telescope unit and an indoor spectrometer (Acton SP-2358 with Princeton Instruments PIXIS-400B), connected to each other by a 14-m bundle cable that consists of 60 cores with 100-μm radii. On the roof top of the anti-rolling system of R/V Mirai, the telescope unit was installed on a gimbal mount, which compensates for the pitch and roll motion of the ship. The line of sight was in directions of the starboard and portside of the vessel. The integration time for UV and visible spectra recording (centered on 340 and 452 nm) was set to 0.20 and 0.08 s. Measurements were made every 30 min at elevation angles of 1.5, 3, 5, 10, 20, 30, 90, 150, 160, 170, 175, and 177 degrees.

For the selected spectra recorded with elevation angles with good accuracy, DOAS spectral fitting was performed to quantify the slant column density (SCD) of $NO_2$ (and other gases) and $O_4$ ($O_2$-$O_2$, collision complex of oxygen) for each elevation angle. Then, the $O_4$ SCDs were converted to the aerosol optical depth (AOD) and the vertical profile of aerosol extinction coefficient (AEC) using an optimal estimation inversion method with a radiative transfer model. Using derived aerosol information,

retrievals of the tropospheric vertical column/profile of $NO_2$ and other gases were made.

2. CO, $O_3$, and black carbon (BC)

Carbon monoxide (CO) and ozone ($O_3$) measurements were also continuously conducted during the cruise. For CO and $O_3$ measurements, ambient air was continuously sampled on the compass deck and drawn through ~20-m-long Teflon tubes connected to a gas filter correlation CO analyzer (Model 48C, Thermo Fisher Scientific) and a UV photometric ozone analyzer (Model 49C, Thermo Fisher Scientific) in the Research Information Center.

BC was measured by an instrument based on laser-induced incandescence (SP2, Droplet Measurement Technologies). Ambient air was sampled from the flying bridge by a 3-m-long conductive tube and then introduced to the instrument.

(5) Observation log

The shipboard measurements were conducted during the entire cruse.

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC web site.

# 3. Physical Oceanography

## 3.1. CTD and Water Samplings

(1) Personnel

| | |
|---|---|
| Shigeto Nishino*1 | (JAMSTEC): Principal Investigator |
| Shinsuke Toyoda*1 | (MWJ): Operation Leader |
| Shungo Oshitani *1 | (MWJ) |
| Hirokatsu Uno*2 | (MWJ) |
| Rei Itou*2 | (MWJ) |

*1: Leg1, Leg2

*2: Leg1

(2) Objective

To investigate ocean structure and water characteristics.

(3) Parameters

Temperature
Conductivity
Pressure
Dissolved Oxygen voltage
Dissolved Oxygen
Transmission %, beam attenuation coefficient and voltage
Fluorescence
Photosynthetically Active Radiation
Altimeter

(4) Instruments and Methods

CTD/Carousel Water Sampling System, which is a 36-position Carousel water sampler (CWS) with Sea-Bird Electronics, Inc. CTD (SBE9plus), was used during this cruise. 12-litter Niskin Bottles, which were washed by alkaline detergent and HCl, were used for sampling seawater. The sensors attached on the CTD were temperature (Primary and Secondary), conductivity (Primary and Secondary), pressure, RINKO III (dissolved oxygen sensor), dissolved oxygen (SBE43), transmission, fluorescence, PAR, deep ocean standards thermometer, and altimeter. The Practical Salinity was calculated by measured values of pressure, conductivity and temperature. The CTD/CWS was deployed from starboard on working deck.

The CTD raw data were acquired on real time using the Seasave-Win32 (ver.7.22.5)

provided by Sea-Bird Electronics, Inc. and stored on the hard disk of the personal computer. Seawater was sampled during the up cast by sending fire commands from the personal computer. We stop at each layer for 1 minute or 30 seconds to stabilize then fire.

213 casts of CTD measurements were conducted (Table 3.1-1). Stn.087 was Leg2.

In the Stn.014, RINKO III (S/N 0079) voltage was bad data. So we detached the sensor.

From the Stn.001 to the Stn.040 and form the Stn.073 to the Stn.086, we used a cable of fluorescence gain 10x. In other Stn, we used a cable of fluorescence gain 30x.

We used a bottom contact switch in some casts.

Data processing procedures and used utilities of SBE Data Processing-Win32 (ver.7.22.5.a) and SEASOFT were as follows:

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

TCORP (original module): Corrected the pressure sensitivity of the primary temperature (SBE3) sensor.

S/N 031359: -1.8386e-007 (deg-C / dbar)

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

ALIGNCTD: Convert the time-sequence of sensor outputs into the pressure sequence to ensure that all calculations were made using measurements from the same parcel of water. Dissolved oxygen (SBE43) data are systematically delayed with respect to depth mainly because of the long time constant of the dissolved oxygen sensors and of an additional delay from the transit time of water in the pumped pluming line. This delay was compensated by 5 seconds advancing dissolved oxygen sensors output (dissolved oxygen voltage) relative to the temperature data. RINKO-III voltage, transmission data and voltage are also delayed by slightly slow response time to the sensor. The delay was compensated by 1 second or 2 seconds advancing.

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

pressure, depth, temperature, conductivity and dissolved oxygen (SBE43) voltage.

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

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

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

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

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

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

DERIVE: Compute dissolved oxygen (SBE43).

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

BOTTOMCUT (original module): Deletes discontinuous scan bottom data, if it's created by BINAVG.

DERIVE: Compute salinity, potential temperature, and sigma-theta.

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

Configuration file

| | |
|---|---|
| Stn.001 | : MR1306Axmlcon |
| Stn.002 - 014 | : MR1306B.xmlcon |
| Stn.014 - 042, 073 - 086 | : MR1306C.xmlcon |
| Stn.041 - 072, 087 | : MR1306D.xmlcon |

Specifications of the sensors are listed below.

CTD: SBE911plus CTD system

Under water unit:

SBE9plus (S/N 09P54451-1027, Sea-Bird Electronics, Inc.)

Pressure sensor: Digiquartz pressure sensor (S/N 117457)

Calibrated Date: 10 May 2013

Temperature sensors:

Primary: SBE03-04/F (S/N 031359, Sea-Bird Electronics, Inc.)

Calibrated Date: 17 Jul. 2013

Secondary: SBE03-04/F (S/N 031525, Sea-Bird Electronics, Inc.)

Calibrated Date: 31 Aug. 2012

Conductivity sensors:

Primary: SBE04C (S/N 042435 Sea-Bird Electronics, Inc.)

Calibrated Date: 17 Jul. 2013

Secondary: SBE04C (S/N 042854, Sea-Bird Electronics, Inc.)

Calibrated Date: 17 Jul. 2013

Dissolved Oxygen sensors:

RINK III (S/N 0024 (144002), Alec Electronics Co. Ltd.)

Calibrated Date: 09 Aug. 2013

RINK- II (S/N 0079 (1204), Alec Electronics Co. Ltd.)

Calibrated Date: 09 Aug. 2013

Used period: 000M001 - 041M014

SBE43 (S/N 430575, Sea-Bird Electronics, Inc.)

Calibrated Date: 21 May 2013

SBE43 (S/N 430330, Sea-Bird Electronics, Inc.)

Calibrated Date: 01 May 2012

Transmissonmeter:

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

Calibrated Date: 05 Aug. 2013

Fluorescence:

Chlorophyll Fluorometer (S/N 2936, Seapoint Sensors, Inc.)

Photosynthetically Active Radiation:

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

Calibrated Date: 22 Jan. 2009

Altimeter:

Benthos PSA-916T (S/N 1100, Teledyne Benthos, Inc.)

Deep Ocean Standards Thermometer:

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

Calibrated Date: 09 May 2013

Carousel water sampler:

SBE32 (S/N 3227443-0391, Sea-Bird Electronics, Inc.)

Submersible Pump:

Primary: SBE5T (S/N 054598, Sea-Bird Electronics, Inc.)

Secondary: SBE5T (S/N 054595, Sea-Bird Electronics, Inc.)

Bottom contact switch:

(Sea-Bird Electronics, Inc.)

Deck unit: SBE11plus (S/N 11P9833-0344, Sea-Bird Electronics, Inc.)

(5) Preliminary Results

During this cruise, 213 casts of CTD observation were carried out. Date, time and locations of the CTD casts are listed in Table 3.1-1. In some casts, we used a bottom contact sensor.

In some casts, we judged noise or spike in the data. These were as follows.

000M001: Fluorescence; down 8 db - down 18 db (outside measurement range)

008M001: Fluorescence; down 7 db and down 18 db, bottle data #1, #2, #3, #4, #28, #29, #33, #35, #36 (outside measurement range)

014M001: RINKO III (S/N 0079); all data were bad

017M001: Secondary temperature and salinity; down 14 db (spike)

019M001: Fluorescence; down 95 db - down 97 db (spike)

029M001: Transmissonmeter data and voltage; down 7 db - down 20 db (spike)

042M003: Secondary salinity; up 13 db - up 8 db (sift)

041M027: Secondary temperature, salinity and dissolved oxygen; up 23 db - up 7 db, bottle data #24, #25, #27 (sift)

044M009: Secondary temperature, salinity and dissolved oxygen; up 19 db - up 15 db (sift)

045M010: Secondary salinity; down 45 db (spike)

Primary temperature and salinity dissolved oxygen; up 50 db - up 40 db (sift)

Primary dissolved oxygen; up 53 db - up 38 db (sift)

087M001: Transmissonmeter data and voltage; down 816 db - down 822 db (spike)

(6) Data archive

All raw and processed data will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "' DWD5 HUHDUFK IRU: KRO H&UXLVH, QIRUP DWLRQ LQ-$ 0 67( &" in JAMSTEC web site.

**Table 3.1-1.** MR13-06 CTD cast table

| Stnnbr | Castno | Date(UTC) | Time(UTC) | | BottomPosition | | Depth | Wire Out | HT Above Bottom | Max Depth | Max Pressure | CTD Filename | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (mmddyy) | Start | End | Latitude | Longitude | | | | | | | |
| 000 | 1 | 082813 | 20:19 | 20:56 | 54-15.74N | 166-32.45W | 1118.0 | 294.5 | - | 298.1 | 301.0 | 000M001 | ・A/R test cast,<br>・no sampling water |
| 001 | 1 | 083113 | 19:49 | 20:17 | 65-46.18N | 168-45.10W | 52.0 | 40.7 | - | 44.6 | 45.0 | 001M001 | changed a cable of the fluorescence (gain 30x - gain 10x) |
| 002 | 1 | 083113 | 21:43 | 21:48 | 65-42.31N | 168-31.39W | 54.0 | 43.5 | - | 46.5 | 47.0 | 002M001 | no sampling water |
| 003 | 1 | 083113 | 22:55 | 23:11 | 65-39.44N | 168-15.15W | 43.0 | 36.0 | - | 36.6 | 37.0 | 003M001 | |
| 004 | 1 | 090113 | 01:43 | 02:00 | 66-00.24N | 168-44.93W | 53.0 | 40.4 | - | 44.6 | 45.0 | 004M001 | |
| 005 | 1 | 090113 | 04:43 | 05:01 | 66-30.19N | 168-45.11W | 54.0 | 42.2 | - | 45.5 | 46.0 | 005M001 | |
| 006 | 1 | 090113 | 08:03 | 08:20 | 67-00.19N | 168-44.69W | 44.0 | 33.0 | - | 35.6 | 36.0 | 006M001 | |
| 007 | 1 | 090113 | 11:10 | 11:27 | 67-30.09N | 168-44.97W | 49.0 | 36.2 | - | 39.6 | 40.0 | 007M001 | |
| 008 | 1 | 090113 | 18:46 | 19:15 | 68-00.25N | 168-45.82W | 58.0 | 49.8 | - | 52.5 | 53.0 | 008M001 | |
| 009 | 1 | 090113 | 22:15 | 22:36 | 68-30.20N | 168-44.78W | 53.0 | 41.5 | - | 44.5 | 45.0 | 009M001 | |
| 010 | 1 | 090213 | 01:48 | 02:05 | 69-00.15N | 168-44.99W | 52.0 | 36.3 | - | 42.6 | 43.0 | 010M001 | |
| 011 | 1 | 090313 | 05:06 | 05:30 | 71-20.58N | 157-36.58W | 101.0 | 86.7 | - | 92.0 | 93.0 | 011M001 | |
| 012 | 1 | 090313 | 07:31 | 07:53 | 71-34.85N | 157-50.66W | 64.0 | 52.7 | - | 58.4 | 59.0 | 012M001 | |
| 013 | 1 | 090313 | 09:20 | 09:25 | 71-32.25N | 157-45.71W | 70.0 | 55.3 | - | 61.4 | 62.0 | 013M001 | no sampling water |
| 014 | 1 | 090413 | 00:27 | 00:40 | 71-14.71N | 157-10.27W | 46.0 | 35.6 | - | 39.6 | 40.0 | 014M001 | RINKO III (S/N 0079) data were bad |
| 015 | 1 | 090413 | 03:04 | 03:11 | 71-16.73N | 157-16.43W | 55.0 | 50.3 | - | 53.4 | 54.0 | 015M001 | ・RINKO III (S/N 0079) was detached<br>・no sampling water |
| 016 | 1 | 090413 | 03:51 | 04:15 | 71-19.58N | 157-21.05W | 89.0 | 76.3 | - | 82.1 | 83.0 | 016M001 | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 017 | 1 | 090413 | 05:27 | 05:34 | 71-22.24N | 157-25.80W | 112.0 | 98.1 | - | 100.9 | 102.0 | 017M001 | no sampling water |
| 018 | 1 | 090413 | 06:47 | 07:13 | 71-24.67N | 157-30.46W | 122.0 | 110.0 | - | 113.8 | 115.0 | 018M001 | |
| 019 | 1 | 090413 | 08:37 | 08:43 | 71-27.25N | 157-35.50W | 110.0 | 98.4 | - | 100.9 | 102.0 | 019M001 | no sampling water |
| 020 | 1 | 090413 | 09:32 | 09:53 | 71-29.85N | 157-40.56W | 85.0 | 69.8 | - | 74.2 | 75.0 | 020M001 | |
| 021 | 1 | 090413 | 11:38 | 12:09 | 71-29.54N | 156-57.16W | 143.0 | 134.8 | 6.2 | 137.5 | 139.0 | 021M001 | |
| 022 | 1 | 090413 | 13:51 | 14:24 | 71-32.81N | 156-21.26W | 159.0 | 151.2 | - | 155.3 | 157.0 | 022M001 | |
| 023 | 1 | 090413 | 16:15 | 16:56 | 71-37.62N | 155-45.62W | 235.0 | 226.3 | 5.3 | 229.5 | 232.0 | 023M001 | |
| 024 | 1 | 090413 | 19:19 | 19:43 | 71-36.52N | 154-51.09W | 44.0 | 32.7 | - | 35.6 | 36.0 | 024M001 | |
| 025 | 1 | 090413 | 21:02 | 21:26 | 71-40.99N | 154-58.54W | 109.0 | 101.1 | - | 103.9 | 105.0 | 025M001 | |
| 026 | 1 | 090413 | 22:46 | 23:24 | 71-44.19N | 155-06.60W | 257.0 | 244.0 | 9.2 | 247.3 | 250.0 | 026M001 | |
| 027 | 1 | 090513 | 01:05 | 01:39 | 71-48.78N | 155-17.80W | 194.0 | 183.5 | 8.2 | 186.0 | 188.0 | 027M001 | |
| 028 | 1 | 090513 | 02:53 | 03:23 | 71-56.09N | 155-39.39W | 139.0 | 129.3 | - | 132.6 | 134.0 | 028M001 | |
| 029 | 1 | 090513 | 08:10 | 10:42 | 72-40.82N | 154-47.95W | 2931.0 | 2922.0 | 8.1 | 2916.0 | 2967.0 | 029M001 | |
| 030 | 1 | 090713 | 22:05 | 00:13 | 74-30.02N | 161-59.06W | 1631.0 | 1619.9 | 10.5 | 1614.7 | 1638.0 | 030M001 | A/R test cast |
| 031 | 1 | 090813 | 05:19 | 06:56 | 74-31.83N | 161-54.72W | 1694.0 | 1695.1 | 8.5 | 1680.5 | 1705.0 | 031M001 | |
| 032 | 1 | 090913 | 02:00 | 03:26 | 74-32.24N | 161-58.02W | 1685.0 | 1675.3 | 9.8 | 1671.6 | 1696.0 | 032M001 | |
| 033 | 1 | 090913 | 08:24 | 09:49 | 74-10.07N | 162-00.34W | 1118.0 | 1104.9 | 8.9 | 1103.5 | 1118.0 | 033M001 | |
| 034 | 1 | 090913 | 21:35 | 22:12 | 73-59.83N | 168-44.53W | 178.0 | 171.6 | 4.3 | 174.1 | 176.0 | 034M001 | |
| 035 | 1 | 091013 | 08:35 | 08:55 | 73-00.21N | 168-44.92W | 61.0 | 48.8 | - | 51.5 | 52.0 | 035M001 | |
| 036 | 1 | 091013 | 10:35 | 10:53 | 72-44.99N | 168-44.89W | 59.0 | 46.1 | - | 49.5 | 50.0 | 036M001 | |
| 037 | 1 | 091013 | 12:34 | 12:52 | 72-30.06N | 168-44.97W | 58.0 | 45.9 | - | 48.5 | 49.0 | 037M001 | |
| 038 | 1 | 091013 | 14:54 | 15:13 | 72-30.07N | 167-44.88W | 52.0 | 41.0 | - | 46.5 | 47.0 | 038M001 | |
| 039 | 1 | 091013 | 16:45 | 17:00 | 72-45.00N | 167-44.53W | 55.0 | 46.1 | - | 49.5 | 50.0 | 039M001 | |
| 040 | 1 | 091013 | 18:45 | 19:06 | 73-00.02N | 167-44.83W | 65.0 | 54.7 | - | 57.4 | 58.0 | 040M001 | |
| 041 | 1 | 091013 | 21:10 | 21:33 | 72-45.19N | 168-14.48W | 56.0 | 51.0 | - | 50.5 | 51.0 | 041M001 | changed a cable of the fluorescence (gain |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | 10x - gain 30x) |
| 042 | 1 | 091113 | 00:31 | 00:35 | 72-53.95N | 168-14.76W | 58.0 | 49.4 | - | 52.4 | 53.0 | 042M001 | no sampling water |
| 041 | 2 | 091113 | 02:39 | 02:56 | 72-44.97N | 168-15.09W | 56.0 | 43.5 | - | 46.5 | 47.0 | 041M002 | |
| 043 | 1 | 091113 | 06:37 | 06:42 | 72-36.04N | 168-14.96W | 54.0 | 41.9 | - | 45.5 | 46.0 | 043M001 | no sampling water |
| 041 | 3 | 091113 | 08:41 | 08:59 | 72-45.02N | 168-14.55W | 56.0 | 43.7 | - | 46.5 | 47.0 | 041M003 | |
| 044 | 1 | 091113 | 12:35 | 12:39 | 72-45.11N | 167-44.65W | 55.0 | 42.8 | - | 45.5 | 46.0 | 044M001 | no sampling water |
| 041 | 4 | 091113 | 14:41 | 14:58 | 72-44.92N | 168-15.00W | 56.0 | 44.4 | - | 48.5 | 49.0 | 041M004 | |
| 045 | 1 | 091113 | 18:33 | 18:38 | 72-45.17N | 168-45.13W | 59.0 | 51.4 | - | 54.4 | 55.0 | 045M001 | no sampling water |
| 041 | 5 | 091113 | 20:39 | 20:56 | 72-45.03N | 168-15.04W | 56.0 | 44.2 | - | 47.5 | 48.0 | 041M005 | |
| 042 | 2 | 091213 | 00:32 | 00:35 | 72-54.00N | 168-14.80W | 58.0 | 47.2 | - | 50.5 | 51.0 | 042M002 | no sampling water |
| 041 | 6 | 091213 | 02:39 | 02:55 | 72-45.06N | 168-15.10W | 56.0 | 41.9 | - | 46.5 | 47.0 | 041M006 | |
| 043 | 2 | 091213 | 06:37 | 06:41 | 72-36.11N | 168-14.92W | 54.0 | 40.7 | - | 44.5 | 45.0 | 043M002 | no sampling water |
| 041 | 7 | 091213 | 08:41 | 08:59 | 72-44.95N | 168-14.79W | 56.0 | 43.0 | - | 46.5 | 47.0 | 041M007 | |
| 044 | 2 | 091213 | 12:36 | 12:40 | 72-44.87N | 167-44.38W | 55.0 | 41.7 | - | 45.5 | 46.0 | 044M002 | no sampling water |
| 041 | 8 | 091213 | 14:40 | 14:57 | 72-44.99N | 168-15.14W | 56.0 | 43.7 | - | 47.5 | 48.0 | 041M008 | |
| 045 | 2 | 091213 | 18:33 | 18:38 | 72-44.98N | 168-45.37W | 59.0 | 48.8 | - | 52.4 | 53.0 | 045M002 | no sampling water |
| 041 | 9 | 091213 | 20:39 | 21:05 | 72-44.99N | 168-15.67W | 56.0 | 44.1 | - | 47.5 | 48.0 | 041M009 | |
| 042 | 3 | 091313 | 00:31 | 00:35 | 72-53.97N | 168-14.71W | 59.0 | 47.7 | - | 50.5 | 51.0 | 042M003 | no sampling water |
| 041 | 10 | 091313 | 02:38 | 02:55 | 72-44.99N | 168-14.71W | 56.0 | 43.1 | - | 46.5 | 47.0 | 041M010 | |
| 043 | 3 | 091313 | 06:36 | 06:41 | 72-36.08N | 168-15.18W | 54.0 | 44.6 | - | 47.5 | 48.0 | 043M003 | no sampling water |
| 041 | 11 | 091313 | 08:41 | 09:03 | 72-45.02N | 168-14.83W | 56.0 | 45.2 | 8.8 | 47.5 | 48.0 | 041M011 | |
| 044 | 3 | 091313 | 12:34 | 12:38 | 72-45.04N | 167-44.38W | 55.0 | 44.2 | - | 47.5 | 48.0 | 044M003 | no sampling water |
| 041 | 12 | 091313 | 14:41 | 15:00 | 72-44.98N | 168-14.83W | 56.0 | 44.8 | - | 48.5 | 49.0 | 041M012 | |
| 045 | 3 | 091313 | 18:40 | 18:45 | 72-45.08N | 168-45.39W | 59.0 | 50.9 | - | 54.4 | 55.0 | 045M003 | no sampling water |
| 041 | 13 | 091313 | 20:39 | 21:01 | 72-45.08N | 168-15.19W | 56.0 | 47.0 | - | 50.5 | 51.0 | 041M013 | |
| 042 | 4 | 091413 | 00:30 | 00:34 | 72-54.03N | 168-14.98W | 59.0 | 47.5 | 8.2 | 50.5 | 51.0 | 042M004 | no sampling water |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 041 | 14 | 091413 | 02:39 | 03:00 | 72-45.05N | 168-14.82W | 56.0 | 47.4 | - | 50.5 | 51.0 | 041M014 | |
| 043 | 4 | 091413 | 06:37 | 06:42 | 72-36.03N | 168-15.21W | 54.0 | 43.3 | 7.2 | 47.5 | 48.0 | 043M004 | no sampling water |
| 041 | 15 | 091413 | 08:40 | 09:01 | 72-44.97N | 168-15.05W | 56.0 | 46.8 | - | 51.5 | 52.0 | 041M015 | |
| 044 | 4 | 091413 | 12:35 | 12:56 | 72-45.02N | 167-44.99W | 55.0 | 44.8 | - | 49.5 | 50.0 | 044M004 | |
| 041 | 16 | 091413 | 14:46 | 15:07 | 72-44.97N | 168-15.05W | 56.0 | 46.1 | - | 51.5 | 52.0 | 041M016 | |
| 045 | 4 | 091413 | 18:33 | 18:54 | 72-45.13N | 168-45.64W | 59.0 | 46.6 | - | 54.4 | 55.0 | 045M004 | |
| 041 | 17 | 091413 | 20:41 | 21:13 | 72-44.89N | 168-14.74W | 56.0 | 47.0 | - | 52.5 | 53.0 | 041M017 | |
| 042 | 5 | 091513 | 00:33 | 00:53 | 72-53.93N | 168-15.03W | 58.0 | 47.2 | - | 53.4 | 54.0 | 042M005 | |
| 041 | 18 | 091513 | 02:39 | 03:02 | 72-45.07N | 168-14.61W | 56.0 | 42.8 | 7.7 | 48.5 | 49.0 | 041M018 | |
| 043 | 5 | 091513 | 06:37 | 06:59 | 72-36.01N | 168-14.90W | 55.0 | 43.1 | 4.8 | 48.5 | 49.0 | 043M005 | |
| 041 | 19 | 091513 | 08:42 | 09:04 | 72-44.93N | 168-14.91W | 56.0 | 43.7 | 7.8 | 48.5 | 49.0 | 041M019 | |
| 044 | 5 | 091513 | 12:37 | 12:41 | 72-45.03N | 167-44.67W | 55.0 | 45.9 | - | 50.5 | 51.0 | 044M005 | no sampling water |
| 041 | 20 | 091513 | 14:40 | 15:01 | 72-44.94N | 168-15.08W | 56.0 | 44.4 | - | 51.5 | 52.0 | 041M020 | |
| 045 | 5 | 091513 | 18:33 | 18:38 | 72-45.08N | 168-45.43W | 59.0 | 47.5 | - | 54.4 | 55.0 | 045M005 | no sampling water |
| 041 | 21 | 091513 | 20:39 | 20:59 | 72-45.07N | 168-15.25W | 56.0 | 46.3 | - | 50.5 | 51.0 | 041M021 | |
| 042 | 6 | 091613 | 00:30 | 00:34 | 72-54.06N | 168-14.82W | 59.0 | 48.1 | - | 52.5 | 53.0 | 042M006 | no sampling water |
| 041 | 22 | 091613 | 02:39 | 02:59 | 72-45.02N | 168-15.21W | 56.0 | 45.7 | - | 51.5 | 52.0 | 041M022 | |
| 043 | 6 | 091613 | 06:37 | 06:43 | 72-36.03N | 168-14.94W | 55.0 | 45.3 | - | 49.5 | 50.0 | 043M006 | no sampling water |
| 041 | 23 | 091613 | 08:41 | 09:02 | 72-44.98N | 168-14.83W | 56.0 | 48.1 | - | 51.5 | 52.0 | 041M023 | |
| 044 | 6 | 091613 | 12:34 | 12:38 | 72-45.10N | 167-44.38W | 55.0 | 45.9 | - | 49.5 | 50.0 | 044M006 | no sampling water |
| 041 | 24 | 091613 | 14:40 | 15:00 | 72-44.81N | 168-14.57W | 56.0 | 45.0 | - | 51.5 | 52.0 | 041M024 | |
| 045 | 6 | 091613 | 18:32 | 18:37 | 72-45.06N | 168-45.46W | 59.0 | 50.9 | - | 55.4 | 56.0 | 045M006 | no sampling water |
| 041 | 25 | 091613 | 20:39 | 21:14 | 72-45.09N | 168-15.20W | 56.0 | 47.4 | - | 50.5 | 51.0 | 041M025 | |
| 042 | 7 | 091713 | 00:31 | 00:35 | 72-54.11N | 168-14.81W | 58.0 | 45.9 | - | 50.5 | 51.0 | 042M007 | no sampling water |
| 041 | 26 | 091713 | 02:39 | 03:00 | 72-45.02N | 168-14.95W | 56.0 | 46.8 | 5.9 | 49.5 | 50.0 | 041M026 | |
| 043 | 7 | 091713 | 06:38 | 06:42 | 72-36.04N | 168-14.85W | 55.0 | 45.9 | - | 50.5 | 51.0 | 043M007 | no sampling water |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 041 | 27 | 091713 | 09:01 | 09:23 | 72-44.92N | 168-14.90W | 56.0 | 45.9 | 5.9 | 50.5 | 51.0 | 041M027 | |
| 044 | 7 | 091713 | 12:34 | 12:39 | 72-45.06N | 167-44.83W | 55.0 | 46.8 | - | 50.5 | 51.0 | 044M007 | no sampling water |
| 041 | 28 | 091713 | 14:40 | 15:00 | 72-45.01N | 168-14.95W | 56.0 | 45.0 | - | 51.5 | 52.0 | 041M028 | |
| 045 | 7 | 091713 | 18:33 | 18:38 | 72-45.08N | 168-45.25W | 59.0 | 49.4 | - | 55.4 | 56.0 | 045M007 | no sampling water |
| 041 | 29 | 091713 | 20:39 | 20:59 | 72-44.97N | 168-14.92W | 56.0 | 47.2 | 5.9 | 50.5 | 51.0 | 041M029 | |
| 042 | 8 | 091813 | 00:31 | 00:35 | 72-54.06N | 168-14.77W | 59.0 | 49.6 | - | 53.4 | 54.0 | 042M008 | no sampling water |
| 041 | 30 | 091813 | 02:38 | 02:59 | 72-45.07N | 168-14.90W | 56.0 | 46.6 | - | 50.5 | 51.0 | 041M030 | |
| 043 | 8 | 091813 | 06:38 | 06:43 | 72-36.07N | 168-14.98W | 55.0 | 43.5 | - | 49.5 | 50.0 | 043M008 | no sampling water |
| 041 | 31 | 091813 | 08:41 | 09:02 | 72-44.96N | 168-15.08W | 56.0 | 46.4 | - | 50.5 | 51.0 | 041M031 | |
| 044 | 8 | 091813 | 12:34 | 12:38 | 72-45.11N | 167-44.78W | 55.0 | 44.8 | - | 48.5 | 49.0 | 044M008 | no sampling water |
| 041 | 32 | 091813 | 14:40 | 14:59 | 72-45.31N | 168-14.65W | 56.0 | 43.9 | - | 49.5 | 50.0 | 041M032 | |
| 045 | 8 | 091813 | 18:32 | 18:36 | 72-45.01N | 168-45.40W | 59.0 | 49.0 | - | 53.4 | 54.0 | 045M008 | no sampling water |
| 041 | 33 | 091813 | 20:39 | 21:10 | 72-44.92N | 168-15.02W | 56.0 | 45.3 | - | 49.5 | 50.0 | 041M033 | |
| 042 | 9 | 091913 | 00:31 | 00:35 | 72-54.05N | 168-15.13W | 59.0 | 49.2 | - | 52.4 | 53.0 | 042M009 | no sampling water |
| 041 | 34 | 091913 | 02:38 | 03:00 | 72-45.08N | 168-15.03W | 56.0 | 46.3 | 5.9 | 49.5 | 50.0 | 041M034 | |
| 043 | 9 | 091913 | 06:40 | 06:45 | 72-36.06N | 168-15.09W | 55.0 | 45.3 | - | 50.5 | 51.0 | 043M009 | no sampling water |
| 041 | 35 | 091913 | 08:41 | 09:03 | 72-44.91N | 168-15.31W | 56.0 | 45.7 | - | 50.5 | 51.0 | 041M035 | |
| 044 | 9 | 091913 | 12:37 | 12:42 | 72-45.07N | 167-45.21W | 55.0 | 45.9 | - | 50.5 | 51.0 | 044M009 | no sampling water |
| 041 | 36 | 091913 | 14:42 | 15:02 | 72-45.18N | 168-15.34W | 56.0 | 44.8 | - | 51.5 | 52.0 | 041M036 | |
| 045 | 9 | 091913 | 18:31 | 18:36 | 72-45.08N | 168-45.31W | 59.0 | 48.1 | - | 55.4 | 56.0 | 045M009 | no sampling water |
| 041 | 37 | 091913 | 20:40 | 21:01 | 72-44.88N | 168-15.13W | 56.0 | 44.4 | - | 49.5 | 50.0 | 041M037 | |
| 042 | 10 | 092013 | 00:39 | 00:44 | 72-53.94N | 168-15.13W | 58.0 | 47.9 | - | 52.5 | 53.0 | 042M010 | no sampling water |
| 041 | 38 | 092013 | 02:39 | 02:59 | 72-45.05N | 168-15.29W | 56.0 | 46.6 | - | 51.5 | 52.0 | 041M038 | |
| 043 | 10 | 092013 | 06:39 | 06:45 | 72-36.07N | 168-15.15W | 54.0 | 44.4 | - | 49.5 | 50.0 | 043M010 | no sampling water |
| 041 | 39 | 092013 | 08:45 | 09:09 | 72-44.60N | 168-15.23W | 56.0 | 46.1 | - | 51.5 | 52.0 | 041M039 | |
| 044 | 10 | 092013 | 12:55 | 13:00 | 72-45.25N | 167-44.92W | 55.0 | 45.0 | - | 50.5 | 51.0 | 044M010 | no sampling water |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 041 | 40 | 092013 | 14:43 | 15:03 | 72-44.79N | 168-14.91W | 56.0 | 46.3 | - | 52.5 | 53.0 | 041M040 | |
| 045 | 10 | 092013 | 18:31 | 18:36 | 72-45.07N | 168-45.51W | 59.0 | 47.7 | - | 53.4 | 54.0 | 045M010 | no sampling water |
| 041 | 41 | 092013 | 20:42 | 21:17 | 72-44.93N | 168-14.45W | 56.0 | 45.9 | - | 51.5 | 52.0 | 041M041 | |
| 042 | 11 | 092113 | 00:37 | 00:42 | 72-54.08N | 168-15.60W | 58.0 | 46.1 | - | 53.4 | 54.0 | 042M011 | no sampling water |
| 041 | 42 | 092113 | 02:43 | 03:03 | 72-45.22N | 168-15.45W | 56.0 | 45.5 | - | 51.5 | 52.0 | 041M042 | |
| 043 | 11 | 092113 | 06:38 | 07:01 | 72-36.14N | 168-15.40W | 54.0 | 41.9 | 7.5 | 47.5 | 48.0 | 043M011 | |
| 041 | 43 | 092113 | 08:44 | 09:06 | 72-45.10N | 168-14.37W | 56.0 | 44.8 | - | 50.5 | 51.0 | 041M043 | |
| 044 | 11 | 092113 | 12:35 | 12:40 | 72-45.02N | 167-45.08W | 55.0 | 44.2 | - | 49.5 | 50.0 | 044M011 | no sampling water |
| 041 | 44 | 092113 | 14:42 | 15:03 | 72-45.04N | 168-14.83W | 56.0 | 44.2 | - | 51.5 | 52.0 | 041M044 | |
| 045 | 11 | 092113 | 18:31 | 18:36 | 72-45.02N | 168-45.17W | 59.0 | 49.6 | - | 55.4 | 56.0 | 045M011 | no sampling water |
| 041 | 45 | 092113 | 20:38 | 20:58 | 72-44.99N | 168-15.07W | 56.0 | 47.0 | - | 50.5 | 51.0 | 041M045 | |
| 042 | 12 | 092213 | 00:31 | 00:36 | 72-54.00N | 168-15.33W | 59.0 | 48.1 | - | 52.5 | 53.0 | 042M012 | no sampling water |
| 041 | 46 | 092213 | 02:38 | 03:01 | 72-45.02N | 168-15.13W | 56.0 | 45.2 | - | 50.5 | 51.0 | 041M046 | |
| 043 | 12 | 092213 | 06:41 | 07:02 | 72-36.04N | 168-15.05W | 55.0 | 44.8 | - | 49.5 | 50.0 | 043M012 | |
| 041 | 47 | 092213 | 08:39 | 09:01 | 72-45.00N | 168-15.00W | 56.0 | 47.4 | 6.1 | 50.5 | 51.0 | 041M047 | |
| 044 | 12 | 092213 | 12:33 | 12:39 | 72-45.06N | 167-44.60W | 55.0 | 46.3 | - | 50.5 | 51.0 | 044M012 | no sampling water |
| 041 | 48 | 092213 | 14:38 | 14:58 | 72-44.97N | 168-14.86W | 56.0 | 45.2 | - | 50.5 | 51.0 | 041M048 | |
| 045 | 12 | 092213 | 18:32 | 18:37 | 72-45.07N | 168-45.15W | 59.0 | 51.0 | - | 55.4 | 56.0 | 045M012 | no sampling water |
| 041 | 49 | 092213 | 20:40 | 21:10 | 72-44.99N | 168-14.95W | 56.0 | 48.1 | - | 50.5 | 51.0 | 041M049 | |
| 042 | 13 | 092313 | 00:33 | 00:38 | 72-54.05N | 168-14.84W | 59.0 | 51.0 | - | 53.4 | 54.0 | 042M013 | no sampling water |
| 041 | 50 | 092313 | 02:40 | 03:01 | 72-44.98N | 168-15.13W | 56.0 | 48.5 | - | 51.5 | 52.0 | 041M050 | |
| 043 | 13 | 092313 | 06:39 | 07:01 | 72-36.11N | 168-14.66W | 54.0 | 46.1 | - | 49.5 | 50.0 | 043M013 | |
| 041 | 51 | 092313 | 08:41 | 09:02 | 72-44.98N | 168-14.81W | 56.0 | 47.2 | - | 50.5 | 51.0 | 041M051 | |
| 044 | 13 | 092313 | 12:34 | 12:40 | 72-45.13N | 167-44.45W | 55.0 | 46.8 | - | 50.5 | 51.0 | 044M013 | no sampling water |
| 041 | 52 | 092313 | 14:39 | 14:59 | 72-44.95N | 168-15.08W | 56.0 | 46.4 | - | 50.5 | 51.0 | 041M052 | |
| 045 | 13 | 092313 | 18:31 | 18:35 | 72-45.06N | 168-45.18W | 59.0 | 48.5 | 6.5 | 52.4 | 53.0 | 045M013 | no sampling water |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 041 | 53 | 092313 | 20:39 | 20:57 | 72-44.93N | 168-14.83W | 56.0 | 45.0 | 9.0 | 48.5 | 49.0 | 041M053 | |
| 042 | 14 | 092413 | 00:32 | 00:36 | 72-54.00N | 168-15.03W | 58.0 | 47.0 | - | 49.5 | 50.0 | 042M014 | no sampling water |
| 041 | 54 | 092413 | 02:39 | 03:01 | 72-44.99N | 168-14.99W | 56.0 | 47.7 | - | 50.5 | 51.0 | 041M054 | |
| 043 | 14 | 092413 | 06:39 | 07:00 | 72-36.02N | 168-14.74W | 54.0 | 47.4 | - | 49.5 | 50.0 | 043M014 | |
| 041 | 55 | 092413 | 08:41 | 09:03 | 72-45.00N | 168-15.01W | 56.0 | 47.5 | - | 50.5 | 51.0 | 041M055 | |
| 044 | 14 | 092413 | 12:36 | 12:41 | 72-45.00N | 167-44.69W | 55.0 | 46.3 | - | 49.5 | 50.0 | 044M014 | no sampling water |
| 041 | 56 | 092413 | 14:44 | 15:04 | 72-44.94N | 168-15.30W | 56.0 | 45.0 | - | 50.5 | 51.0 | 041M056 | |
| 045 | 14 | 092413 | 18:30 | 18:34 | 72-45.04N | 168-44.72W | 59.0 | 50.5 | - | 54.4 | 55.0 | 045M014 | no sampling water |
| 041 | 57 | 092413 | 20:40 | 21:08 | 72-45.03N | 168-14.96W | 56.0 | 47.0 | - | 50.5 | 51.0 | 041M057 | |
| 042 | 15 | 092513 | 00:33 | 00:55 | 72-54.00N | 168-15.00W | 59.0 | 49.9 | - | 53.4 | 54.0 | 042M015 | |
| 041 | 58 | 092513 | 02:39 | 03:00 | 72-44.96N | 168-14.78W | 56.0 | 47.2 | - | 51.5 | 52.0 | 041M058 | |
| 043 | 15 | 092513 | 06:40 | 07:03 | 72-36.20N | 168-14.86W | 54.0 | 46.4 | - | 49.5 | 50.0 | 043M015 | |
| 041 | 59 | 092513 | 08:46 | 09:07 | 72-45.29N | 168-14.92W | 56.0 | 47.5 | - | 50.5 | 51.0 | 041M059 | |
| 044 | 15 | 092513 | 12:35 | 12:41 | 72-44.92N | 167-44.42W | 55.0 | 47.2 | - | 50.5 | 51.0 | 044M015 | no sampling water |
| 046 | 1 | 092513 | 13:19 | 13:41 | 72-48.43N | 167-46.56W | 57.0 | 47.2 | - | 51.5 | 52.0 | 046M001 | |
| 041 | 60 | 092513 | 15:01 | 15:21 | 72-45.05N | 168-14.92W | 56.0 | 46.8 | - | 51.5 | 52.0 | 041M060 | |
| 045 | 15 | 092513 | 18:31 | 18:50 | 72-44.99N | 168-45.27W | 59.0 | 49.2 | - | 53.4 | 54.0 | 045M015 | |
| 041 | 61 | 092513 | 20:39 | 20:59 | 72-45.11N | 168-14.88W | 56.0 | 47.5 | - | 51.5 | 52.0 | 041M061 | |
| 047 | 1 | 092613 | 01:11 | 01:35 | 72-59.16N | 168-55.75W | 69.0 | 60.0 | - | 63.3 | 64.0 | 047M001 | |
| 048 | 1 | 092613 | 06:38 | 07:17 | 74-00.15N | 168-45.05W | 180.0 | 170.1 | - | 172.1 | 174.0 | 048M001 | |
| 049 | 1 | 092613 | 11:23 | 11:49 | 73-30.05N | 168-45.73W | 116.0 | 106.4 | - | 108.8 | 110.0 | 049M001 | |
| 050 | 1 | 092613 | 13:34 | 14:01 | 73-29.89N | 167-45.16W | 114.0 | 104.7 | - | 106.9 | 108.0 | 050M001 | |
| 051 | 1 | 092613 | 16:35 | 16:55 | 72-59.91N | 167-45.02W | 64.0 | 56.2 | - | 60.4 | 61.0 | 051M001 | |
| 052 | 1 | 092613 | 22:00 | 22:35 | 73-03.75N | 164-37.14W | 72.0 | 64.3 | 5.6 | 67.3 | 68.0 | 052M001 | |
| 053 | 1 | 092713 | 02:02 | 02:22 | 73-22.96N | 163-17.94W | 84.0 | 71.1 | 5.9 | 75.2 | 76.0 | 053M001 | |
| 054 | 1 | 092713 | 04:26 | 05:01 | 73-41.58N | 162-39.10W | 192.0 | 184.8 | 6.9 | 188.0 | 190.0 | 054M001 | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 055 | 1 | 092713 | 07:30 | 08:23 | 74-00.04N | 161-59.63W | 359.0 | 354.6 | - | 356.0 | 360.0 | 055M001 | |
| 056 | 1 | 092713 | 11:42 | 13:51 | 73-48.03N | 159-59.38W | 2652.0 | 2647.1 | 9.0 | 2637.5 | 2682.0 | 056M001 | |
| 057 | 1 | 092713 | 22:22 | 23:15 | 73-18.20N | 160-50.02W | 407.0 | 400.5 | - | 402.4 | 407.0 | 057M001 | |
| 058 | 1 | 092813 | 02:09 | 02:45 | 73-08.99N | 162-18.73W | 195.0 | 185.4 | 6.5 | 188.0 | 190.0 | 058M001 | |
| 059 | 1 | 092813 | 05:31 | 05:47 | 72-44.32N | 162-28.45W | 48.0 | 36.9 | - | 39.6 | 40.0 | 059M001 | |
| 045 | 16 | 093013 | 18:30 | 18:50 | 72-45.06N | 168-45.32W | 59.0 | 47.5 | - | 50.5 | 51.0 | 045M016 | |
| 041 | 62 | 093013 | 20:58 | 21:36 | 72-45.11N | 168-15.42W | 56.0 | 48.3 | - | 50.5 | 51.0 | 041M062 | |
| 042 | 16 | 100113 | 00:30 | 00:51 | 72-54.01N | 168-14.98W | 58.0 | 45.7 | - | 49.5 | 50.0 | 042M016 | |
| 041 | 63 | 100113 | 02:40 | 03:01 | 72-45.06N | 168-14.83W | 56.0 | 48.7 | - | 51.5 | 52.0 | 041M063 | |
| 043 | 16 | 100113 | 06:37 | 06:59 | 72-35.98N | 168-14.79W | 54.0 | 47.0 | - | 50.5 | 51.0 | 043M016 | |
| 041 | 64 | 100113 | 08:41 | 09:02 | 72-44.98N | 168-15.11W | 56.0 | 47.5 | - | 51.5 | 52.0 | 041M064 | |
| 044 | 16 | 100113 | 12:34 | 12:55 | 72-45.06N | 167-44.12W | 55.0 | 46.4 | - | 49.5 | 50.0 | 044M016 | |
| 041 | 65 | 100113 | 14:38 | 14:57 | 72-44.91N | 168-14.94W | 56.0 | 44.4 | - | 48.5 | 49.0 | 041M065 | |
| 060 | 1 | 100113 | 19:29 | 19:59 | 72-30.17N | 168-45.05W | 58.0 | 47.4 | - | 50.5 | 51.0 | 060M001 | |
| 061 | 1 | 100113 | 22:44 | 23:06 | 72-00.04N | 168-44.63W | 50.0 | 41.3 | 5.1 | 45.5 | 46.0 | 061M001 | |
| 062 | 1 | 100213 | 02:03 | 02:22 | 71-30.02N | 168-44.80W | 48.0 | 39.8 | - | 42.6 | 43.0 | 062M001 | |
| 063 | 1 | 100213 | 05:07 | 05:22 | 70-59.97N | 168-44.98W | 44.0 | 33.8 | - | 38.6 | 39.0 | 063M001 | |
| 064 | 1 | 100213 | 08:17 | 08:33 | 70-30.00N | 168-44.94W | 38.0 | 29.9 | 5.1 | 33.6 | 34.0 | 064M001 | |
| 065 | 1 | 100213 | 12:03 | 12:20 | 70-00.06N | 168-44.96W | 40.0 | 32.5 | 4.5 | 35.6 | 36.0 | 065M001 | |
| 066 | 1 | 100213 | 15:05 | 15:21 | 69-30.00N | 168-44.72W | 51.0 | 38.7 | - | 42.6 | 43.0 | 066M001 | |
| 067 | 1 | 100213 | 18:02 | 18:21 | 69-00.08N | 168-44.84W | 52.0 | 43.7 | - | 46.5 | 47.0 | 067M001 | |
| 068 | 1 | 100213 | 22:55 | 23:08 | 68-18.08N | 167-02.75W | 38.0 | 27.5 | - | 29.7 | 30.0 | 068M001 | |
| 069 | 1 | 100313 | 00:57 | 01:01 | 68-14.98N | 167-12.09W | 45.0 | 36.2 | - | 38.6 | 39.0 | 069M001 | no sampling water |
| 070 | 1 | 100313 | 01:37 | 01:55 | 68-12.12N | 167-20.03W | 47.0 | 36.3 | - | 39.6 | 40.0 | 070M001 | |
| 071 | 1 | 100313 | 03:53 | 03:56 | 68-06.06N | 167-40.59W | 52.0 | 41.5 | - | 44.5 | 45.0 | 071M001 | no sampling water |
| 072 | 1 | 100313 | 05:05 | 05:24 | 68-00.15N | 168-00.22W | 54.0 | 42.2 | - | 45.5 | 46.0 | 072M001 | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 073 | 1 | 100313 | 07:06 | 07:10 | 67-52.40N | 168-15.08W | 57.0 | 47.5 | 6.2 | 50.5 | 51.0 | 073M001 | ・changed a cable of the fluorescence (gain 30x - gain 10x)<br>・no sampling water |
| 074 | 1 | 100313 | 08:38 | 08:58 | 67-44.90N | 168-30.03W | 49.0 | 40.6 | - | 43.6 | 44.0 | 074M001 | |
| 075 | 1 | 100313 | 15:05 | 15:21 | 68-30.07N | 168-44.98W | 53.0 | 40.2 | - | 44.5 | 45.0 | 075M001 | |
| 076 | 1 | 100313 | 17:34 | 17:53 | 68-15.01N | 168-45.04W | 56.0 | 45.5 | - | 49.5 | 50.0 | 076M001 | |
| 077 | 1 | 100313 | 20:29 | 21:07 | 68-00.05N | 168-45.37W | 58.0 | 47.2 | - | 50.5 | 51.0 | 077M001 | |
| 078 | 1 | 100413 | 00:06 | 00:24 | 67-45.04N | 168-45.03W | 50.0 | 40.9 | - | 44.6 | 45.0 | 078M001 | |
| 079 | 1 | 100413 | 02:35 | 02:52 | 67-29.97N | 168-44.96W | 49.0 | 39.6 | - | 42.6 | 43.0 | 079M001 | |
| 080 | 1 | 100413 | 05:08 | 05:24 | 67-15.05N | 168-45.05W | 47.0 | 36.5 | - | 40.6 | 41.0 | 080M001 | |
| 081 | 1 | 100413 | 07:39 | 07:55 | 67-00.03N | 168-45.33W | 45.0 | 36.5 | - | 40.6 | 41.0 | 081M001 | |
| 082 | 1 | 100413 | 11:06 | 11:25 | 66-30.07N | 168-45.78W | 51.0 | 41.5 | - | 45.5 | 46.0 | 082M001 | |
| 083 | 1 | 100413 | 14:39 | 14:57 | 65-59.99N | 168-45.03W | 52.0 | 39.8 | - | 44.6 | 45.0 | 083M001 | |
| 084 | 1 | 100413 | 18:21 | 18:50 | 65-45.80N | 168-45.44W | 51.0 | 40.0 | - | 44.6 | 45.0 | 084M001 | |
| 085 | 1 | 100413 | 20:19 | 20:24 | 65-42.28N | 168-31.25W | 53.0 | 43.0 | - | 46.5 | 47.0 | 085M001 | no sampling water |
| 086 | 1 | 100413 | 21:22 | 21:38 | 65-39.05N | 168-15.10W | 43.0 | 31.0 | - | 34.7 | 35.0 | 086M001 | |
| 087 | 1 | 101313 | 20:02 | 20:53 | 48-52.51N | 166-36.87E | 6111.0 | 1190.5 | - | 1190.4 | 1204.0 | 087M001 | ・Leg2<br>・RM cast<br>・changed a cable of the fluorescence (gain 10x - gain 30x) |
| 087 | 2 | 101313 | 23:04 | 23:53 | 48-51.64N | 166-35.35E | 6092.0 | 1210.7 | - | 1188.4 | 1202.0 | 087M002 | ・Leg2<br>・RM cast |

A/R test cast: Acoustic Releasers test cast

RM cast: Reference Material cast

## 3.2. XCTD

(1) Personnel

| | |
|---|---|
| Shigeto Nishino | JAMSTEC: PI |
| Jun Inoue | JAMSTEC/NIPR |
| Yusuke Kawaguchi | JAMSTEC |
| Souichiro Sueyoshi | GODI |
| Katsuhisa Maeno | GODI |
| Masanori Murakami | GODI |
| Koichi Inagaki | GODI |
| Ryo Ohyama | MIRAI Crew |

(2) Objective

To investigate ocean structure.

(3) Parameters

According to the manufacturer's nominal specifications, the range and accuracy of parameters measured by the XCTD (eXpendable Conductivity, Temperature & Depth profiler) are as follows;

| Parameter | Range | Accuracy |
|---|---|---|
| Conductivity | 0 ~ 60 [mS/cm] | +/- 0.03 [mS/cm] |
| Temperature | -2 ~ 35 [deg-C] | +/- 0.02 [deg-C] |
| Depth | 0 ~ 1000 [m] | 5 [m] or 2 [%] (either of them is major) |

(4) Methods

We observed the vertical profiles of the sea water temperature and salinity measured by XCTD-1 manufactured by Tsurumi-Seiki Co.. The signal was converted by digital converter MK-150N, and was recorded by AL-12B software (Ver.1.1.4). We launched 143 probes (XCTD-1 ～ XCTD-143) by using automatic launcher. The summary of XCTD observation log is shown in Table 3.2-1.

(5) Observation log

**Table3.2-1.** XCTD observation log

| No. | Station No. | Date [YYYY/MM/DD] | Time [hh:mm] | Latitude [degN] | Longitude [degW] | Depth [m] | SST [deg-C] | SSS [PSU] | Probe S/N |
|---|---|---|---|---|---|---|---|---|---|
| 1 | XCTD-1 | 2013/09/04 | 20:02 | 71-38.4943 | 154-55.2481 | 61 | 2.704 | 27.249 | 11011561 |
| 2 | XCTD-2 | 2013/09/04 | 21:47 | 71-41.9048 | 155-03.8591 | 159 | 2.975 | 25.944 | 11011560 |
| 3 | XCTD-3 | 2013/09/05 | 00:14 | 71-45.9112 | 155-14.3367 | 228 | 3.116 | 26.088 | 11011563 |
| 4 | XCTD-4 | 2013/09/05 | 02:01 | 71-51.1150 | 155-24.7504 | 159 | 3.331 | 27.056 | 11011562 |
| 5 | XCTD-5 | 2013/09/05 | 02:17 | 71-53.5134 | 155-32.2418 | 156 | 3.315 | 27.657 | 11011569 |

**Table3.2-1.** (Continued)

| No. | Station No. | Date [YYYY/MM/DD] | Time [hh:mm] | Latitude [degN] | Longitude [degW] | Depth [m] | SST [deg-C] | SSS [PSU] | Probe S/N |
|---|---|---|---|---|---|---|---|---|---|
| 6 | XCTD-6 | 2013/09/05 | 04:15 | 72-01.2236 | 155-29.2257 | 211 | 3.335 | 28.154 | 11011566 |
| 7 | XCTD-7 | 2013/09/05 | 04:46 | 72-06.5502 | 155-18.8737 | 366 | 2.372 | 26.888 | 11011565 |
| 8 | XCTD-8 | 2013/09/05 | 05:15 | 72-11.8725 | 155-08.5420 | 1016 | 2.754 | 25.778 | 11011558 |
| 9 | XCTD-9 | 2013/09/05 | 05:49 | 72-17.1837 | 154-58.1364 | 1884 | 2.873 | 25.601 | 11011567 |
| 10 | XCTD-10 | 2013/09/05 | 06:18 | 72-22.4976 | 154-48.1017 | 2237 | 2.680 | 25.927 | 11011559 |
| 11 | XCTD-11 | 2013/09/05 | 06:51 | 72-29.9981 | 154-48.0435 | 2521 | 2.224 | 25.858 | 11011564 |
| 12 | XCTD-12 | 2013/09/05 | 07:53 | 72-39.9791 | 154-48.1281 | 2876 | 0.297 | 26.265 | 11011568 |
| 13 | XCTD-13 | 2013/09/06 | 04:03 | 71-36.5250 | 154-50.7075 | 43 | 2.342 | 27.740 | 13041459 |
| 14 | XCTD-14 | 2013/09/06 | 04:16 | 71-38.4814 | 154-55.1652 | 58 | 2.555 | 26.810 | 13041467 |
| 15 | XCTD-15 | 2013/09/06 | 04:29 | 71-40.8386 | 154-58.4660 | 106 | 2.555 | 27.363 | 13041460 |
| 16 | XCTD-16 | 2013/09/06 | 04:43 | 71-41.9075 | 155-03.9833 | 157 | 2.693 | 27.421 | 13041457 |
| 17 | XCTD-17 | 2013/09/06 | 04:56 | 71-44.0514 | 155-07.1814 | 249 | 2.932 | 26.146 | 13041458 |
| 18 | XCTD-18 | 2013/09/06 | 05:12 | 71-45.9193 | 155-14.3260 | 226 | 3.090 | 26.118 | 13041456 |
| 19 | XCTD-19 | 2013/09/06 | 05:42 | 71-48.7464 | 155-17.6367 | 197 | 3.153 | 26.043 | 13041466 |
| 20 | XCTD-20 | 2013/09/06 | 06:08 | 71-51.9932 | 155-29.7400 | 151 | 3.113 | 26.711 | 13041465 |
| 21 | XCTD-21 | 2013/09/06 | 06:34 | 71-55.8871 | 155-39.4391 | 139 | 3.220 | 27.214 | 13041461 |
| 22 | XCTD-22 | 2013/09/07 | 07:09 | 72-50.3474 | 155-01.0741 | 3232 | 0.328 | 26.090 | 13072720 |
| 23 | XCTD-23 | 2013/09/07 | 08:19 | 72-57.0839 | 155-41.9493 | 3100 | 0.614 | 26.263 | 13072715 |
| 24 | XCTD-24 | 2013/09/07 | 09:41 | 73-04.0381 | 156-24.3632 | 2830 | 0.673 | 25.833 | 13072717 |
| 25 | XCTD-25 | 2013/09/07 | 10:51 | 73-11.0626 | 157-06.4706 | 2835 | 0.951 | 25.983 | 13072713 |
| 26 | XCTD-26 | 2013/09/07 | 12:05 | 73-18.0211 | 157-47.9944 | 2664 | 1.642 | 26.705 | 13072718 |
| 27 | XCTD-27 | 2013/09/07 | 13:11 | 73-24.9754 | 158-29.9880 | 2390 | 1.044 | 26.172 | 13072721 |
| 28 | XCTD-28 | 2013/09/07 | 14:16 | 73-31.8324 | 159-10.9973 | 2519 | 0.287 | 26.119 | 13041462 |
| 29 | XCTD-29 | 2013/09/07 | 15:34 | 73-39.0203 | 159-54.0830 | 2408 | 0.381 | 26.350 | 13041463 |
| 30 | XCTD-30 | 2013/09/07 | 16:42 | 73-46.0096 | 160-36.0067 | 2015 | 0.930 | 26.085 | 13041464 |
| 31 | XCTD-31 | 2013/09/07 | 17:55 | 73-53.0038 | 161-17.9748 | 413 | 1.786 | 26.146 | 13072716 |
| 32 | XCTD-32 | 2013/09/07 | 19:02 | 73-59.9631 | 161-59.9910 | 361 | 0.869 | 26.056 | 13072719 |
| 33 | XCTD-33 | 2013/09/07 | 20:19 | 74-14.9489 | 162-00.0339 | 1288 | 1.524 | 26.280 | 13072714 |
| 34 | XCTD-34 | 2013/09/07 | 22:01 | 74-29.8133 | 161-59.3492 | 1631 | 0.299 | 26.156 | 13072710 |
| 35 | XCTD-35 | 2013/09/08 | 01:34 | 74-45.0001 | 162-03.7114 | 1873 | 0.171 | 26.200 | 13072711 |
| 36 | XCTD-36 | 2013/09/08 | 03:27 | 74-47.9089 | 161-59.4904 | 1901 | -1.003 | 25.892 | 13072722 |
| 37 | XCTD-37 | 2013/09/09 | 11:10 | 74-15.0743 | 162-41.4584 | 1015 | 1.039 | 26.060 | 13072730 |
| 38 | XCTD-38 | 2013/09/09 | 12:09 | 74-20.0088 | 163-22.2083 | 790 | 0.959 | 26.131 | 13072733 |
| 39 | XCTD-39 | 2013/09/09 | 13:08 | 74-24.9928 | 164-03.5950 | 509 | 0.903 | 26.398 | 13072729 |
| 40 | XCTD-40 | 2013/09/09 | 14:09 | 74-29.9929 | 164-45.0028 | 381 | 0.600 | 26.011 | 13072732 |
| 41 | XCTD-41 | 2013/09/09 | 15:26 | 74-30.0011 | 165-45.0092 | 370 | 0.682 | 26.163 | 13072728 |
| 42 | XCTD-42 | 2013/09/09 | 16:45 | 74-29.9982 | 166-44.9661 | 322 | 0.520 | 26.066 | 13072712 |
| 43 | XCTD-43 | 2013/09/09 | 18:06 | 74-30.0089 | 167-44.9804 | 305 | 0.152 | 26.274 | 13072726 |
| 44 | XCTD-44 | 2013/09/09 | 19:37 | 74-15.0065 | 168-15.9742 | 224 | -0.246 | 26.388 | 13072725 |
| 45 | XCTD-45 | 2013/09/10 | 01:07 | 73-44.9977 | 168-44.3918 | 147 | -0.459 | 26.521 | 13072734 |

**Table3.2-1.** (Continued)

| No. | Station No. | Date [YYYY/MM/DD] | Time [hh:mm] | Latitude [degN] | Longitude [degW] | Depth [m] | SST [deg-C] | SSS [PSU] | Probe S/N |
|---|---|---|---|---|---|---|---|---|---|
| 46 | XCTD-46 | 2013/09/10 | 03:09 | 73-30.0038 | 168-17.5372 | 115 | -0.843 | 26.767 | 13072724 |
| 47 | XCTD-47 | 2013/09/10 | 06:42 | 73-14.9909 | 168-21.0628 | 74 | 0.452 | 28.622 | 13072727 |
| 48 | XCTD-48 | 2013/09/10 | 13:48 | 72-30.0254 | 168-15.0268 | 53 | 3.414 | 31.411 | 13072723 |
| 49 | XCTD-49 | 2013/09/11 | 01:12 | 72-49.5034 | 168-14.9311 | 57 | 3.145 | 31.219 | 13072739 |
| 50 | XCTD-50 | 2013/09/11 | 07:26 | 72-40.4950 | 168-14.9945 | 55 | 3.067 | 31.124 | 13072740 |
| 51 | XCTD-51 | 2013/09/11 | 13:20 | 72-44.9973 | 167-59.9097 | 57 | 2.594 | 31.184 | 13072741 |
| 52 | XCTD-52 | 2013/09/11 | 19:22 | 72-45.0109 | 168-30.0079 | 55 | 2.700 | 30.825 | 13072742 |
| 53 | XCTD-53 | 2013/09/12 | 01:19 | 72-49.4985 | 168-15.0151 | 57 | 2.756 | 31.019 | 13072743 |
| 54 | XCTD-54 | 2013/09/12 | 07:24 | 72-40.4950 | 168-15.0896 | 55 | 2.959 | 31.326 | 13072736 |
| 55 | XCTD-55 | 2013/09/12 | 13:30 | 72-44.9932 | 167-59.8840 | 57 | 2.831 | 31.283 | 13072737 |
| 56 | XCTD-56 | 2013/09/12 | 19:24 | 72-45.0149 | 168-29.9933 | 55 | 2.552 | 30.758 | 13072738 |
| 57 | XCTD-57 | 2013/09/13 | 01:26 | 72-49.4988 | 168-14.9055 | 57 | 2.526 | 30.858 | 13072748 |
| 58 | XCTD-58 | 2013/09/13 | 05:56 | 72-40.5055 | 168-15.0137 | 55 | 3.215 | 31.139 | 13072747 |
| 59 | XCTD-59 | 2013/09/13 | 13:30 | 72-45.0169 | 167-59.8989 | 57 | 3.094 | 31.361 | 13072746 |
| 60 | XCTD-60 | 2013/09/13 | 18:06 | 72-44.9997 | 168-29.9922 | 55 | 2.627 | 30.768 | 13072744 |
| 61 | XCTD-61 | 2013/09/14 | 01:27 | 72-49.4991 | 168-15.0520 | 55 | 3.200 | 31.152 | 13072755 |
| 62 | XCTD-62 | 2013/09/14 | 05:57 | 72-40.4989 | 168-15.0485 | 55 | 3.005 | 31.246 | 13072745 |
| 63 | XCTD-63 | 2013/09/14 | 13:34 | 72-44.9865 | 167-59.8820 | 57 | 3.021 | 31.424 | 13072749 |
| 64 | XCTD-64 | 2013/09/14 | 18:00 | 72-44.9999 | 168-30.0074 | 55 | 3.032 | 31.152 | 13072750 |
| 65 | XCTD-65 | 2013/09/15 | 01:36 | 72-49.4902 | 168-14.9182 | 56 | 2.780 | 31.364 | 13072735 |
| 66 | XCTD-66 | 2013/09/15 | 05:55 | 72-40.4969 | 168-15.0153 | 55 | 3.005 | 31.397 | 13072751 |
| 67 | XCTD-67 | 2013/09/15 | 13:30 | 72-45.0056 | 167-59.9306 | 57 | 2.283 | 31.446 | 13072752 |
| 68 | XCTD-68 | 2013/09/15 | 17:57 | 72-44.9971 | 168-29.9833 | 55 | 2.964 | 31.311 | 13072753 |
| 89 | XCTD-69 | 2013/09/16 | 01:30 | 72-49.4916 | 168-15.0594 | 54 | 2.793 | 31.415 | 13072760 |
| 70 | XCTD-70 | 2013/09/16 | 05:56 | 72-40.4970 | 168-14.9565 | 55 | 2.872 | 31.459 | 13072754 |
| 71 | XCTD-71 | 2013/09/16 | 13:29 | 72-45.0191 | 167-59.9050 | 58 | 2.697 | 31.405 | 13072756 |
| 72 | XCTD-72 | 2013/09/16 | 17:57 | 72-45.0057 | 168-30.0256 | 55 | 2.976 | 31.400 | 13072757 |
| 73 | XCTD-73 | 2013/09/17 | 01:30 | 72-49.4869 | 168-15.0278 | 54 | 2.671 | 31.425 | 13072758 |
| 74 | XCTD-74 | 2013/09/17 | 06:00 | 72-40.4958 | 168-14.9825 | 55 | 2.728 | 31.494 | 13072759 |
| 75 | XCTD-75 | 2013/09/17 | 13:30 | 72-45.0078 | 167-59.9047 | 58 | 2.830 | 31.546 | 13072763 |
| 76 | XCTD-76 | 2013/09/17 | 17:59 | 72-44.9938 | 168-29.9804 | 55 | 2.901 | 31.390 | 13072762 |
| 77 | XCTD-77 | 2013/09/18 | 01:29 | 72-49.4861 | 168-15.0497 | 56 | 2.610 | 31.351 | 13072761 |
| 78 | XCTD-78 | 2013/09/18 | 06:02 | 72-40.4903 | 168-14.9937 | 55 | 2.761 | 31.556 | 13072646 |
| 79 | XCTD-79 | 2013/09/18 | 13:31 | 72-45.0006 | 167-59.9048 | 57 | 2.678 | 31.527 | 13072645 |
| 80 | XCTD-80 | 2013/09/18 | 17:58 | 72-44.9989 | 168-29.9871 | 55 | 2.500 | 31.390 | 13072644 |
| 81 | XCTD-81 | 2013/09/19 | 01:31 | 72-49.4882 | 168-14.9064 | 55 | 2.473 | 31.368 | 13072643 |
| 82 | XCTD-82 | 2013/09/19 | 05:57 | 72-45.5037 | 168-14.9999 | 55 | 2.576 | 31.471 | 13072702 |
| 83 | XCTD-83 | 2013/09/19 | 13:24 | 72-4439892 | 167-59.9374 | 57 | 2.428 | 31.508 | 13072703 |
| 84 | XCTD-84 | 2013/09/19 | 17:56 | 72-44.9881 | 168-30.0143 | 55 | 2.301 | 31.396 | 13072704 |
| 85 | XCTD-85 | 2013/09/20 | 01:33 | 72-49.4801 | 168-15.0386 | 56 | 2.167 | 31.473 | 13072705 |

**Table3.2-1.** (Continued)

| No. | Station No. | Date [YYYY/MM/DD] | Time [hh:mm] | Latitude [degN] | Longitude [degW] | Depth [m] | SST [deg-C] | SSS [PSU] | Probe S/N |
|---|---|---|---|---|---|---|---|---|---|
| 86 | XCTD-86 | 2013/09/20 | 05:54 | 72-40.4976 | 168-15.0311 | 55 | 2.612 | 31.625 | 13072706 |
| 87 | XCTD-87 | 2013/09/20 | 13:45 | 72-45.0097 | 167-59.9018 | 57 | 2.158 | 31.548 | 13072707 |
| 88 | XCTD-88 | 2013/09/20 | 17:56 | 72-44.9890 | 168-30.0029 | 54 | 2.086 | 31.612 | 13072708 |
| 89 | XCTD-89 | 2013/09/21 | 01:37 | 72-49.4761 | 168-15.1431 | 54 | 2.038 | 31.647 | 13072709 |
| 90 | XCTD-90 | 2013/09/21 | 05:52 | 72-40.4970 | 168-14.9510 | 55 | 2.455 | 31.614 | 13072767 |
| 91 | XCTD-91 | 2013/09/21 | 13:39 | 72-44.9915 | 168-00.4158 | 57 | 2.013 | 31.661 | 13072766 |
| 92 | XCTD-92 | 2013/09/21 | 17:58 | 72-44.9969 | 168-29.9936 | 55 | 1.730 | 31.661 | 13072765 |
| 93 | XCTD-93 | 2013/09/22 | 01:26 | 72-49.5031 | 168-14.9642 | 54 | 1.852 | 31.381 | 13072764 |
| 94 | XCTD-94 | 2013/09/22 | 05:58 | 72-40.4940 | 168-15.0722 | 55 | 2.229 | 31.619 | 13072768 |
| 95 | XCTD-95 | 2013/09/22 | 13:34 | 72-45.0056 | 167-59.9079 | 57 | 1.743 | 31.135 | 13072769 |
| 96 | XCTD-96 | 2013/09/22 | 17:57 | 72-45.0082 | 168-30.0117 | 55 | 1.643 | 31.641 | 13072770 |
| 97 | XCTD-97 | 2013/09/23 | 01:33 | 72-49.5039 | 168-15.0659 | 55 | 1.626 | 31.623 | 13072771 |
| 98 | XCTD-98 | 2013/09/23 | 05:56 | 72-40.4977 | 168-15.0040 | 55 | 1.970 | 31.643 | 13072772 |
| 99 | XCTD-99 | 2013/09/23 | 13:35 | 72-44.9955 | 167-59.9149 | 57 | 1.705 | 31.639 | 13072773 |
| 100 | XCTD-100 | 2013/09/23 | 17:58 | 72-45.0080 | 168-29.9944 | 55 | 1.971 | 31.646 | 13072774 |
| 101 | XCTD-101 | 2013/09/24 | 01:32 | 72-49.5034 | 168-15.0005 | 55 | 1.896 | 31.637 | 13072775 |
| 102 | XCTD-102 | 2013/09/24 | 05:56 | 72-40.4981 | 168-14.9984 | 55 | 2.113 | 31.580 | 13072776 |
| 103 | XCTD-103 | 2013/09/24 | 13:34 | 72-44.9998 | 168-00.0287 | 57 | 1.670 | 31.640 | 13072777 |
| 104 | XCTD-104 | 2013/09/24 | 17:56 | 72-45.0065 | 168-30.0294 | 55 | 2.115 | 31.603 | 13072778 |
| 105 | XCTD-105 | 2013/09/25 | 01:42 | 72-49.5012 | 168-15.0035 | 55 | 1.519 | 31.559 | 13072779 |
| 106 | XCTD-106 | 2013/09/25 | 06:02 | 72-40.4984 | 168-14.9812 | 55 | 2.008 | 31.536 | 13072780 |
| 107 | XCTD-107 | 2013/09/25 | 14:19 | 72-44.9921 | 168-59.8954 | 57 | 2.066 | 31.508 | 13072781 |
| 108 | XCTD-108 | 2013/09/25 | 17:57 | 72-45.0013 | 168-30.0076 | 55 | 1.907 | 31.625 | 13072782 |
| 109 | XCTD-109 | 2013/09/27 | 09:34 | 73-56.0077 | 161-19.9924 | 407 | -0.207 | 26.678 | 13072783 |
| 110 | XCTD-110 | 2013/09/27 | 10:29 | 73-52.0366 | 160-40.4385 | 2178 | -0.308 | 26.518 | 13072784 |
| 111 | XCTD-111 | 2013/09/27 | 19:55 | 73-37.9626 | 160-16.4763 | 2206 | 0.799 | 27.226 | 13072785 |
| 112 | XCTD-112 | 2013/09/27 | 21:00 | 73-27.9156 | 160-32.9355 | 1424 | 0.754 | 27.504 | 13072786 |
| 113 | XCTD-113 | 2013/09/28 | 00:29 | 73-13.3033 | 161-34.6853 | 256 | 0.825 | 27.476 | 13072787 |
| 114 | XCTD-114 | 2013/09/29 | 05:55 | 72-55.5492 | 156-28.0040 | 2652 | -0.251 | 25.844 | 13072796 |
| 115 | XCTD-115 | 2013/09/29 | 06:05 | 72-57.2794 | 156-31.4269 | 2706 | -0.133 | 25.797 | 13072797 |
| 116 | XCTD-116 | 2013/09/29 | 06:15 | 72-59.0119 | 156-34.9086 | 2659 | 0.071 | 26.155 | 13072805 |
| 117 | XCTD-117 | 2013/09/29 | 06:24 | 73-00.7506 | 156-38.2598 | 2549 | 0.090 | 26.292 | 13072802 |
| 118 | XCTD-118 | 2013/09/29 | 06:34 | 73-02.4642 | 156-41.5773 | 2624 | -0.015 | 26.523 | 13072788 |
| 119 | XCTD-119 | 2013/09/29 | 06:44 | 73-04.1954 | 156-45.0510 | 2635 | 0.125 | 26.504 | 13072789 |
| 120 | XCTD-120 | 2013/09/29 | 06:54 | 73-05.9290 | 156-48.4415 | 2631 | 0.233 | 26.375 | 13072790 |
| 121 | XCTD-121 | 2013/09/29 | 07:04 | 73-07.6642 | 156-51.9865 | 2556 | 0.242 | 26.336 | 13072791 |
| 122 | XCTD-122 | 2013/09/29 | 07:14 | 73-09.3829 | 156-55.3282 | 2871 | 0.260 | 26.378 | 13072792 |
| 123 | XCTD-123 | 2013/09/29 | 07:25 | 73-11.1108 | 156-59.0157 | 3018 | 0.035 | 26.301 | 13072793 |
| 124 | XCTD-124 | 2013/09/29 | 08:20 | 73-05.1929 | 156-39.1546 | 2717 | 0.265 | 26.327 | 13072794 |
| 125 | XCTD-125 | 2013/09/29 | 08:28 | 73-04.1880 | 156-44.9850 | 2641 | 0.216 | 26.380 | 13072795 |

**Table3.2-1.** (Continued)

| No. | Station No. | Date [YYYY/MM/DD] | Time [hh:mm] | Latitude [degN] | Longitude [degW] | Depth [m] | SST [deg-C] | SSS [PSU] | Probe S/N |
|---|---|---|---|---|---|---|---|---|---|
| 126 | XCTD-126 | 2013/09/29 | 08:37 | 73-03.1771 | 156-51.0824 | 2566 | 0.116 | 26.476 | 13072806 |
| 127 | XCTD-127 | 2013/09/29 | 08:44 | 73-02.1728 | 156-56.9812 | 2439 | 0.207 | 26.503 | 13072809 |
| 128 | XCTD-128 | 2013/09/29 | 08:52 | 73-01.1686 | 157-02.7193 | 2230 | 0.230 | 26.523 | 13072810 |
| 129 | XCTD-129 | 2013/09/29 | 09:00 | 73-00.1579 | 157-08.5539 | 2056 | 0.174 | 26.553 | 13072808 |
| 130 | XCTD-130 | 2013/09/29 | 09:08 | 72-59.1529 | 157-14.2922 | 2096 | 0.210 | 26.548 | 13072811 |
| 131 | XCTD-131 | 2013/09/29 | 09:16 | 72-58.1481 | 157-20.2942 | 2183 | 0.280 | 26.222 | 13072804 |
| 132 | XCTD-132 | 2013/09/29 | 09:24 | 72-57.1411 | 157-26.3717 | 2181 | 0.192 | 25.948 | 13072801 |
| 133 | XCTD-133 | 2013/09/29 | 09:32 | 72-56.1332 | 157-32.2886 | 1945 | 0.219 | 25.918 | 13072798 |
| 134 | XCTD-134 | 2013/09/29 | 10:17 | 72-49.3140 | 157-05.8386 | 1723 | -0.125 | 25.865 | 13072807 |
| 135 | XCTD-135 | 2013/09/29 | 11:03 | 72-38.5110 | 157-08.6033 | 447 | 0.125 | 25.852 | 13072803 |
| 136 | XCTD-136 | 2013/09/29 | 13:39 | 72-14.1859 | 157-19.9546 | 121 | -0.014 | 27.944 | 13072813 |
| 137 | XCTD-137 | 2013/09/29 | 13:52 | 71-55.5006 | 157-26.2338 | 72 | 0.653 | 29.019 | 13072812 |
| 138 | XCTD-138 | 2013/09/30 | 19:34 | 72-44.9967 | 168-30.0071 | 53 | 0.348 | 30.889 | 13072817 |
| 139 | XCTD-139 | 2013/10/01 | 01:41 | 72-49.4999 | 168-15.0857 | 55 | -0.561 | 29.057 | 13072816 |
| 140 | XCTD-140 | 2013/10/01 | 05:55 | 72-40.4965 | 168-15.0160 | 55 | 1.335 | 31.482 | 13072815 |
| 141 | XCTD-141 | 2013/10/01 | 12:02 | 72-45.0005 | 167-56.1140 | 57 | 1.331 | 31.384 | 13072814 |
| 142 | XCTD-142 | 2013/10/03 | 23:16 | 67-52.4912 | 168-44.8730 | 52 | 1.107 | 32.306 | 13072818 |
| 143 | XCTD-143 | 2013/10/04 | 01:25 | 67-37.4985 | 168-45.0404 | 49 | 2.185 | 31.102 | 13072819 |

Acronyms in Table XCTD observation log are as follows;

Depth: Water Depth [m]

SST: Sea Surface Temperature [deg-C] measured by TSG (ThermoSalinoGraph).

SSS: Sea Surface Salinity [PSU] measured by TSG.

(6) Data archive

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC web site.

## 3.3. Shipboard ADCP

(1) Personnel

| | |
|---|---|
| Yusuke Kawaguchi | JAMSTEC: principal investigator |
| Souichiro Sueyoshi | GODI |
| Katsuhisa Maeno | GODI |
| Masanori Murakami | GODI |
| Koichi Inagaki | GODI |
| Ryo Ohyama | MIRAI Crew |

(2) Objectives

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

(3) Instruments and methods

Upper ocean current measurements were made in MR13-06 cruise, using the hull-mounted Acoustic Doppler Current Profiler (ADCP) system. For most of its operation the instrument was configured for water-tracking mode. Bottom-tracking mode, interleaved bottom-ping with water-ping, was made to get the calibration data for evaluating transducer misalignment angle in the shallow water. The system consists of following components;

1. R/V MIRAI has installed the Ocean Surveyor for vessel-mount ADCP (frequency 76.8 kHz; Teledyne RD Instruments, USA). It has a phased-array transducer with single ceramic assembly and creates 4 acoustic beams electronically. We mounted the transducer head rotated to a ship-relative angle of 45 degrees azimuth from the keel
2. For heading source, we use ship's gyro compass (Tokimec, Japan), continuously providing heading to the ADCP system directory. Additionally, we have Inertial Navigation System which provide high-precision heading, attitude information, pitch and roll, are stored in ".N2R" data files with a time stamp.
3. DGPS system (Trimble SPS751 & Fugro Multifix ver.6) providing precise ship's position.
4. We used VmDas software version 1.46.5 (TRDI) for data acquisition.
5. To synchronize time stamp of ping with GPS time, the clock of the logging computer is adjusted to GPS time every 1 minute.
6. Fresh water is charged in the sea chest to prevent bio fouling at transducer face.
7. The sound speed at the transducer does affect the vertical bin mapping and vertical velocity measurement, is calculated from temperature, salinity (constant value; 35.0 PSU) and depth (6.5 m; transducer depth) by equation in Medwin (1975).

Data was configured for "8 m" intervals starting about 23 m below sea

surface. Data was recorded every ping as raw ensemble data (.ENR). Also, 60 seconds and 300 seconds averaged data were recorded as short-term average (.STA) and long-term average (.LTA) data, respectively. Major parameters for the measurement, Direct Command, are shown in Table 3.3-1.

**Table 3.3-1.** Major parameters

| | |
|---|---|
| *Bottom-Track Commands* | |
| BP = 001 | Pings per Ensemble (almost less than 1,200m depth) |
| *Environmental Sensor Commands* | |
| EA = 04500 | Heading Alignment (1/100 deg) |
| EB = +00000 | Heading Bias (1/100 deg) |
| ED = 00065 | Transducer Depth (0 - 65535 dm) |
| EF = +001 | Pitch/Roll Divisor/Multiplier (pos/neg) [1/99 - 99] |
| EH = 00000 | Heading (1/100 deg) |
| ES = 35 | Salinity (0-40 pp thousand) |
| EX = 00000 | Coordinate Transform (Xform:Type; Tilts; 3Bm; Map) |
| EZ = 10200010 | Sensor Source (C; D; H; P; R; S; T; U) |
| C (1): Sound velocity calculates using ED, ES, ET (temp.) | |
| D (0): Manual ED | |
| H (2): External synchro | |
| P (0), R (0): Manual EP, ER (0 degree) | |
| S (0): Manual ES | |
| T (1): Internal transducer sensor | |
| U (0): Manual EU | |
| *Timing Commands* | |
| TE = 00:00:02.00 | Time per Ensemble (hrs:min:sec.sec/100) |
| TP = 00:02.00 | Time per Ping (min:sec.sec/100) |
| *Water-Track Commands* | |
| WA = 255 | False Target Threshold (Max) (0-255 count) |
| WB = 1 | Mode 1 Bandwidth Control (0=Wid, 1=Med, 2=Nar) |
| WC = 120 | Low Correlation Threshold (0-255) |
| WD = 111 100 000 | Data Out (V; C; A; PG; St; Vsum; Vsum^2; #G; P0) |
| WE = 1000 | Error Velocity Threshold (0-5000 mm/s) |
| WF = 0800 | Blank After Transmit (cm) |
| WG = 001 | Percent Good Minimum (0-100%) |
| WI = 0 | Clip Data Past Bottom (0 = OFF, 1 = ON) |
| WJ = 1 | Rcvr Gain Select (0 = Low, 1 = High) |
| WM = 1 | Profiling Mode (1-8) |
| WN = 100 | Number of depth cells (1-128) |
| WP = 00001 | Pings per Ensemble (0-16384) |
| WS = 800 | Depth Cell Size (cm) |
| WT = 000 | Transmit Length (cm) [0 = Bin Length] |
| WV = 0390 | Mode 1 Ambiguity Velocity (cm/s radial) |

(4) Preliminary results

Based on measurements using the shipboard ADCP, we successfully captured oceanic circulation around an anticyclonic eddy in the Canada Basin (Figure 3.3-1). The eddy was discovered on September 5, 2013, at 200 km offshore in the northwest direction from the Barrow Canyon, and then, the eddy was reinvestigated on September 25 in greater detail. During the time interval between the first and second intense surveys by R/V Mirai, the same eddy had been in pursuit by Surface Velocity Profiler (SVP) (see Section 3.5.), identified as SVP8130. During the latter eddy survey, the shipboard ADCP measurement revealed some characteristic features of the eddy. For example, the eddy has an approximate diameter of 40 km, and it rotates clockwise with 30 cm $s^{-1}$ in azimuthal direction (Figure 3.3-1b). From comparison with the SVP8130 trajectory, the ADCP current represented well the buoy motion along the pathway that it traveled (Figure 3.3-1a).

(5) Data archive

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

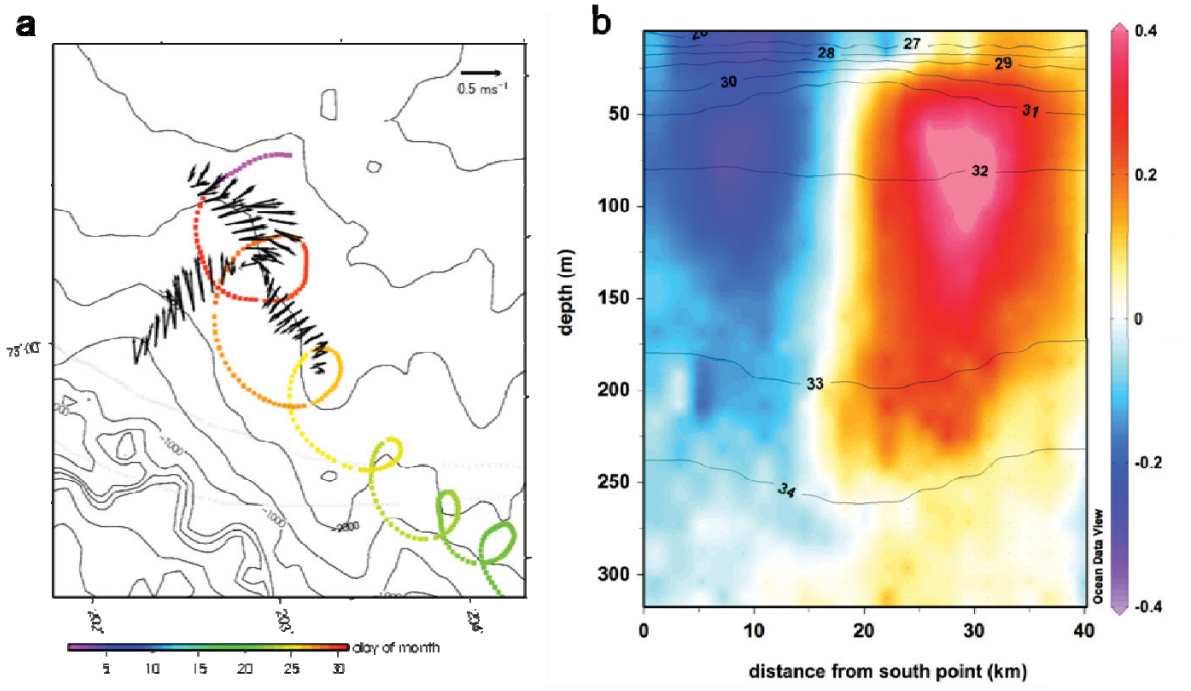



**Figure 3.3-1.** (a) horizontal current velocity at depths between 40 and 60 m, which were detected by shipboard ADCP. Color dots indicate the course of SVP8130. (b) vertical section of eastward current speed [m $s^{-1}$] detected by the shipboard ADCP. Velocity for the section was collected during a passage from southeast to northwest points.

## 3.4. Microstructure Observations

(1) Personnel

Yusuke Kawaguchi (JAMSTEC): Principal Investigator

Soichiro Sueyoshi (GODI): Operation Leader

Katsuhisa Maeno (GODI)

Masanori Murakami (GODI)

Koich Inagaki (GODI)

Ryo Oyama (Mirai crew)

(2) Objectives and methodology

To understand turbulent mixing and diapycnal heat transfer in upper part of the Arctic Ocean, microscale temperature and vertical shear data were collected during MR13-06. During the stationary point observation in the Chukchi Sea, the microstructure measurements were regularly and intensively conducted, where turbulent mixing and its evolution in ocean mixed layer were focuses on. Most of these microstructure measurements were performed at CTD stations for comparison with temporal changes in biogeochemical variables.

(3) Parameters

According to the manufacture's nominal specifications, the range, accuracy and sample rate of parameters are as follows

| Parameter | Type | Range | Accuracy | Sampling rate |
|---|---|---|---|---|
| $\partial u/\partial z$ (primary) | Shear probe | 0~10 /s | 5% | 512Hz |
| $T+\partial T/\partial z$ | EPO-7 thermistor | -5~45°C | ±0.01°C | 512Hz |

| | | | | |
|---|---|---|---|---|
| T | Platinum wire thermometer | -5~45°C | ±0.01°C | 64 Hz |
| Conductivity | Inductive Cell | 0~70 mS | ±0.01 mS | 64 Hz |
| Depth | Semiconductor strain gauge | 0~1000 m | ±0.2% | 64 Hz |
| x- acceleration | Solid-state fixed mass | ±2 G | ±1% | 256 Hz |
| y- acceleration | Solid-state fixed mass | ±2 G | ±1% | 256 Hz |
| z- acceleration | Solid-state fixed mass | ±2 G | ±1% | 64Hz |
| Chlorophyll | Fluorescence | 0~100 μg/Lm | 0.5 μg/L or ±1% | 256 Hz |
| Turbidity | Backscatter | 0~100 ppm | 1ppm or ±2% | 256 Hz |
| ∂u/∂z (Secondary) | ∂u/∂z Shear | 0~10 $s^{-1}$ | 5% | 512 Hz |

(4) Instruments

Turbulence Ocean Microstructure Acquisition Profiles (TurboMAP-L, build by Alec Electronics Co Ltd.) was used to measure turbulence-scale temperature and current shear. TurboMap is a quasi-free-falling instrument that measures turbulence parameters (∂u/∂z and ∂T/∂z), bio-optical parameters (in vivo fluorescence and back scatter) and hydrographic parameters (conductivity, temperature, and pressure).

(5) Station list

| No. | Date [YYYY/MM/DD] | Longitude [deg-min] | Latitude [deg-min] | Logging Time | | Depth [m] | Observation Depth [m] |
|---|---|---|---|---|---|---|---|
| | | | | Start | Stop | | |
| 01 | 2013/09/03 | 157-51.9889 | 71-35.5216 | 8:14 | 8:18 | 64 | 41 |
| 02 | 2013/09/03 | 157-52.3986 | 71-35.6039 | 8:19 | 8:22 | 63 | 53 |
| 03 | 2013/09/12 | 168-15.5248 | 72-45.1726 | 3:05 | 3:10 | 56 | 44.6 |
| 04 | 2013/09/12 | 168-15.6876 | 72-45.1945 | 3:10 | 3:13 | 56 | 43 |
| 05 | 2013/09/13 | 168-15.5248 | 72-45.1726 | 3:05 | 3:06 | 56 | 45 |
| 06 | 2013/09/13 | 168-19.2859 | 72-45.3137 | 3:10 | 3:13 | 56 | 44 |
| 07 | 2013/09/14 | 168-15.1039 | 72-45.0856 | 3:09 | 3:13 | 56 | 50 |
| 08 | 2013/09/14 | 168-15.1039 | 72-45.0856 | 3:14 | 3:15 | 56 | 48 |
| 09 | 2013/09/14 | 168-15.6485 | 72-45.0270 | 15:17 | 15:20 | 56 | 43 |
| 10 | 2013/09/14 | 168-15.6485 | 72-45.0329 | 15:20 | 15:23 | 56 | 41 |
| 11 | 2013/09/15 | 168-14.9001 | 72-45.1262 | 3:11 | 3:14 | 56 | 49 |
| 12 | 2013/09/15 | 168-14.9461 | 72-45.1195 | 3:14 | 3:16 | 56 | 48 |
| 13 | 2013/09/15 | 168-15.4717 | 72-45.0244 | 15:17 | 15:20 | 56 | 46 |
| 14 | 2013/09/15 | 168-15.5488 | 72-45.0272 | 15:21 | 15:23 | 56 | 45 |
| 15 | 2013/09/16 | 168-15.4136 | 72-45.0822 | 3:08 | 3:11 | 56 | 49 |
| 16 | 2013/09/16 | 168-15.4302 | 72-45.0835 | 3:11 | 3:14 | 56 | 48 |
| 17 | 2013/09/16 | 168-14.6604 | 72-44.8861 | 15:10 | 15:13 | 56 | 48 |
| 18 | 2013/09/16 | 168-14.6484 | 72-44.9032 | 15:13 | 15:15 | 56 | 47 |
| 19 | 2013/09/17 | 168-15.2570 | 72-45.0550 | 3:08 | 3:11 | 56 | 47 |
| 20 | 2013/09/17 | 168-15.4353 | 72-45.1131 | 15:55 | 15:57 | 56 | 46 |
| 21 | 2013/09/17 | 168-15.4948 | 72-45.1112 | 15:57 | 15:59 | 56 | 41 |
| 22 | 2013/09/18 | 168-14.9672 | 72-45.2180 | 3:43 | 3:46 | 56 | 48 |
| 23 | 2013/09/18 | 168-14.9866 | 72-45.2235 | 3:46 | 3:50 | 56 | 48 |
| 24 | 2013/09/18 | 168-15.3952 | 72-45.4801 | 15:46 | 15:48 | 56 | 52 |
| 25 | 2013/09/18 | 168-15.4320 | 72-45.5002 | 15:49 | 15:51 | 56 | 47 |
| 26 | 2013/09/18 | 168-16.6468 | 72-45.1979 | 22:15 | 22:19 | 56 | 49 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 27 | 2013/09/18 | 168-16.6984 | 72-45.2045 | 22:21 | 22:24 | 56 | 50 |
| 28 | 2013/09/19 | 168-15.5380 | 72-45.2943 | 3:47 | 3:50 | 56 | 46 |
| 29 | 2013/09/19 | 168-15.5785 | 72-45.3073 | 3:51 | 3:53 | 56 | 49 |
| 30 | 2013/09/19 | 168-16.3999 | 72-45.7375 | 15:49 | 15:52 | 56 | 46 |
| 31 | 2013/09/19 | 168-16.4593 | 72-45.7620 | 15:53 | 15:55 | 56 | 51 |
| 32 | 2013/09/19 | 168-16.6756 | 72-45.5252 | 3:45 | 3:49 | 56 | 47 |
| 33 | 2013/09/19 | 168-16.7856 | 72-45.5463 | 3:49 | 3:51 | 56 | 48 |
| 34 | 2013/09/21 | 168-16.3812 | 72-45.3203 | 15:52 | 15:55 | 56 | 49 |
| 35 | 2013/09/21 | 168-16.4329 | 72-45.3300 | 15:56 | 15:58 | 56 | 50 |
| 36 | 2013/09/22 | 168-15.3386 | 72-45.0776 | 3:45 | 3:48 | 56 | 48 |
| 37 | 2013/09/22 | 168-15.4044 | 72-45.0820 | 3:48 | 3:50 | 56 | 49 |
| 38 | 2013/09/22 | 168-15.1468 | 72-45.2393 | 15:46 | 15:49 | 56 | 49 |
| 39 | 2013/09/22 | 168-15.1776 | 72-45.2683 | 15:49 | 15:52 | 56 | 49 |
| 40 | 2013/09/22 | 168-14.0175 | 72-45.2273 | 22:43 | 22:46 | 57 | 47 |
| 41 | 2013/09/22 | 168-13.9320 | 72-45.2227 | 22:48 | 22:50 | 57 | 49 |
| 42 | 2013/09/23 | 168-14.7729 | 72-45.1032 | 3:44 | 3:48 | 56 | 52 |
| 43 | 2013/09/23 | 168-14.7544 | 72-45.1174 | 3:48 | 3:50 | 56 | 51 |
| 44 | 2013/09/23 | 168-14.6715 | 72-45.2522 | 15:49 | 15:52 | 56 | 52 |
| 45 | 2013/09/23 | 168-14.6604 | 72-45.2614 | 15:52 | 15:54 | 56 | 50 |
| 46 | 2013/09/23 | 168-13.8486 | 72-45.4622 | 22:49 | 22:52 | 57 | 49 |
| 47 | 2013/09/23 | 168-13.8526 | 72-45.4656 | 22:53 | 22:57 | 57 | 49 |
| 48 | 2013/09/24 | 168-14.9544 | 72-45.1200 | 3:44 | 3:48 | 56 | 48 |
| 49 | 2013/09/24 | 168-14.9686 | 72-45.1362 | 3:49 | 3:51 | 56 | 47 |
| 50 | 2013/09/24 | 168-14.4046 | 72-45.1873 | 15:54 | 15:58 | 56 | 47 |
| 51 | 2013/09/24 | 168-14.3460 | 72-45.2069 | 15:59 | 16:01 | 56 | 49 |
| 52 | 2013/09/24 | 168-15.1958 | 72-45.6839 | 22:48 | 22:50 | 56 | 49 |
| 53 | 2013/09/24 | 168-15.1594 | 72-45.7135 | 22:51 | 22:54 | 56 | 48 |
| 54 | 2013/09/25 | 168-15.0410 | 72-45.3163 | 3:44 | 3:46 | 56 | 47 |
| 55 | 2013/09/25 | 168-15.0829 | 72-45.3411 | 3:49 | 3:51 | 56 | 48 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 56 | 2013/09/25 | 168-14.5646 | 72-44.9791 | 15:29 | 15:32 | 56 | 45 |
| 57 | 2013/09/25 | 168-14.4815 | 72-44.9695 | 15:33 | 15:36 | 56 | 46 |
| 58 | 2013/09/25 | 168-14.3521 | 72-45.1553 | 22:45 | 22:51 | 56 | 50 |
| 59 | 2013/09/25 | 168-14.2844 | 72-45.1457 | 22:51 | 22:55 | 56 | 50 |
| 60 | 2013/09/25 | 168-14.2257 | 72-45.1346 | 22:55 | 22:58 | 56 | 50 |
| 61 | 2013/09/30 | 168-14.8155 | 72-45.2836 | 22:44 | 22:47 | 56 | 50 |
| 62 | 2013/09/30 | 168-14.7784 | 72-45.2869 | 22:48 | 22:50 | 56 | 50 |
| 63 | 2013/10/01 | 168-14.5075 | 72-45.1735 | 3:10 | 3:13 | 56 | 50 |
| 64 | 2013/10/01 | 168-14.4691 | 72-45.1813 | 3:14 | 3:16 | 56 | 50 |
| 65 | 2013/10/01 | 168-14.3814 | 72-45.2626 | 3:32 | 3:34 | 56 | 50 |
| 66 | 2013/10/01 | 168-14.3700 | 72-45.2715 | 3:34 | 3:36 | 56 | 49 |
| 67 | 2013/10/01 | 168-14.4637 | 72-45.0134 | 15:06 | 15:11 | 56 | 48 |
| 68 | 2013/10/01 | 168-14.3264 | 72-45.0658 | 15:12 | 15:14 | 56 | 49 |
| 69 | 2013/10/03 | 167-02.7653 | 68-18.3618 | 0:09 | 0:12 | 38 | 30 |
| 70 | 2013/10/03 | 167-02.7690 | 68-18.3689 | 0:12 | 0:14 | 38 | 31 |
| 71 | 2013/10/03 | 167-19.7836 | 68-12.1813 | 2:18 | 2:22 | 47 | 40 |
| 72 | 2013/10/03 | 167-19.8162 | 68-12.2155 | 2:24 | 2:26 | 47 | 41 |
| 73 | 2013/10/03 | 167-40.3589 | 68-06.0753 | 3:29 | 3:34 | 52 | 46 |
| 74 | 2013/10/03 | 167-40.4582 | 68-06.0736 | 3:35 | 3:37 | 52 | 47 |
| 75 | 2013/10/03 | 168-00.4503 | 68-00.1313 | 5:31 | 5:36 | 54 | 48 |
| 76 | 2013/10/03 | 168-00.5897 | 68-00.1552 | 5:37 | 5:38 | 54 | 48 |
| 77 | 2013/10/03 | 168-45.5694 | 67-59.9253 | 22:18 | 22:22 | 58 | 51 |
| 78 | 2013/10/03 | 168-45.5625 | 67-59.9134 | 22:23 | 22:25 | 58 | 54 |
| 79 | 2013/10/03 | 168-45.5786 | 67-59.9105 | 22:26 | 22:28 | 58 | 53 |
| 80 | 2013/10/04 | 168-45.2533 | 65-45.7710 | 17:34 | 17:36 | 52 | 45 |
| 81 | 2013/10/04 | 168-45.2578 | 65-45.7683 | 17:37 | 17:39 | 52 | 44 |

(6) Technical report: noise corruption due to side-shift power thrusters

We will make a brief report for a test of side-shift power thrusters equipped at bow and stern sides of right-side gunwale from which the microstructure measurements are usually operated. In the experiment, we tried to clarify as to how much running the thrusters can give noise corruption on the micro-shear profiles as the device descends into water. Since the shallow mixed layer is the special focus at the stationary point observation, it is fairly important to make it clear an approximate noise level of the side-shift power thrusters onto the microscale shear data. The test was performed on September 26, when winds were relatively calm, weaker than 7 m $s^{-1}$, throughout the three-time falling tests. During the test, the instrument was lowered in the water three times successively (stations 58, 59, and 60). For the first lowering, the thrusters at bow and stern sides were both turned off for 5 minutes before the instrument was landed at water surface, and then, it was kept off while it descends. For the second and third falling experiments, those thrusters were kept purposely on running until the device starts to descend from the water line. Then, the thrusters were turned off as the device started to descend. From these experiments, we know that the thrusters could give huge noise corruption on micro-shear profiles within depths of 5 m below the water surface. Below 8 m depth, the noise corruption was however dramatically reduced, although there were still increased spikes on the profiles (they can be removed in the data processing). Thus, we conclude that the micro-shear profiles are valid to be analyzed for the depths below 8 m.

(7) Data archive

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via “Data Research for Whole Cruise Information in JAMSTEC” in JAMSTEC web site.

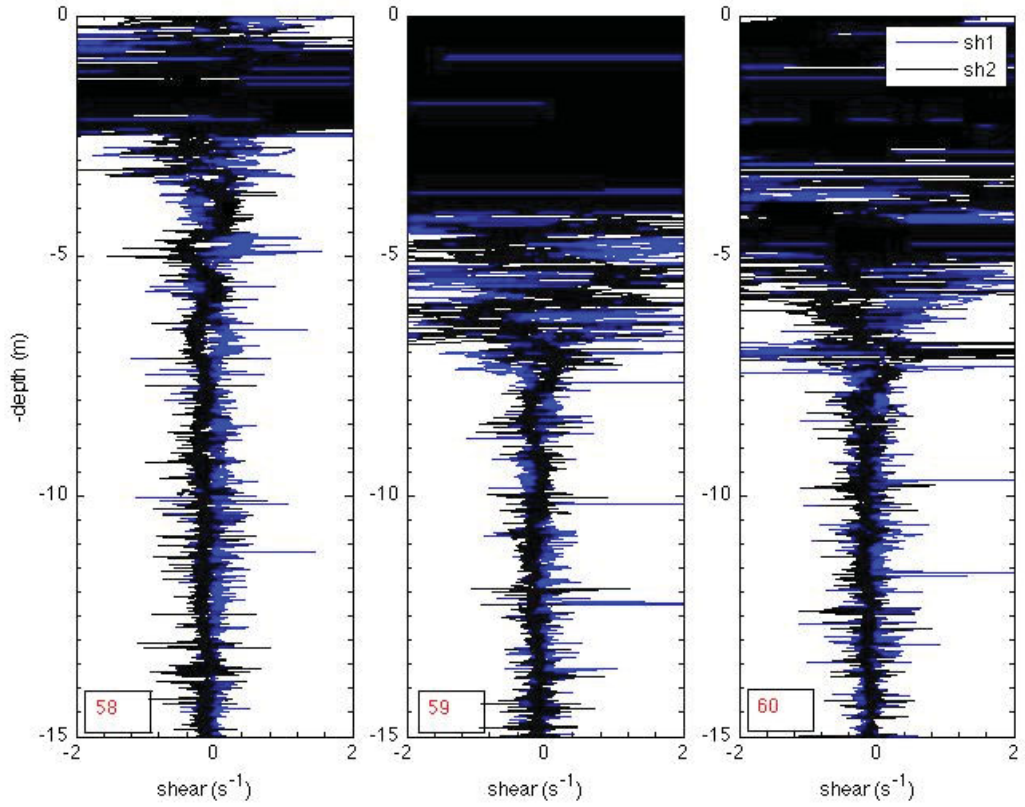



**Figure 3.4-1.** Micro-shear profiles taken at stations 58, 59 and 60, where noise level due to side-shift power thrusters were tested. Blue and black curves denote current shear [$s^{-1}$] detected with shear probes 1 and 2, respectively. For station 58, thrusts were turned off 5 minutes before the device was landed at water line, while for the stations 59 and 60 thrusters at bow and stern sides were kept on running until the device starts to descend in the water.

## 3.5. Subsurface Current Observation with Surface Velocity Profilers

(1) Personnel

Yusuke Kawaguchi (JAMSTEC): Principal investigator

Shigeto Nishino (JAMSTEC)

(2) Objectives

To examine subsurface ocean currents in open water region of the Pacific-side of Arctic Ocean.

(3) Instruments and methodology

We used drifting buoy systems (Surface Velocity Profiler, SVP) for which a storm drogue is tethered into subsurface water from surface floating units. The drogue is designed to capture representative current velocity at depths interested. We deployed four SVPs around jet-like structure at southern part of the Beaufort Gyre, where two buoys, SVP7120 and SVP9130, were deployed right on the jet feature and the other two buoys, SVP8130 and SVP5130, were put adjacent to an anti-cyclonic eddy. For this experiment, the drogues for SVP7120, 9130, and 8130, were uniformly rigged at 50 m depth at which major current is supposed to be centered, according to a prior survey on September 5, 2013. The one for SVP5130 was set at depth of 20 m.

In the stationary point observation between September 12th and 26th in the Chukchi Sea, we investigated vertical heat transfer between atmosphere and ocean during a transition from summer to winter. In the Chukchi Sea observation, we see that there were two distinctive layer systems vertically for thermohaline structure of seawater. For the central observation station, two SVPs were deployed to obtain the upper and lower parts of oceanic current, SVP0500 and SVP3130, which have the drogues at depths of 15 and 40 m from the water surface.

The all SVPs transmitted their GPS positioning data every an hour via the Iridium satellite by email as it drifts.

(4) Buoy deployment positions

| Unit NO. | Deployment information | | | Drogue depth [m] |
|---|---|---|---|---|
| | Date [YYYY/MM/DD] | Longitude [deg-min] | Latitude [deg-min] | |
| SVP9130 | 2013/09/07 | 72-25.98 | -154-53.80 | 50 |
| SVP 7120 | 2013/09/07 | 72-31.95 | -154-55.74 | 50 |
| SVP 8130 | 2013/09/07 | 72-41.18 | -154-51.56 | 50 |
| SVP 5130 | 2013/09/07 | 72-49.69 | -154-57.68 | 20 |
| SVP 3130 | 2013/09/17 | 72-44.62 | -168-13.85 | 15 |
| SVP 0500 | 2013/09/17 | 72-45.84 | -168-13.97 | 40 |

(5) Preliminary results

In the Canada Basin, the positioning data of SVP9130 and SVP7120 indicated that the jet flow goes along a pathway rather close to the shelf-break line of the Chukchi Sea shelf, where the current stream went across the North Wind Ridge to the east and entered a region inside the Chukchi Boarder Land (Figure 3.5-1). The anti-cyclonic eddy, tracked by SVP8130, showed that it traveled roughly along with the pathway of the jet until its middle way. The eddy moved the jet course off around 158°W, and then it went to the further north for the pack ice region.

For the stationary observation in the Chukchi Sea, according to the buoy motion, ocean currents were commonly dominated by an inertial oscillation with a period of ~12.5 hour. On September 26, we also revisited and investigated again the same water masses that we deployed the buoys at on September 17 (Figure 3.5-2). As the results, we could know how the water masses had been changed in their properties after they had drifted for two weeks.

(6) Data archive

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via “Data Research for Whole Cruise Information in JAMSTEC” in JAMSTEC web site.

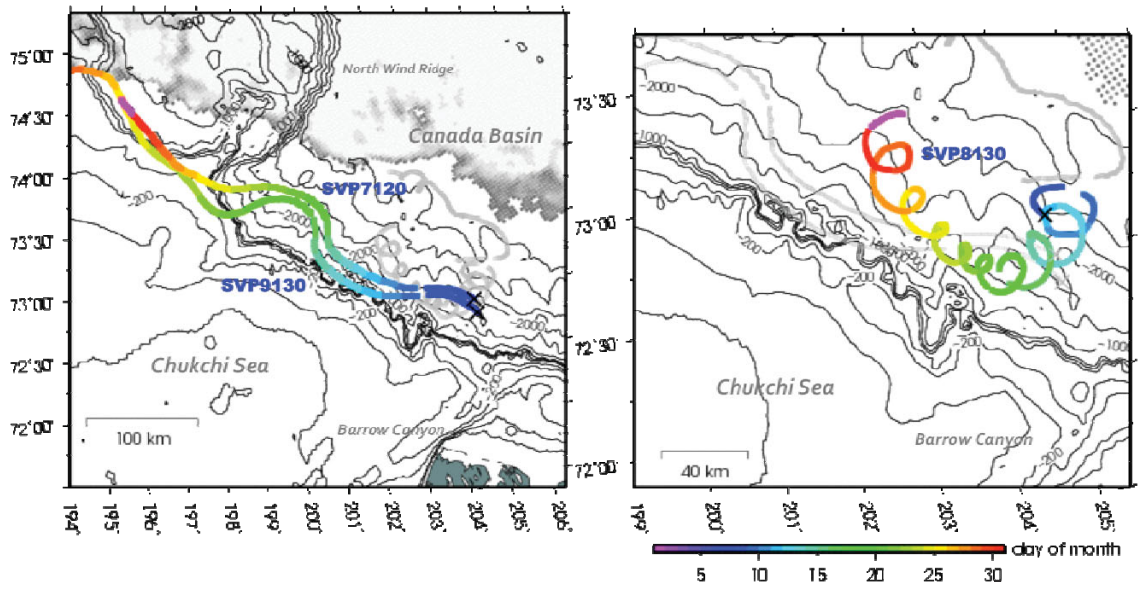



**Figure 3.5-1.** Drifting courses of buoys that were deployed in the Canada Basin: SVP7120 and SVP9130 (left panel) and SVP8130 (right panel). Color indicates day of each month that starts from September in 2013. Buoys were deployed at positions of × on September 7, 2013. Gray region displays sea ice concentration on September 23.

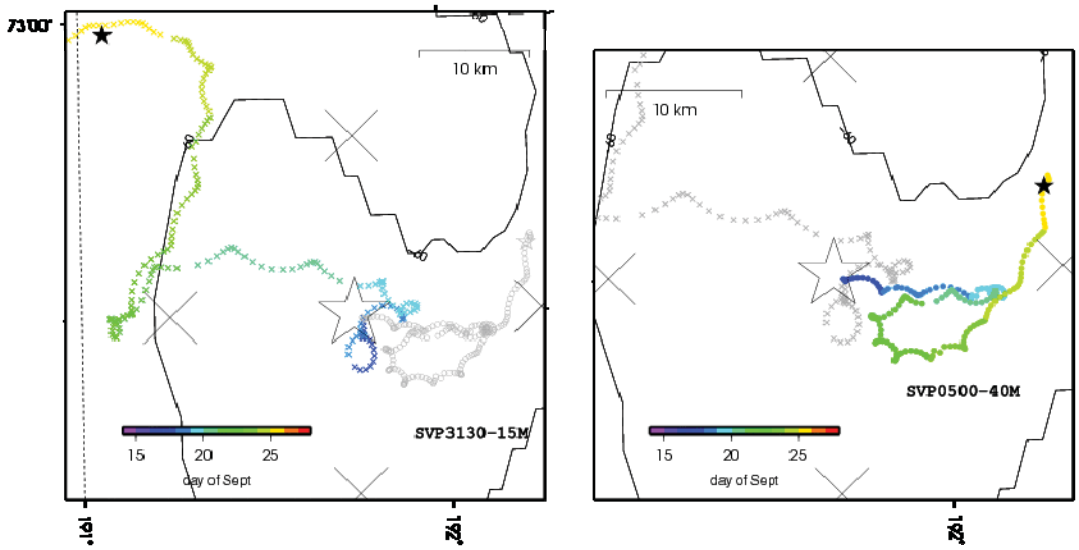



**Figure 3.5-2.** Travelling courses for SVP3130 (left) and SVP0500 (right) while the stationary observation campaign was conducted, where mid-depth drogues were deployed at 15 and 40 m depths, respectively. Deployment of both buoys were conducted at ☆ on September 17, 2013, and the water masses were tracked throughout the duration and reinvestigated on September 26 at ★.

## 3.6. Salinity Measurements

(1)Personnel

Shigeto Nishino (JAMSTEC): Principal investigator
Tatsuya Tanaka (MWJ)

(2)Objective

To understand the spatial and temporal variation of salinity and to provide calibrations for the measurements of salinity collected from CTD and TSG (Underway surface water monitoring).

(3)Parameters

The specifications of the AUTOSAL salinometer are shown as follows;

Salinometer (Model 8400B "AUTOSAL" ; Guildline Instruments Ltd.)
Measurement Range : 0.005 to 42 (PSU)
Accuracy : Better than ±0.002 (PSU) over 24 hours without re-standardization
Maximum Resolution : Better than ±0.0002 (PSU) at 35 (PSU)

(4) Instruments and Methods

a. Salinity Sample Collection

Seawater samples were collected with 12 liter Niskin-X bottles, bucket, and TSG. The salinity sample bottle of 250ml brown glass with screw cap was used for collecting the sample water. Each bottle was rinsed 3 times with the sample water, and was filled with sample water to the bottle shoulder. All of sample bottles for TSG were sealed with a plastic insert thimble and a screw cap because we took into consideration the possibility of storage for about a month. The thimble was rinsed 3 times with the sample water before use. The bottle was stored for more than 24 hours in the laboratory before the salinity measurement.

Types and numbers (n) of the samples are shown in Table 3.6-1.

**Table 3.6-1.** Types and numbers (n) of samples

| Types | N |
|---|---|
| Samples for CTD and bucket | 1738 |
| Samples for TSG in Leg1 | 35 |
| Samples for TSG in Leg2 | 9 |
| Total | 1782 |

b. Instruments and Method

The salinity analysis was carried out on R/V MIRAI during the cruise of MR13-06 Leg1 and Leg2 using the salinometer (Model 8400B "AUTOSAL" ; Guildline Instruments Ltd.: S/N 62827) with an additional peristaltic-type intake pump (Ocean Scientific International, Ltd.).

One pair of precision digital thermometers (Model 9540 ; Guildline Instruments

Ltd.) were used. The thermometer monitored the ambient temperature and the other monitored the bath temperature.

The specifications of the thermometer are shown as follows;

Thermometer (Model 9540 ; Guildline Instruments Ltd.)

| | | |
|---|---|---|
| Measurement Range | : | -40 to +180 deg C |
| Resolution | : | 0.001 |
| Limits of error ±deg C | : | 0.01 (24 hours @ 23 deg C ±1 deg C) |
| Repeatability | : | ±2 least significant digits |

The measurement system was almost the same as Aoyama *et al.* (2002). The salinometer was operated in the air-conditioned ship's laboratory at a bath temperature of 24 deg C. The ambient temperature varied from approximately 22.5 deg C to 24.5 deg C, while the bath temperature was very stable and varied within +/- 0.002 deg C on rare occasion.

The measurement for each sample was done with a double conductivity ratio and defined as the median of 31 readings of the salinometer. Data collection was started 10 seconds after filling the cell with the sample and it took about 15 seconds to collect 31 readings by the personal computer. Data were taken for the sixth and seventh filling of the cell after rinsing 5 times. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity with the algorithm for the practical salinity scale, 1978 (UNESCO, 1981). If the difference was greater than or equal to 0.00003, an eighth filling of the cell was done. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity. In the case of the double conductivity ratio of eighth filling did not satisfy the criteria above, the operator measured a ninth or tenth filling of the cell and calculated the bottle salinity above. The cell was cleaned with detergent after the measurement of the day.

(5) Results

a. Standard Seawater (SSW)

The specifications of SSW used in this cruise are shown as follows;

| | | |
|---|---|---|
| Batch | : | P155 |
| conductivity ratio | : | 0.99981 |
| salinity | : | 34.993 |
| expiration date | : | 19th Sept 2015 |

Standardization control of the salinometer S/N 62827 was set to 507 (2th Sep.) and all measurements were carried out at this setting. The value of STANDBY was 5431 +/- 0001 and that of ZERO was 0.0+0000 +/- 0001. 87 bottles of SSW were measured in Leg1 and 2 bottles of SSW were measured in Leg2.

Figure3.6-1 shows the history of the double conductivity ratio of the Standard Seawater batch P155 before correction in Leg1. The average of the double conductivity ratio was 1.99959 and the standard deviation was 0.00001, which is equivalent to 0.0002 in salinity.

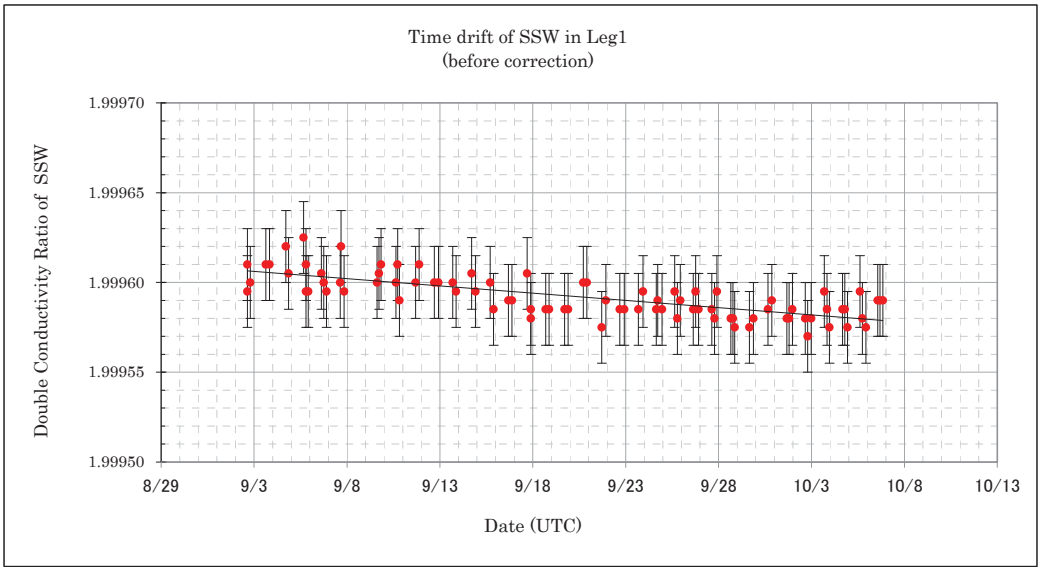



**Figure 3.6-1.** History of double conductivity ratio for the standard seawater batch P155 in Leg1 (before correction).

Figure3.6-2 shows the history of the double conductivity ratio of the Standard Seawater batch P155 after correction in Leg1. The average of the double conductivity ratio after correction was 1.99962 and the standard deviation was 0.00001, which is equivalent to 0.0001 in salinity.

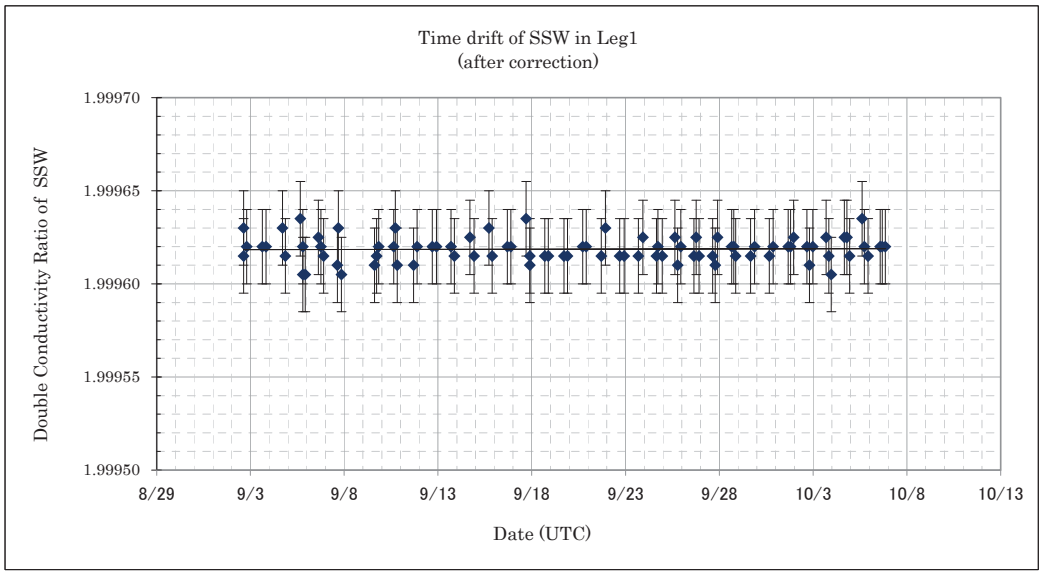



**Figure 3.6-2.** History of double conductivity ratio for the standard seawater batch P155 in Leg1 (after correction).

Figure3.6-3 shows the history of the double conductivity ratio of the Standard Seawater batch P155 before correction in Leg1 and Leg2. The average of the double conductivity ratio was 1.99959 and the standard deviation was 0.00001, which is equivalent to 0.0002 in salinity.

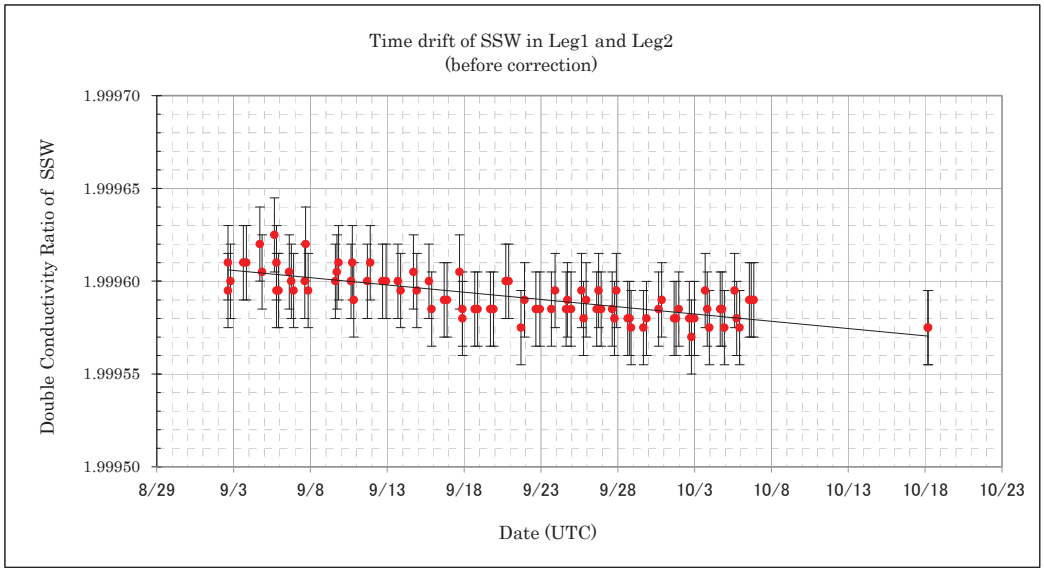



**Figure 3.6-3.** History of double conductivity ratio for the standard seawater batch P155 in Leg1 and Leg2 (before correction).

Figure 3.6-4 shows the history of the double conductivity ratio of the Standard Seawater batch P155 after correction in Leg1 and Leg2. The average of the double conductivity ratio after correction was 1.99962 and the standard deviation was 0.00001, which is equivalent to 0.0001 in salinity.

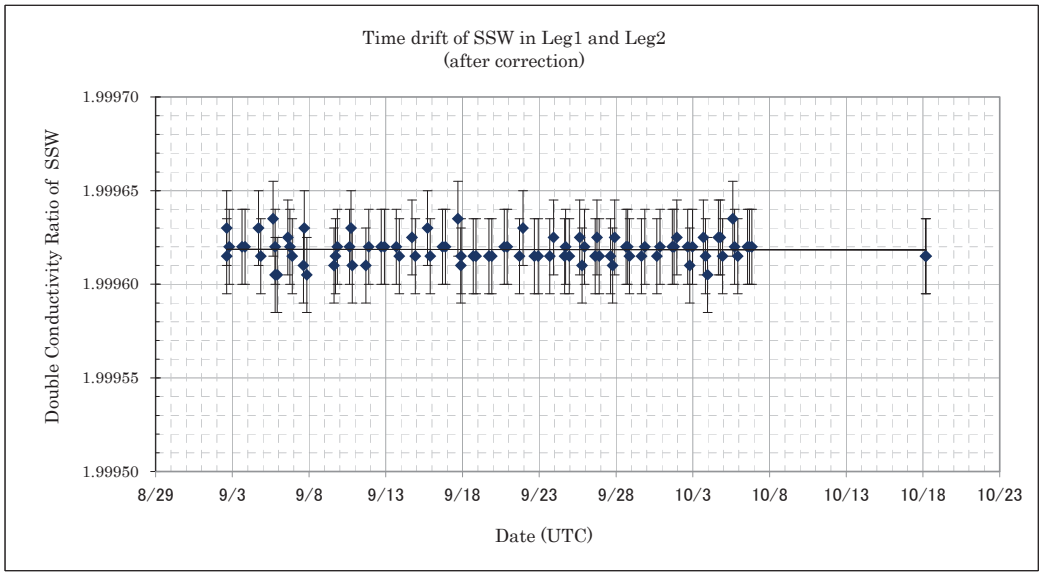



**Figure 3.6-4.** History of double conductivity ratio for the standard seawater batch P155 in Leg1 and Leg2 (after correction).

b. Sub-Standard Seawater

Sub-standard seawater was made from surface-sea water (poor in nutrient) filtered by a pore size of 0.45 micrometer and stored in a 20 liter container made of polyethylene and stirred for at least 24 hours before measuring. It was measured between every station in order to check for the possible sudden drifts of the salinometer.

c. Replicate Samples

We estimated the precision of this method using 314 pairs of replicate samples taken from the same Niskin bottle.

Figure 3.6-5 shows the histogram of the absolute difference between each pair of all replicate samples. The average and the standard deviation of absolute difference among 314 pairs were 0.0022 and 0.0066 in salinity, respectively.

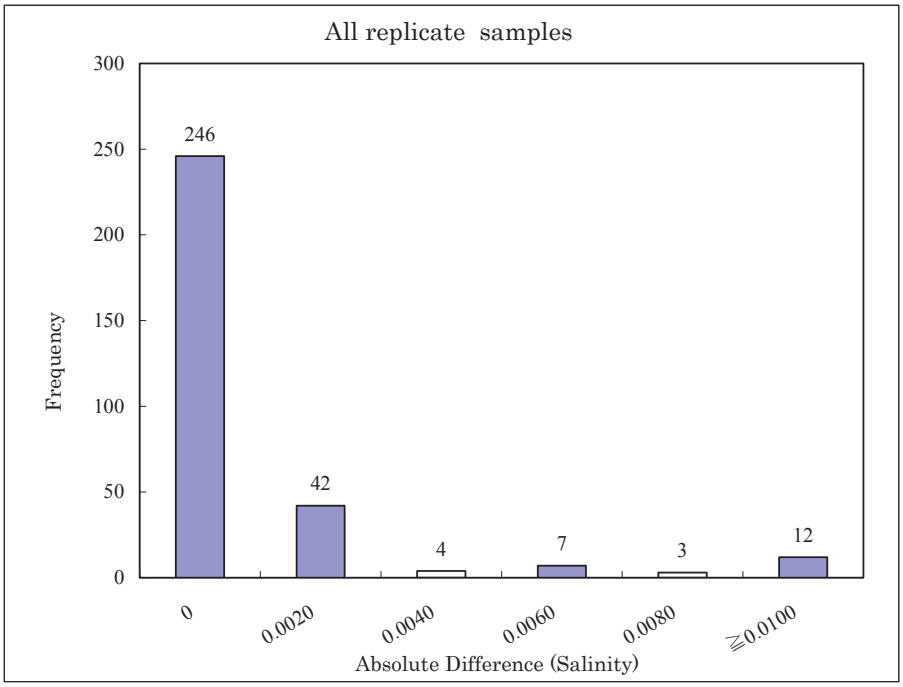



**Figure 3.6-5.** Histogram of the absolute difference of all replicate samples.

286 pairs of replicate samples were to estimate the precision of shallow (<200dbar) samples. Figure 3.6-6 shows the histogram of the absolute difference between each pair of shallow (<200dbar) replicate samples. The average and the standard deviation of absolute difference among 286 pairs were 0.0023 and 0.0068 in salinity, respectively.

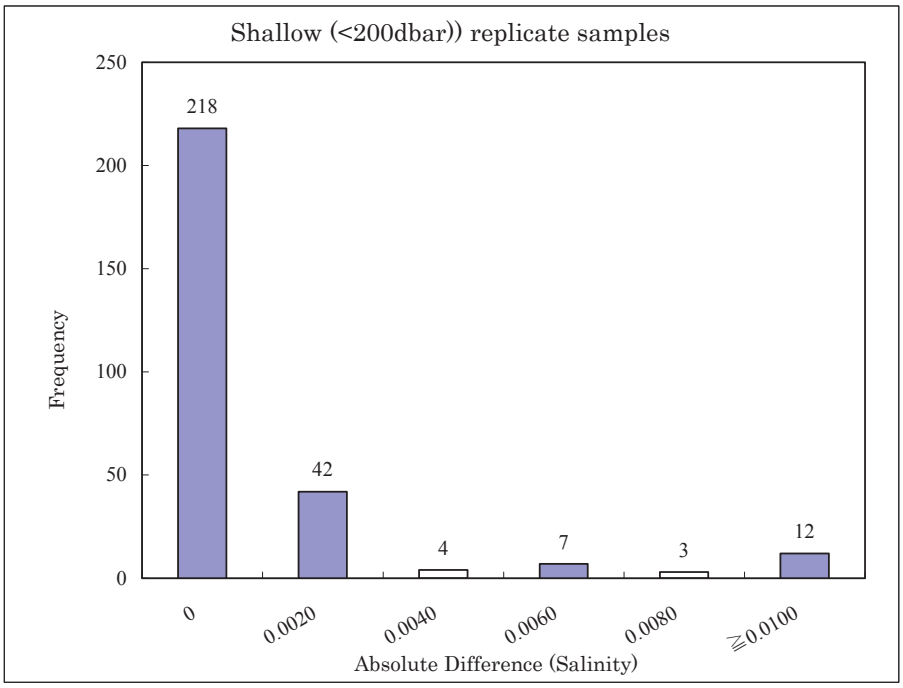



**Figure 3.6-6.** Histogram of the absolute difference between shallow (<200dbar) replicate samples.

28 pairs of replicate samples were to estimate the precision of deep (>200dbar) samples. Figure 3.6-7 shows the histogram of the absolute difference between each pair of deep (>200dbar) replicate samples. The average and the standard deviation of absolute difference among 28 pairs were 0.0002 and 0.0002 in salinity, respectively.

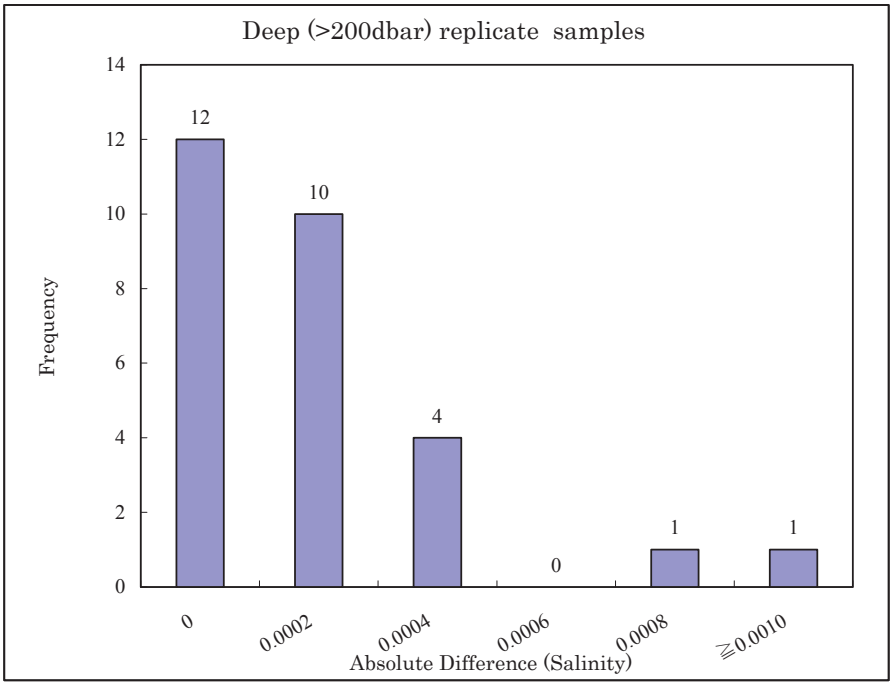



**Figure 3.6-7.** Histogram of the absolute difference between deep (>200dbar) replicate samples.

d. Data Correction for Samples

All data were corrected according to the result of the offset correction for SSW.

(6) Data archive

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC web site.

Citations


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

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

## 3.7. Mooring Deployments and Recoveries

(1) Personnel

| | |
|---|---|
| Takashi Kikuchi (JAMSTEC, not onboard) | Principal Investigator |
| Motoyo Itoh (JAMSTEC, not onboard) | |
| Shigeto Nishino (JAMSTEC) | |
| Yusuke Kawaguchi (JAMSTEC) | |
| Hirokatsu Uno (MWJ) | Operation leader |
| Kenichiro Sato (MWJ) | Technical staff |
| Tatsuya Tanaka (MWJ) | Technical staff |
| Shinsuke Toyoda (MWJ) | Technical staff |

(2) Objectives

The purpose of mooring measurements in the Barrow Canyon (BCE-12, -13, BCC-12, -13, and BCW-12, -13) is to monitor the variations of volume, heat and fresh water fluxes of Pacific Water. At the head of Barrow Canyon, where the biological activity is extremely high and is called a biological hot spot, the mooring measuring temperature, salinity, dissolved oxygen, chlorophyll *a*, and turbidity (BCH-12-2) was deployed with a biological mooring recording whale voices (BCH-12w-2). The purpose of these moorings is to understand the ocean environment and its annual changes maintaining the hot spot and its influences to the ecosystem of higher trophic levels such as whales.

We recovered five moorings (BCH-12-2, BCH-12w-2, BCE-12, BCC-12, and BCW-12) and deployed three moorings (BCE-13, BCC-13, and BCW-13) at the locations which are the almost same as those of the deployed moorings in the Barrow Canyon. Components of recovered and deployed moorings are depicted in Figures 3.7-1a (BCH-12-2 and BCH-12w-2), 3.7-1b (BCE-12, BCC-12, and BCW-12), and 3.7-2 (BCE-13, BCC-13, and BCW-13), respectively.

(3)Measured parameters

- Oceanic velocities
- Pressure, Temperature and Conductivity
- Dissolved oxygen
- Chlorophyll *a* and turbidity
- Whale voices

(4) Instruments

1) CTD or CT sensors

SBE37-SM (Sea-Bird Electronics Inc.)

SBE37-SMP-IDO (Sea-Bird Electronics Inc.)

A7CT-USB (JFE Advantech)

2) Current meters

Workhorse ADCP 300 kHz SC Sentinel (Teledyne RD Instruments, Inc.)

Aquadopp Current Meter 2MHz (NORTEK AS)

S4D current meter (InterOcean systems, Inc. )

3) Dissolved oxygen sensors

AROW-USB (JFE Advantech)

SBE37-SMP-IDO (Sea-Bird Electronics Inc.)

4) Chlorophyll-a and turbidity sensors

MFL50W-USB (JFE Advantech)

ACLW-USB (JFE Advantech)

5) Whale voice recorder

Acoustic Monitoring System (Fusion co., LTD)

6) Acoustic transponders

XT-6000-10 (Teledyne Benthos, Inc.)

XT-6001-13 (Teledyne Benthos, Inc.)

7) Acoustic releasers

Model L-Ti (Nichiyu giken kogyo co., LTD)

Model L-BL (Nichiyu giken kogyo co., LTD)

Model L-GC (Nichiyu giken kogyo co., LTD)

8242XS (ORE offshore /EdgeTech)

Model 865A (Teledyne Benthos, Inc.)

(5) Lists of recovered and deployed moorings

**Table 3.7-1.** List of recovered moorings

| Mooring ID | Recovery Date [UTC] | Latitude [N] | Longitude [W] | Bottom depth [m] |
|---|---|---|---|---|
| BCH-12-2 | 29/09/2013 | 71-19.6310 | 157-39.6674 | 99 |
| BCH-12w-2 | 03/09/2013 | 71-20.4868 | 157-36.3630 | 101 |
| BCE-12 | 05/09/2013 | 71-40.3514 | 154-59.7409 | 106 |
| BCC-12 | 05/09/2013 | 71-43.5852 | 155-11.1081 | 283 |
| BCW-12 | 05/09/2013 | 71-47.7415 | 155-20.7499 | 170 |

**Table 3.7-2.** List of deployed moorings

| Mooring ID | Deployment Date [UTC] | Latitude [N] | Longitude [W] | Bottom depth [m] |
|---|---|---|---|---|
| BCE-13 | 06/09/2013 | 71-40.3469 | 154-59.7276 | 105 |
| BCC-13 | 06/09/2013 | 71-43.5969 | 155-11.1048 | 283 |
| BCW-13 | 07/09/2013 | 71-47.7647 | 155-20.7258 | 171 |

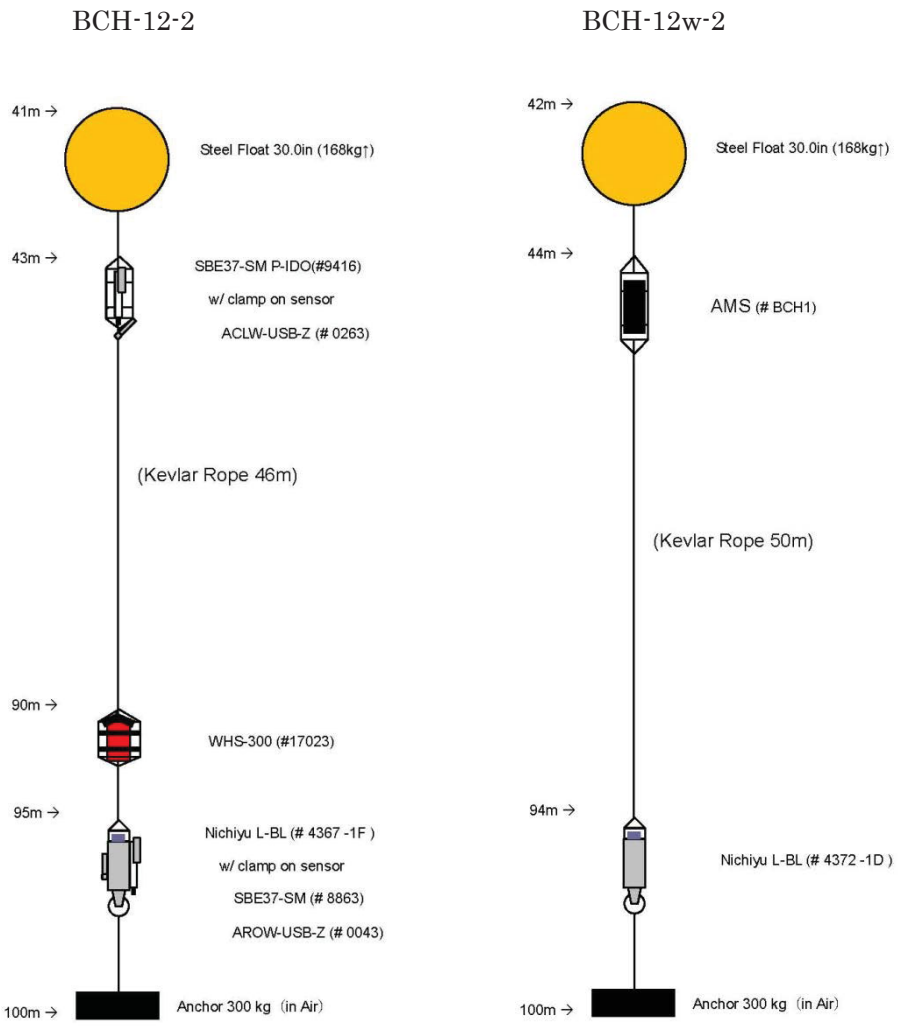



**Figure 3.7-1a.** Recovered mooring diagrams (BCH-12-2 and BCH-12w-2).

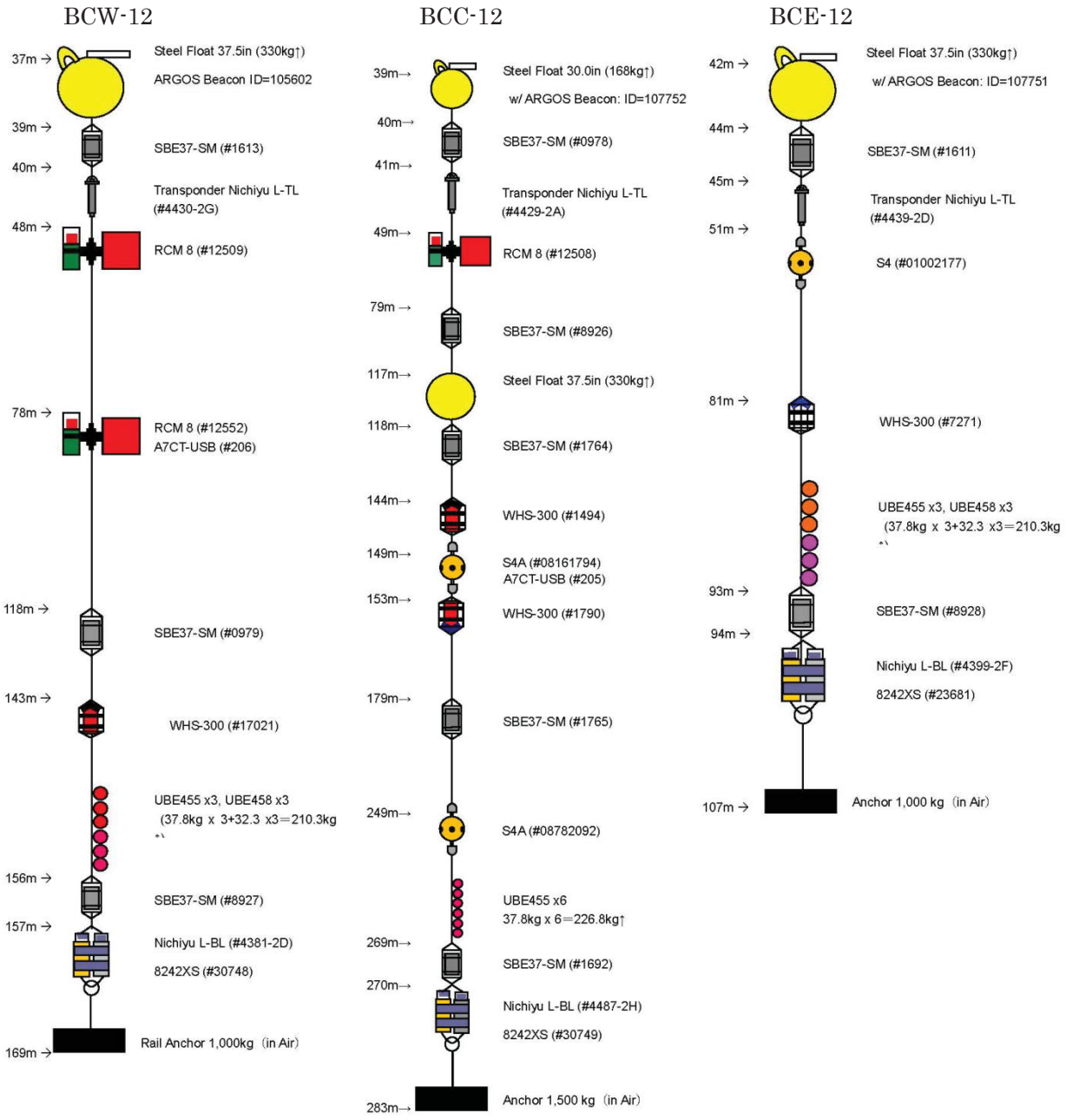



**Figure 3.7-1b.** Recovered mooring diagrams (BCW-12, BCC-12, and BCE-12).

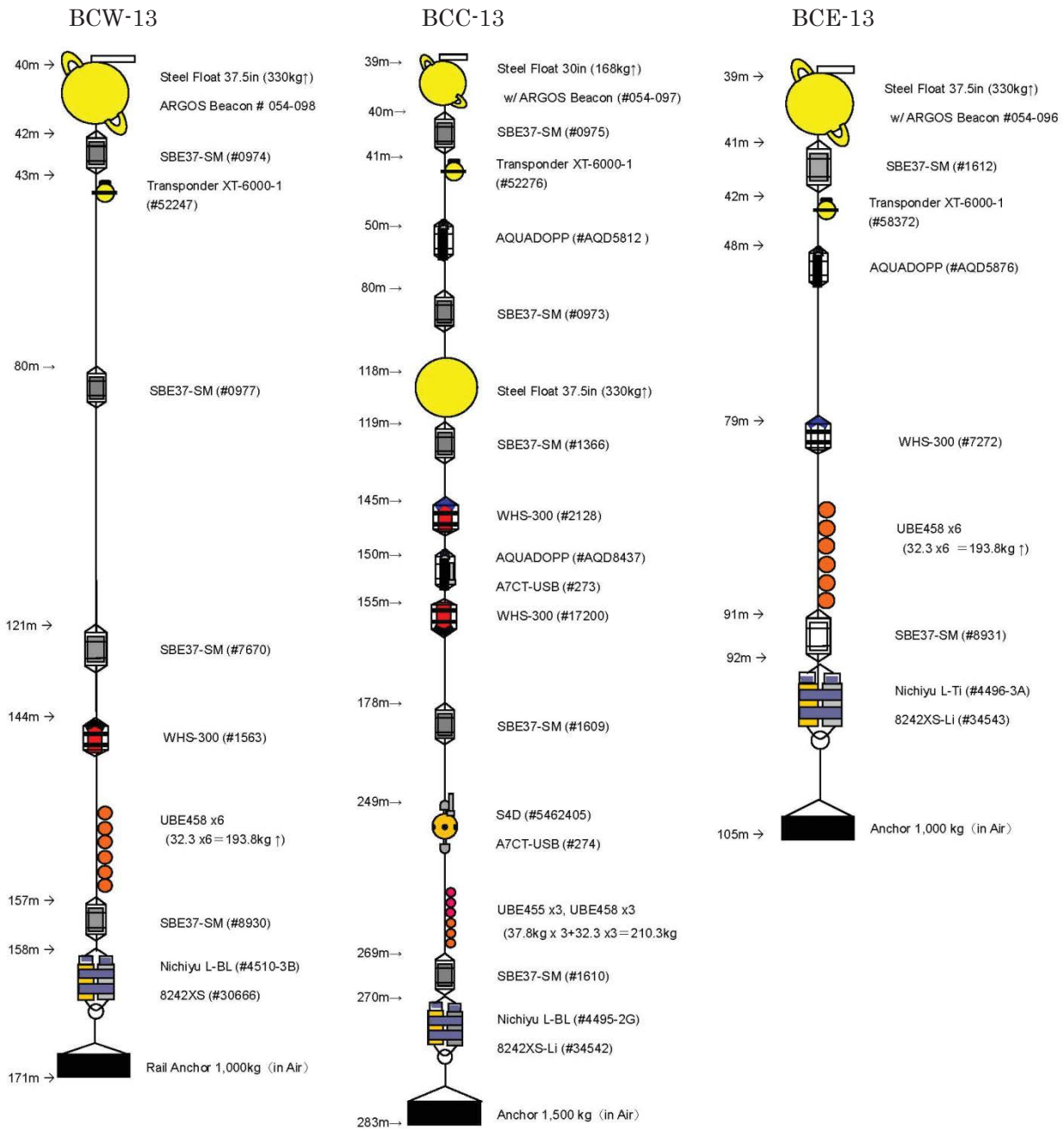



**Figure 3.7-2.** Deployed mooring diagrams (BCW-13, BCC-13, and BCE-13).

# 4. Chemical and Biological Oceanography

## 4.1. Dissolved Oxygen

(1) Personnel

Shigeto NISHINO (JAMSTEC): Principal Investigator

Katsunori SAGISHIMA(Marine Works Japan Co. Ltd): Operation Leader

Shinichiro YOKOGAWA (Marine Works Japan Co. Ltd)

Masahiro ORUI (Marine Works Japan Co. Ltd)

(2) Objectives

Determination of dissolved oxygen in seawater by Winkler titration.

(3) Parameter

Dissolved Oxygen

(4) Instruments and Methods

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

a. Instruments

Burette for sodium thiosulfate and potassium iodate;

APB-510 / APB-620 manufactured by Kyoto Electronic Co. Ltd. / 10 $cm^3$ of titration vessel

Detector;

Automatic photometric titrator (DOT-01X) manufactured by Kimoto Electronic Co. Ltd.

Software;

DOT_Terminal Ver. 1.2.0

b. Reagents

Pickling Reagent I: Manganese chloride solution (3 mol $dm^{-3}$)

Pickling Reagent II:

Sodium hydroxide (8 mol $dm^{-3}$) / sodium iodide solution (4 mol $dm^{-3}$)

Sulfuric acid solution (5 mol $dm^{-3}$)

Sodium thiosulfate (0.025 mol $dm^{-3}$)

Potassium iodide (0.001667 mol $dm^{-3}$)

CSK standard of potassium iodide:

Lot DCE2131, Wako Pure Chemical Industries Ltd., 0.0100N

c. Sampling

Seawater samples were collected with Niskin bottle attached to the CTD-system and surface bucket sampler. Seawater for oxygen measurement was transferred from sampler to a volume calibrated flask (ca. 100 $cm^3$). Three times volume of the flask of seawater was overflowed. Temperature was measured by digital thermometer during the overflowing. Then two reagent solutions (Reagent I and II) of 0.5 $cm^3$ each were added immediately into the sample flask and the stopper was inserted carefully into the flask. The sample flask was then shaken vigorously to mix the contents and to disperse the precipitate finely throughout. After the precipitate has settled at least halfway down the flask, the flask was shaken again vigorously to disperse the precipitate. The sample flasks containing pickled samples were stored in a laboratory until they were titrated.

d. Sample measurement

At least two hours after the re-shaking, the pickled samples were measured on board. 1 $cm^3$ sulfuric acid solution and a magnetic stirrer bar were added into the sample flask and stirring began. Samples were titrated by sodium thiosulfate solution whose morality was determined by potassium iodate solution. Temperature of sodium thiosulfate during titration was recorded by a digital thermometer. During this cruise, we measured dissolved oxygen concentration using 2 sets of the titration apparatus. Dissolved oxygen concentration (μmol $kg^{-1}$) was calculated by sample temperature during seawater sampling, salinity of the bottole sampling, flask volume, and titrated volume of sodium thiosulfate solution without the blank.

e. Standardization and determination of the blank

Concentration of sodium thiosulfate titrant was determined by potassium iodate solution. Pure potassium iodate was dried in an oven at 130 $^oC$. 1.7835 g potassium iodate weighed out accurately was dissolved in deionized water and diluted to final volume of 5 $dm^3$ in a calibrated volumetric flask (0.001667 mol $dm^{-3}$). 10 $cm^3$ of the standard potassium iodate solution was added to a flask using a volume-calibrated dispenser. Then 90 $cm^3$ of deionized water, 1 $cm^3$ of sulfuric acid solution, and 0.5 $cm^3$ of

pickling reagent solution II and I were added into the flask in order. Amount of titrated volume of sodium thiosulfate (usually 5 times measurements average) gave the morality of sodium thiosulfate titrant.

The oxygen in the pickling reagents I (0.5 $cm^3$) and II (0.5 $cm^3$) was assumed to be 3.8 x $10^{-8}$ mol (Murray *et al.*, 1968). The blank due to other than oxygen was determined as follows. 1 and 2 $cm^3$ of the standard potassium iodate solution were added to two flasks respectively using a calibrated dispenser. Then 100 $cm^3$ of deionized water, 1 $cm^3$ of sulfuric acid solution, and 0.5 $cm^3$ of pickling reagent solution II and I each were added into the flask in order. The blank was determined by difference between the first (1 $cm^3$ of $KIO_3$) titrated volume of the sodium thiosulfate and the second (2 $cm^3$ of $KIO_3$) one. The results of 3 times blank determinations were averaged.

Table 4.1-1 shows results of the standardization and the blank determination during this cruise.

**Table 4.1-1.** Results of the standardization and the blank determinations during this cruise

| Date | $KIO_3$ ID | $Na_2S_2O_3$ | DOT-01X(No.7) | | DOT-01X(No.8) | | Stations |
|---|---|---|---|---|---|---|---|
| | | | E.P. | Blank | E.P. | Blank | |
| 2013/08/30 | 20130509-02-01 | 20130514-02 | 3.951 | 0.001 | 3.951 | -0.001 | 001, 003, 004, 005, 006, 007, 008, 009, 010, 011, 012, 014, 016, 018, 020, 021, 022, 023, 024, 025, 026, 027, 028, 029, 030, 031 |
| 2013/08/31 | CSK DCE2131 | 20130514-02 | 3.951 | - | 3.952 | - | |
| 2013/09/08 | 20130509-02-03 | 20130514-02 | 3.953 | 0.002 | 3.950 | 0.000 | |
| 2013/09/08 | 20130509-02-03 | 20130514-03 | 3.956 | 0.001 | 3.954 | 0.001 | 032, 033, 034, 035, 036, 037, 038, 039, 040, 041 Cast 001 – 013 |
| 2013/09/14 | 20130509-02-04 | 20130514-03 | 3.955 | 0.000 | 3.951 | 0.002 | 041 Cast 014 – 031 |
| 2013/09/18 | 20130509-02-05 | 20130514-03 | 3.955 | 0.000 | 3.952 | 0.000 | |
| 2013/09/18 | 20130509-02-05 | 20130514-04 | 3.954 | -0.002 | 3.951 | 0.000 | 041 Cast 032 – 061, 043 Cast 011 – 015, 045 Cast 015 046, 047, 048, 049, 050, 051 |
| 2013/09/26 | 20130509-02-06 | 20130514-04 | 3.956 | 0.000 | 3.953 | 0.001 | |
| 2013/09/26 | 20130509-02-06 | 20130514-05 | 3.955 | 0.000 | 3.950 | -0.002 | 052, 053, 054, 055, 056, 057, 058, 059, 060, 061, 062, 063, 064, 065, 066, 067, 068, 070, 072, 074, 075, 076, 078, 079, 080, 081, 082, 083, 086, |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | 041 Cast062 – 065, 043 Cast016, 044 Cast016, 045 Cast016 |
| 2013/10/05 | 20130509-02-07 | 20130514-05 | 3.953 | 0.002 | 3.952 | 0.001 | |
| 2013/10/06 | 20130509-02-07 | 20130514-06 | 3.953 | 0.001 | 3.950 | 0.001 | |

f. Repeatability of sample measurement

Replicate samples were taken at every CTD casts. Total amount of the replicate sample pairs of good measurement was 317. The standard deviation of the replicate measurement was 0.12 μmol $kg^{-1}$ that was calculated by a procedure in Guide to best practices for ocean $CO_2$ measurements Chapter4 SOP23 Ver.3.0 (2007). Results of replicate samples were shown in Table 4.1-2 and this diagram shown in Figures 4.1-1 and -2.

**Table 4.1-2.** Results of the replicate sample measurements

| Layer | Number of replicate sample pairs | Oxygen concentration (μmol $kg^{-1}$) Standard Deviation. |
|---|---|---|
| 100m>= | 281 | 0.79 |
| >100m | 36 | 0.09 |
| All | 317 | 0.74 |

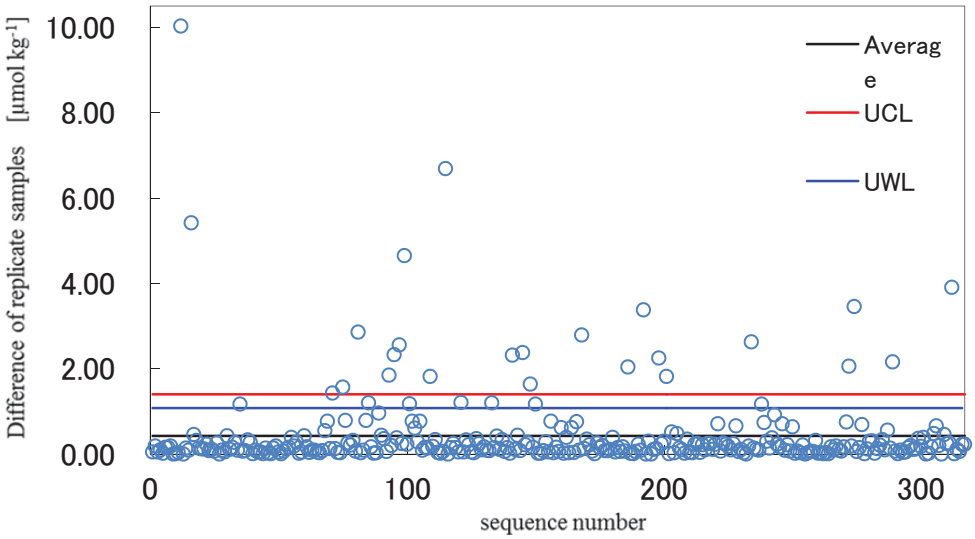



**Figure 4.1-1.** Differences of replicate samples against sequence number.

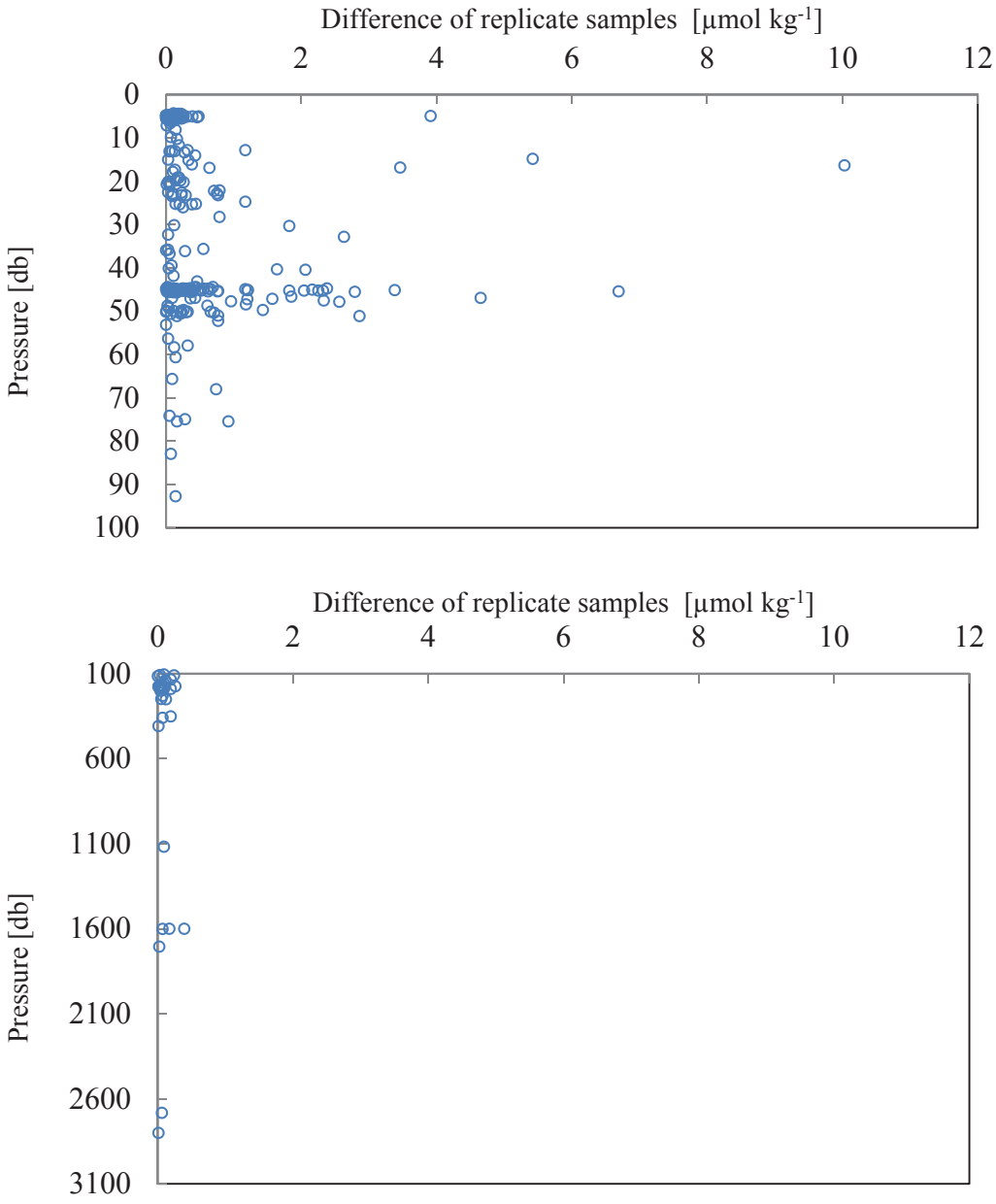



**Figure 4.1-2.** Differences of replicate samples against pressure.

(5) Data archive

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC web site.

(6) References

Dickson, A.G., Determination of dissolved oxygen in sea water by Winkler titration. (1996)

Dickson, A.G., Sabine, C.L. and Christian, J.R. (Eds.), Guide to best practices for ocean CO2 measurements. (2007)

Culberson, C.H., WHP Operations and Methods July-1991 "Dissolved Oxygen", (1991)

Japan Meteorological Agency, Oceanographic research guidelines(Part 1). (1999)

KIMOTO electric CO. LTD., Automatic photometric titrator DOT-01 Instruction manual

## 4.2. Nutrients

(1) Personnel

Shigeto Nishino (JAMSTEC): Principal investigator

Masanori ENOKI (MWJ): Operation leader

Elena HAYASHI (MWJ)

Yoshiko ISHIKAWA (MWJ)

Minoru KAMATA (MWJ)

(2) Objective

The objective of nutrient analyses during the R/V Mirai MR13-06 cruise in the Arctic Ocean is as follows:

- Describe the present status of nutrient concentrations with excellent comparability.

(3) Parameters

The determinants are nitrate, nitrite, phosphate, silicate and ammonia in the Arctic Ocean.

(4) Summary of nutrients analysis

We made 57 QuAAtro runs for the water columns sample at 150 casts during MR13-06. The total amount of layers of the seawater sample reached up to 1537. We made basically duplicate measurement. The station locations for nutrients measurement is shown in Figure 4.2.1

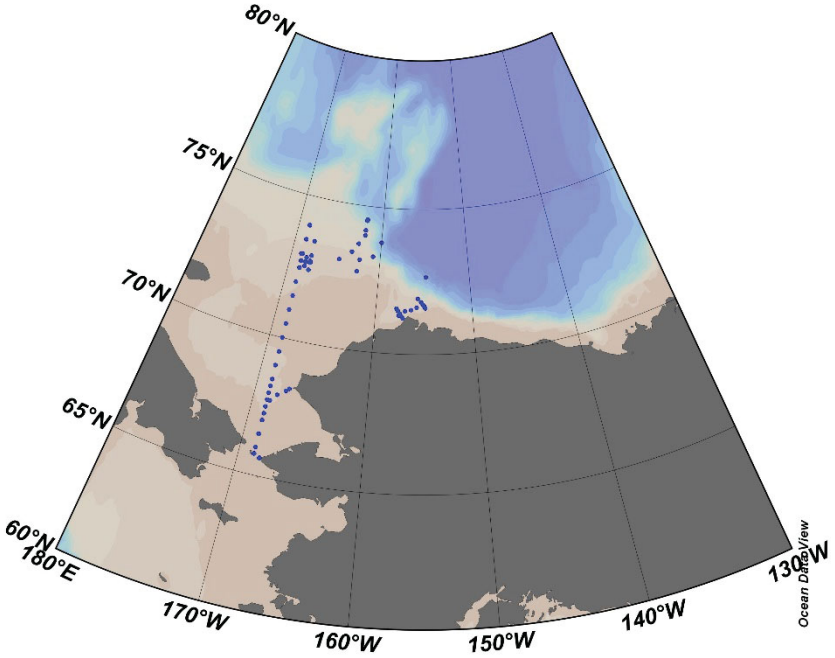



**Figure 4.2-1.** Sampling positions of nutrients sample.

(5) Instrument and Method

Analytical detail using QuAAtro system

The phosphate analysis is a modification of the procedure of Murphy and Riley (1962).

Molybdic acid is added to the seawater sample to form phosphomolybdic acid which is in turn reduced to phosphomolybdous acid using L-ascorbic acid as the reductant.

Nitrate + nitrite and nitrite are analyzed according to the modification method of Grasshoff (1970). The sample nitrate is reduced to nitrite in a cadmium tube inside of which is coated with metallic copper. The sample stream 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-Naphthylethylene-diamine added to the sample stream then couples with the diazonium ion to produce a red, azo dye. With reduction of the nitrate to nitrite, both nitrate and nitrite react and are measured; without reduction, only nitrite reacts. Thus, for the nitrite analysis, no reduction is performed and the alkaline buffer is not necessary. Nitrate is computed by difference.

The silicate method is analogous to that described for phosphate. The method used is

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

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

The flow diagrams and reagents for each parameter are shown in Figures 4.2.2 to 4.2.6.

c. Nitrate + Nitrite Reagents

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

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

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

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

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

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

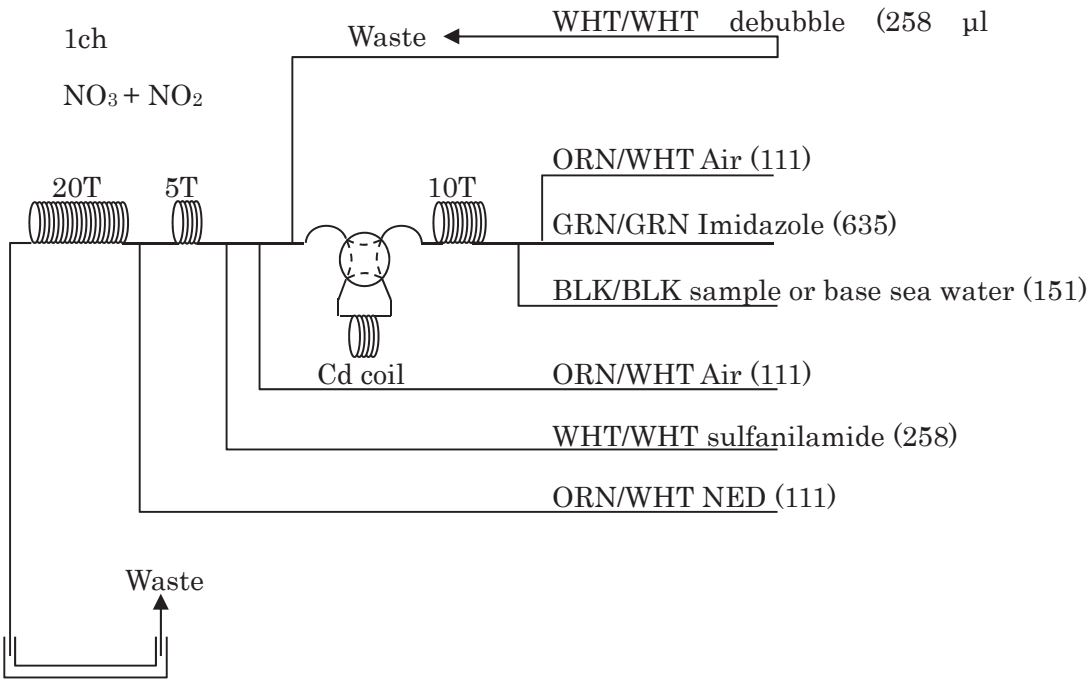



**Figure 4.2-2.** $NO_3$+$NO_2$ (1ch.) Flow diagram.

d. Nitrite Reagents

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

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

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

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

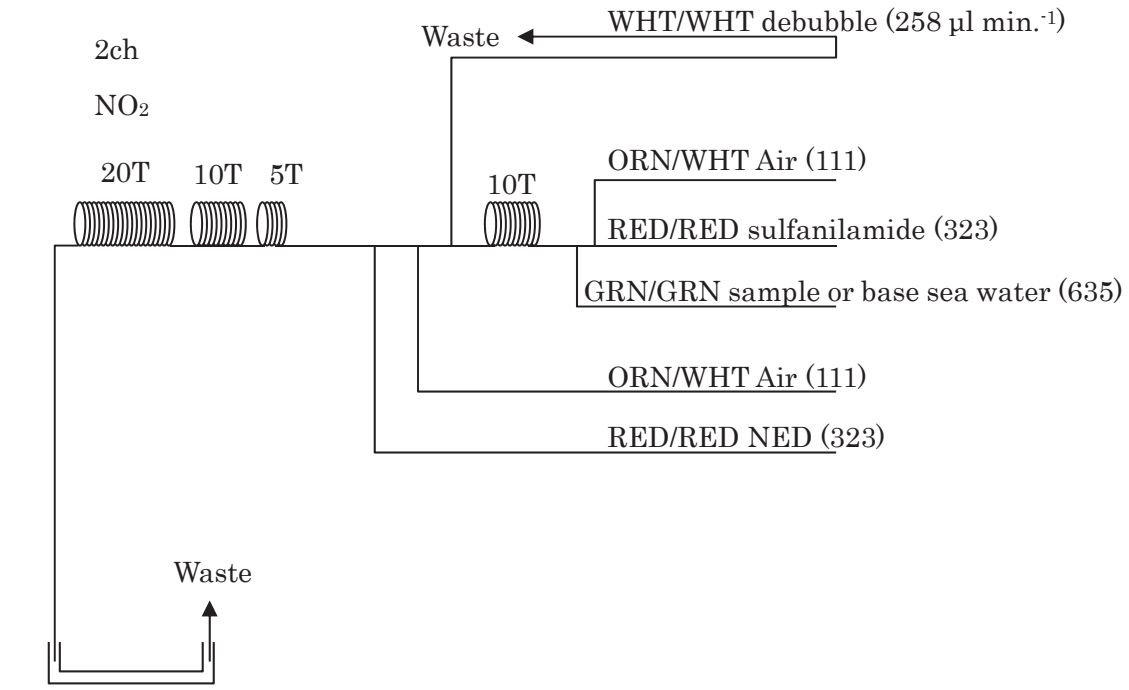



**Figure 4.2-3.** $NO_2$ (2ch.) Flow diagram.

e. Silicate Reagents

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

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

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

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

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

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

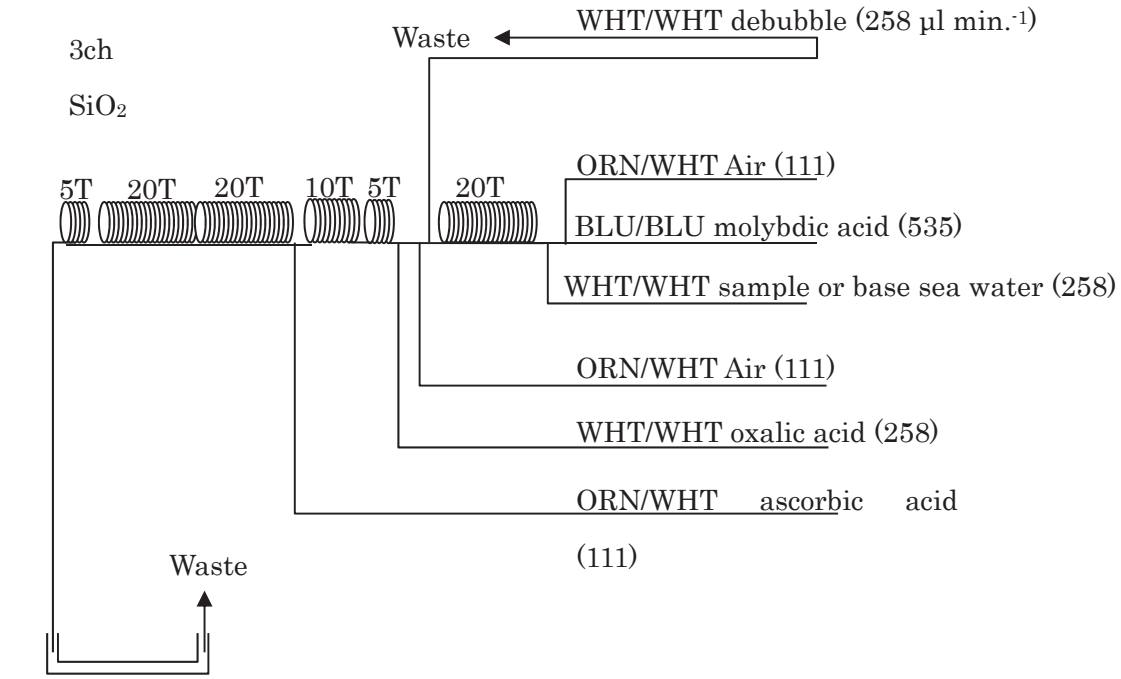



**Figure 4.2-4.** $SiO_2$ (3ch.) Flow diagram.

f. Phosphate Reagents

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

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

Mixed Reagent

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

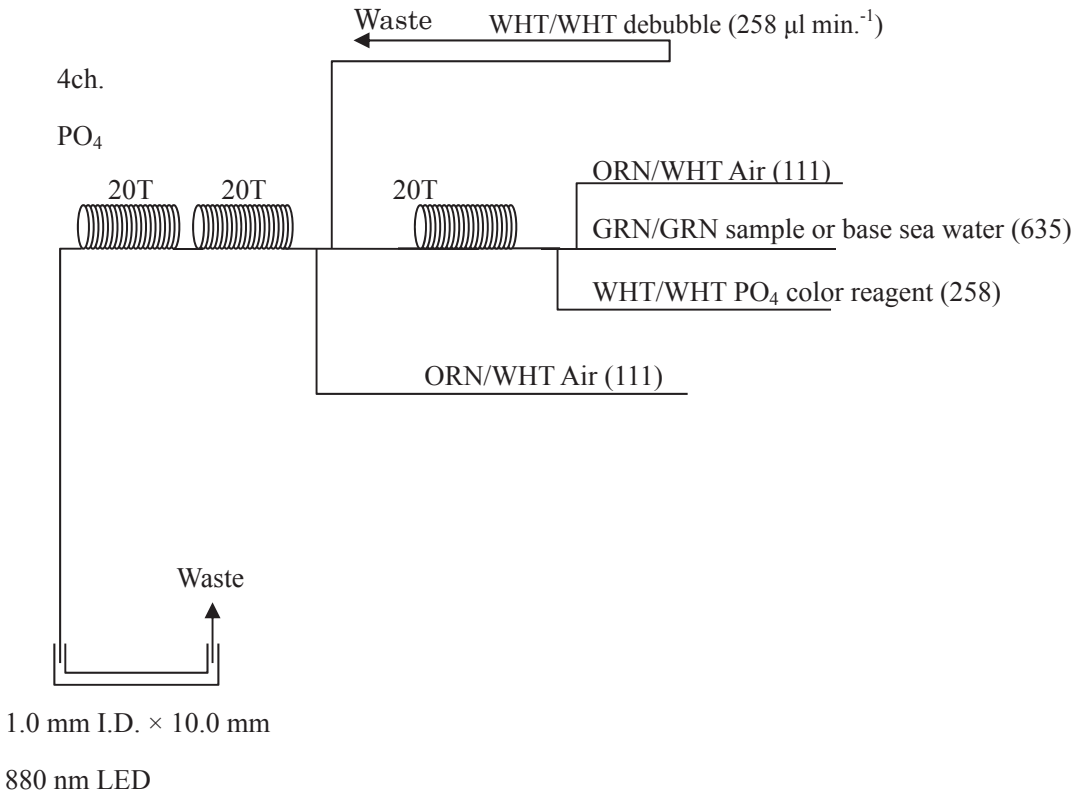



**Figure 4.2-5.** $PO_4$ (4ch.) Flow diagram.

g. Ammonia Reagents

EDTA

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

NaOH

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

Stock Nitroprusside

Dissolved 0.25 g sodium pentacyanonitrosylferrate(II), $Na_2[Fe(CN)_5NO]$, in 100 ml of

DIW and add 0.2 ml 1N $H_2SO_4$. Stored in a dark bottle and prepared at a month about.

Nitroprusside solution

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

Alkaline phenol

Dissolved 10 g phenol, $C_6H_5OH$, 5 g sodium hydroxide and citric acid, $C_6H_8O_7$, in 200 ml DIW. Stored in a dark bottle and prepared at a week about.

NaClO solution

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

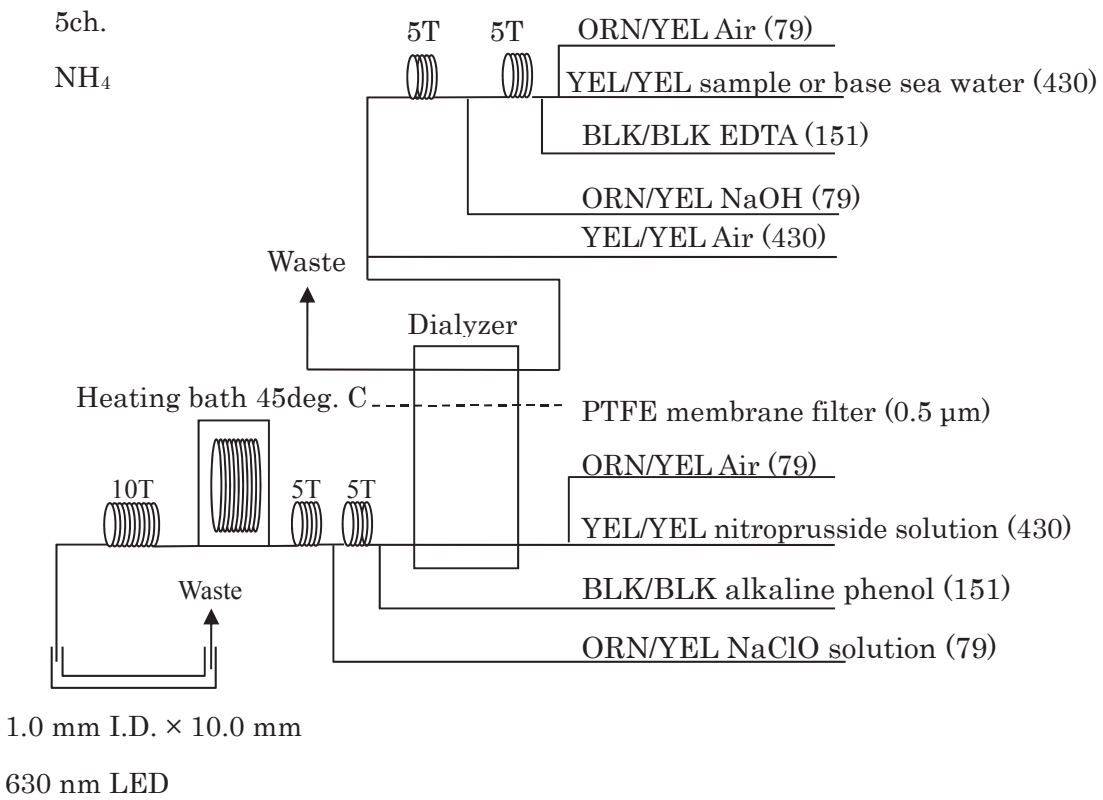



**Figure 4.2-6.** $NH_4$ (5ch.) Flow diagram.

i. Sampling procedures

Sampling of nutrients followed that oxygen, salinity and trace gases. Samples were drawn into a virgin 10 ml polyacrylates vials without sample drawing tubes. These were rinsed three times before filling and vials were capped immediately after the drawing. The vials are put into water bath adjusted to ambient temperature, 24 ± 1.5 deg. C, in about 30 minutes before use to stabilize the temperature of samples.

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

j. Data processing

Raw data from QuAAtro were treated as follows:

- Check baseline shift.
- Check the shape of each peak and positions of peak values taken, and then change the

positions of peak values taken if necessary.

- Carry-over correction and baseline drift correction were applied to peak heights of each samples followed by sensitivity correction.
- Baseline correction and sensitivity correction were done basically using liner regression.
- Load pressure and salinity from CTD data due to calculate density of seawater.
- Calibration curves to get nutrients concentration were assumed second order equations.

(6) Nutrients standards

a. Volumetric laboratory ware of in-house standards

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

Volumetric flasks

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

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

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

Pipettes and pipettors

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

b. Reagents, general considerations

Specifications

For nitrate standard, “potassium nitrate 99.995 suprapur®” provided by Merck, Lot. B0771365211, CAS No.: 7757-91-1, was used.

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

For nitrite standard, “sodium nitrate” provided by Wako, CAS No.: 7632-00-0, was used. And assay of nitrite was determined according JIS K8019 and assays of nitrite salts were 98.73 %. We use that value to adjust the weights taken.

For the silicate standard, we use “Silicon standard solution $SiO_2$ in NaOH 0.5 mol/l CertiPUR®” provided by Merck, CAS No.: 1310-73-2, of which lot number is HC122701 are used. The silicate concentration is certified by NIST-SRM3150 with the uncertainty of 0.5 %. HC122701 is certified as 1000+-5 mg L-1, however, our direct comparison between two Merck standards and estimation based on 13 lots of RMNS gave us a factor of 975 mg L-1 for HC074650 which was exceed 5mg of certification by Merck. We use this factor throughout MR13-06 to keep comparability for silicate concentration.

For ammonia standard, “ammonia sulfate” provided by Wako, CAS No.: 7783-20-2, was used. The purity of this standard was greater than 99.5%.

Ultra pure water

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

Low-nutrients seawater (LNSW)

Surface water having low nutrient concentration was taken and filtered using 0.45 μm pore size membrane filter. This water is stored in 20 liter cubitainer with paper box.

The concentrations of nutrient of this water were measured carefully in August 2012.

c. Concentrations of nutrients for A, B and C standards

Concentrations of nutrients for A, B and C standards are set as shown in Table 4.2.1. The C standard is prepared according recipes as shown in Table 4.2.2. All volumetric laboratory tools were calibrated prior the cruise as stated in chapter (5)a. Then the actual concentration of nutrients in each fresh standard was calculated based on the ambient, solution temperature and determined factors of volumetric laboratory wares.

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

For high concentration of ammonia in Chukchi Sea at MR12-E03 cruise, we used 5 levels calibration curve adding to C-5 standard in Chukchi Sea observation.

**Table 4.2-1.** Nominal concentrations of nutrients for A, B and C standards

| | A | B | C-1 | C-2 | C-3 | C-4 | C-5 |
|---|---|---|---|---|---|---|---|
| $NO_3$ (μM) | 22000 | 680 | 0.03 | 7 | 20 | 34 | - |
| $NO_2$ (μM) | 4000 | 20 | 0.00 | 0.2 | 0.6 | 1.0 | - |
| $SiO_2$ (μM) | 36000 | 1400 | 1.3 | 15 | 42 | 70 | - |
| $PO_4$ (μM) | 3000 | 60 | 0.04 | 0.6 | 1.8 | 3.0 | - |
| $NH_4$ (μM) | 4000 | 160 | 0.00 | 1.6 | 3.2 | 6.4 | 12.8 |

**Table 4.2-2.** Working calibration standard recipes

| C Std. | B-1 Std. | B-2 Std. | B-3 Std. | DIW |
|---|---|---|---|---|
| C-1 | 0 ml | 0 ml | 0 ml | 70 ml |
| C-2 | 5 ml | 5 ml | 5 ml | 55 ml |
| C-3 | 15 ml | 15 ml | 10 ml | 30 ml |
| C-4 | 25 ml | 25 ml | 20 ml | 0 ml |

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

B-2 Std.: Nitrite

B-3 Std.: Ammonia

d. Renewal of in-house standard solutions

In-house standard solutions as stated in paragraph c were renewed as shown in Table 4.2.3(a) to (c).

**Table 4.2-3a**. Timing of renewal of in-house standards

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

**Table 4.2-3b.** Timing of renewal of working calibration standards

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

**Table 4.2-3c.** Timing of renewal of in-house standards for reduction estimation

| Reduction estimation | Renewal |
|---|---|
| D-1 Std.<br>(3600 μM $NO_3$) | maximum a week |
| 22 μM $NO_3$ | when C Std. renewed |
| 24 μM $NO_2$ | when C Std. renewed |

(7) Reference material of nutrients in seawater

To get the more accurate and high quality nutrients data to achieve the objectives stated above, huge numbers of the bottles of the reference material of nutrients in seawater (hereafter RMNS) are prepared (Aoyama et al., 2006, 2007, 2008, 2009). In the

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

a. RMNS for this cruise

RMNS lots BS, BU, BT and BD, which cover full range of nutrients concentrations in the Arctic ocean are prepared. 32 sets of BS, BU, BT and BD are prepared.

These RMNS assignment were completely done based on random number. The RMNS bottles were stored at a room in the ship, REAGENT STORE, where the temperature was maintained around 18.5 deg. C.

b. Assigned concentration for RMNSs

We assigned nutrients concentrations for RMNS lots BS, BU, BT and BD as shown in Table 4.2.4.

**Table 4.2-4.** Assigned concentration of RMNSs

unit: μmol $kg^{-1}$

| | Nitrate | Nitrite | Phosphate | Silicate | Assigned year |
|---|---|---|---|---|---|
| BS | 0.07 | 0.02 | 0.063 | 1.61 | 2011 |
| BU | 3.96 | 0.07 | 0.378 | 20.27 | 2011 |
| BT | 18.18 | 0.47 | 1.318 | 40.94 | 2011 |
| BD | 29.82 | 0.05 | 2.191 | 64.30 | 2011 |

(8) Quality control

a. Precision of nutrients analyses during the cruise

Precision of nutrients analyses during this cruise was evaluated based on the 5 to 7 measurements, which are measured every 8 to 14 samples, during a run at the concentration of C-4 std. Summary of precisions are shown as shown in Table 4.2.5 and Figures 4.2.8 to 4.2.12, Analytical precisions previously evaluated were 0.08 % for nitrate, 0.10 % for phosphate and 0.07 % for silicate in CLIVAR P21 revisited cruise of MR09-01 cruise in 2009, respectively. During in this cruise, analytical precisions were 0.11% for nitrate, 0.19% for nitrite, 0.16% for phosphate, 0.11% for silicate and 0.30% for ammonia in terms of median of precision, respectively. Then we can conclude that the analytical precisions for nitrate, nitrite, phosphate and silicate were maintained throughout this cruise. The time series of precision are shown in Figures 4.2.8 to 4.2.12.

**Table 4.2-5.** Summary of precision based on the replicate analyses

| | Nitrate CV % | Nitrite CV % | Phosphate CV % | Silicate CV % | Ammonia CV% |
|---|---|---|---|---|---|
| Median | 0.11 | 0.19 | 0.11 | 0.16 | 0.30 |
| Mean | 0.11 | 0.19 | 0.12 | 0.16 | 0.31 |
| Maximum | 0.23 | 0.39 | 0.24 | 0.33 | 0.96 |
| Minimum | 0.04 | 0.05 | 0.05 | 0.07 | 0.10 |
| N | 59 | 59 | 59 | 59 | 58 |

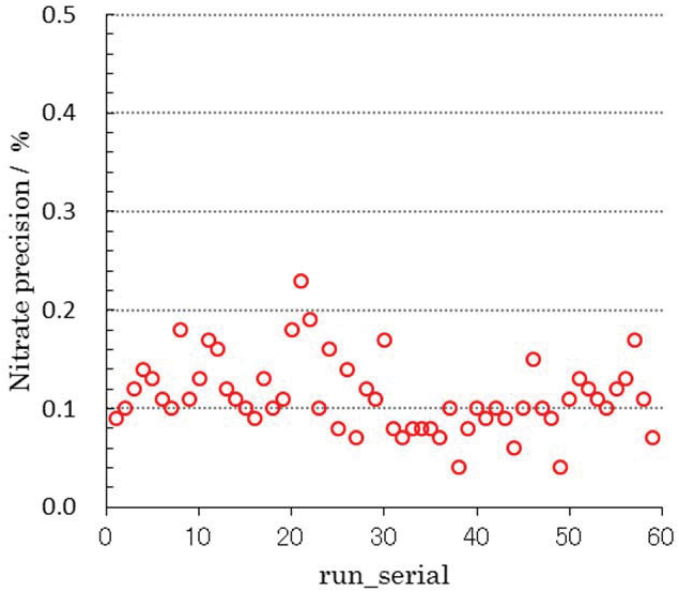



**Figure 4.2-8.** Time series of precision of nitrate for MR13-06.

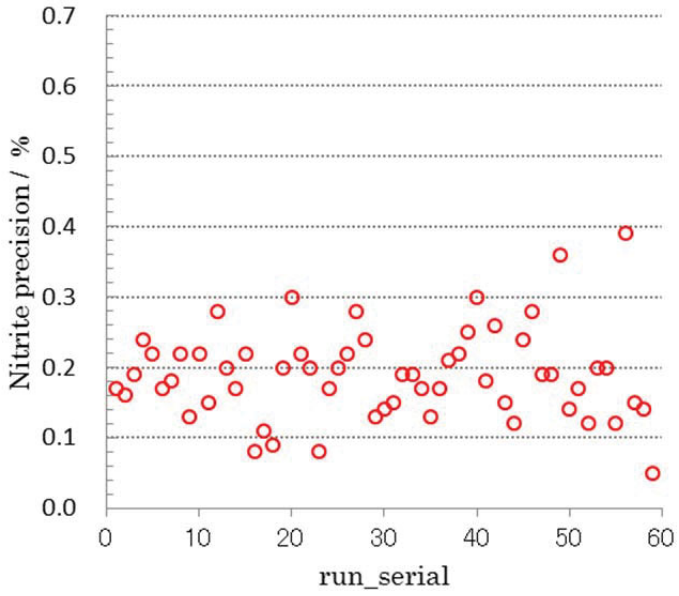



**Figure 4.2-9.** Time series of precision of nitrite for MR13-06.

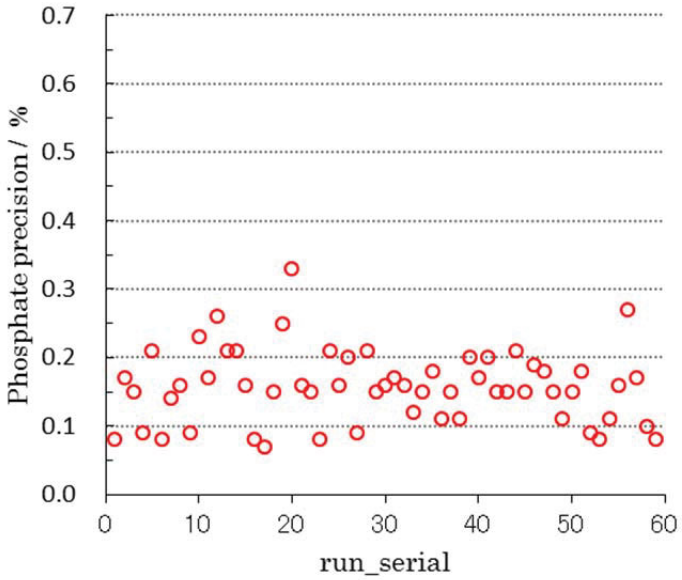



**Figure 4.2-10.** Time series of precision of phosphate for MR13-06.

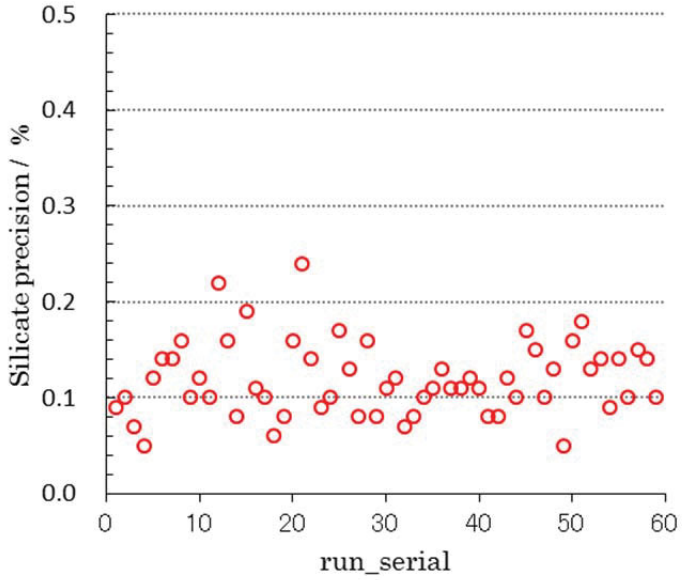



**Figure 4.2-11.** Time series of precision of silicate for MR13-06.

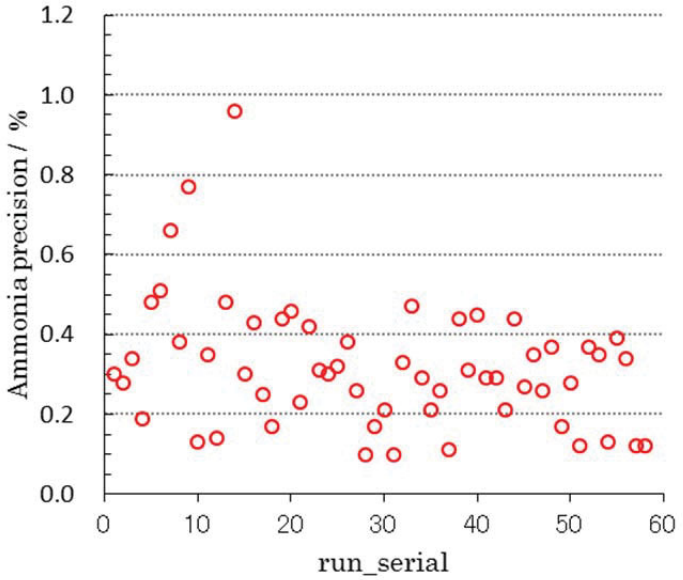



**Figure 4.2-12.** Time series of precision of ammonia for MR13-06.

b. Results of RMNS mesurements

We measured RMNSs in every run during this cruise. The control chart of RM-BD are shown in Figures 4.2.13 to 4.2.17.

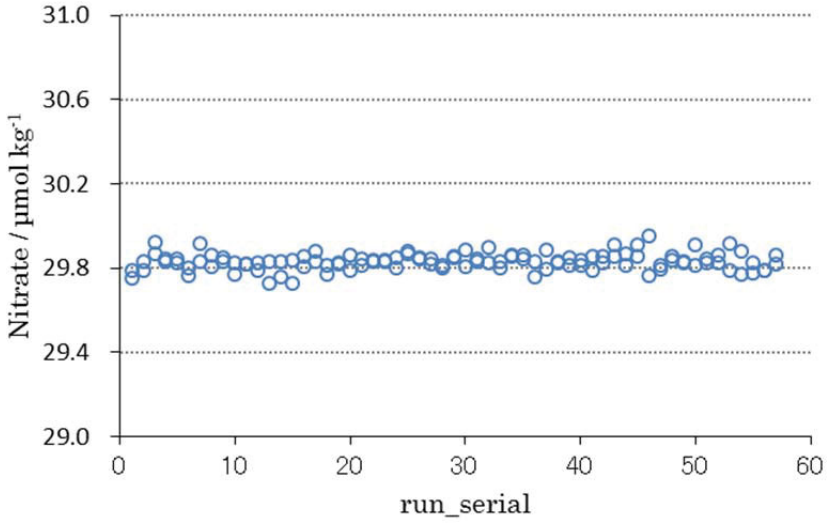



**Figure 4.2-13.** Summary of nitrate concentration of RM-BD.

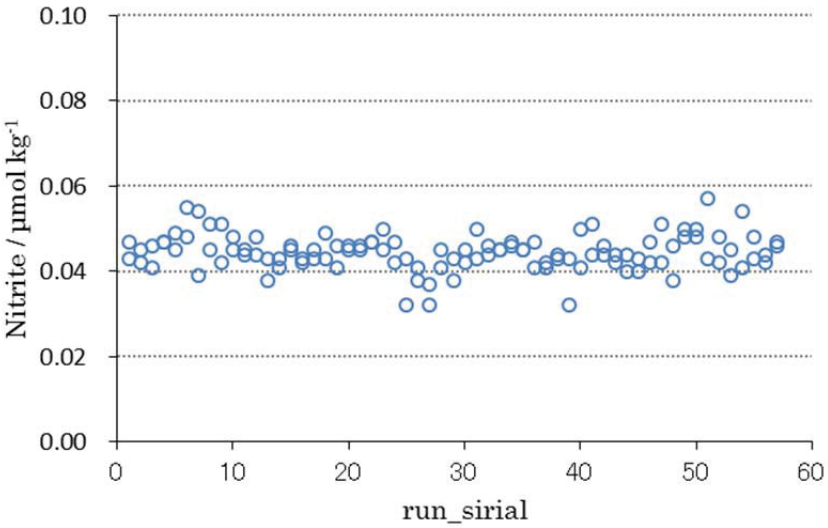



**Figure 4.214.** Summary of nitrite concentration of RM-BD.

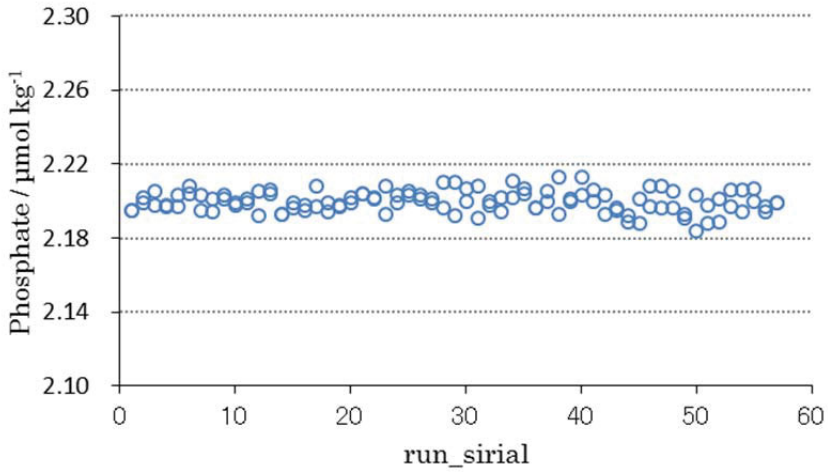



**Figure 4.2-15.** Summary of phosphate concentration of RM-BD.

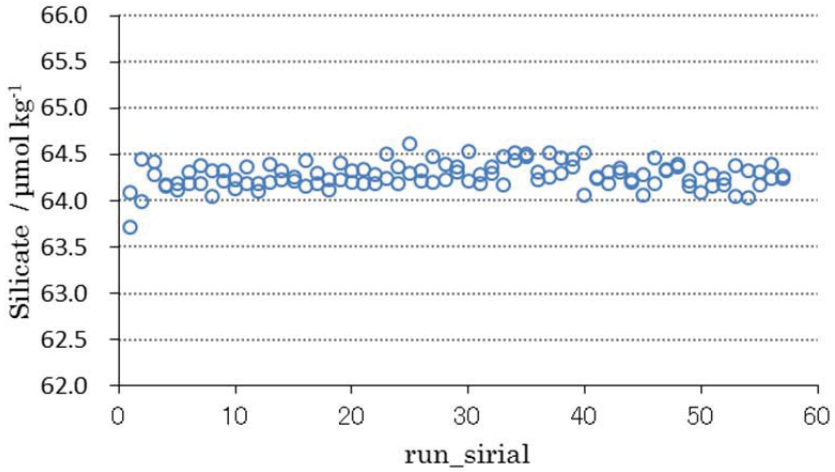



**Figure 4.2-16.** Summary of silicate concentration of RM-BD.

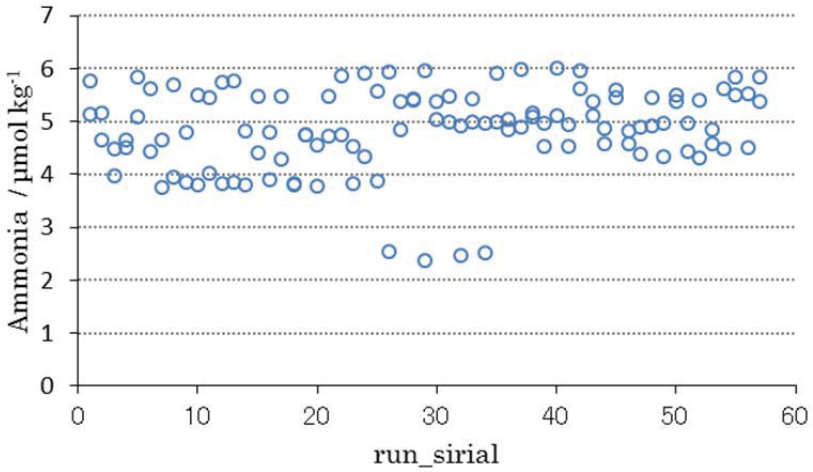



**Figure 4.2-17.** Summary of ammonia concentration of RM-BD.

c. Carry over

We can also summarize the magnitudes of carry over throughout the cruise. These are small enough within acceptable levels as shown in Table 4.2.6.

**Table 4.2-6.** Summary of carry over throughout MR13-06

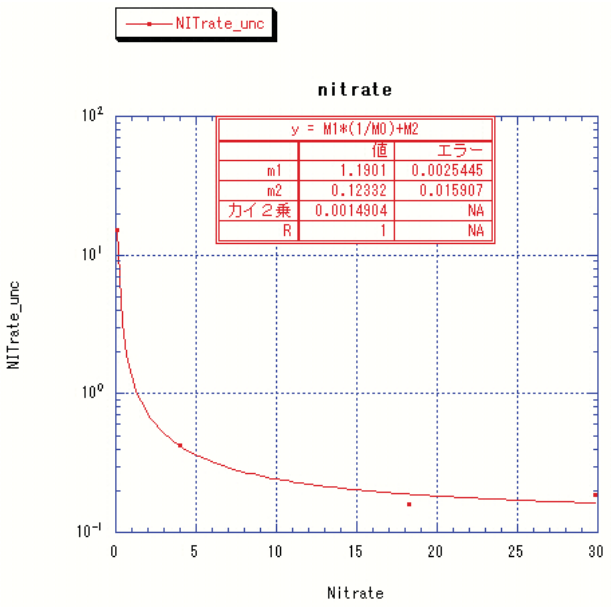
| | Nitrate | Nitrite | Phosphate | Silicate | Ammonia |
|---|---|---|---|---|---|
| | % | % | % | % | % |
| Median | 0.15 | 0.13 | 0.21 | 0.33 | 0.62 |
| Mean | 0.15 | 0.23 | 0.21 | 0.34 | 0.61 |
| Maximum | 0.32 | 1.50 | 0.40 | 0.77 | 1.21 |
| Minimum | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 |
| N | 59 | 59 | 59 | 59 | 58 |

d. Concentration dependent uncertainty

We can evaluate concentration dependent uncertainty based on repeat RMNS measurements.

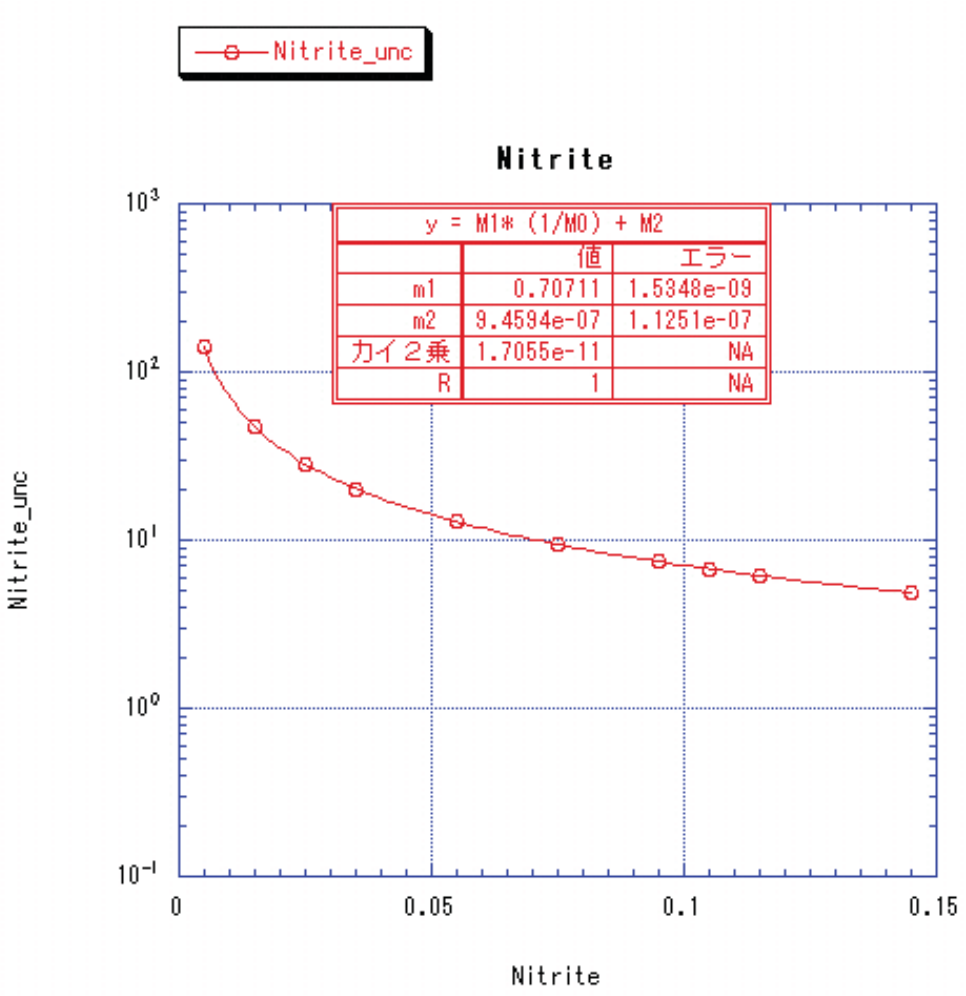
For Nitrate, uncertainty in terms of % is expressed by eq. (1)

$$\text{Unc}\ (\%) = 0.12 + 1.19 / C_{no3} \qquad (1)$$



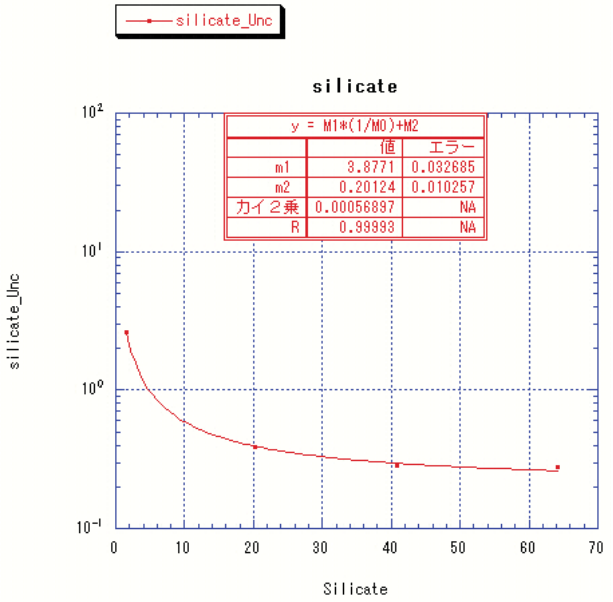

For nitrite, uncertainty in terms of % is expressed by eq. (2)

$$Unc\ (\%) = 0.009 + 0.707 / C_{no2} \qquad (2)$$



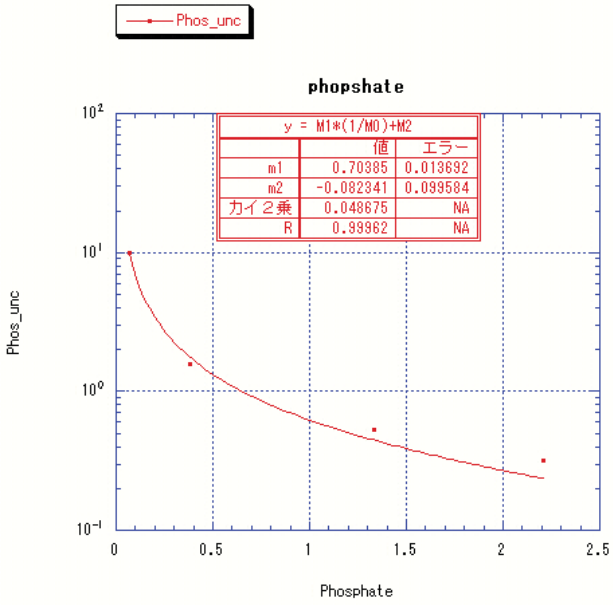

For silicate, uncertainty in terms of % is expressed by eq. (3)

$$Unc\ (\%) = 0.20 + 3.88 / C_{sil} \qquad (3)$$




For phosphate, uncertainty in terms of % is expressed by eq. (4)

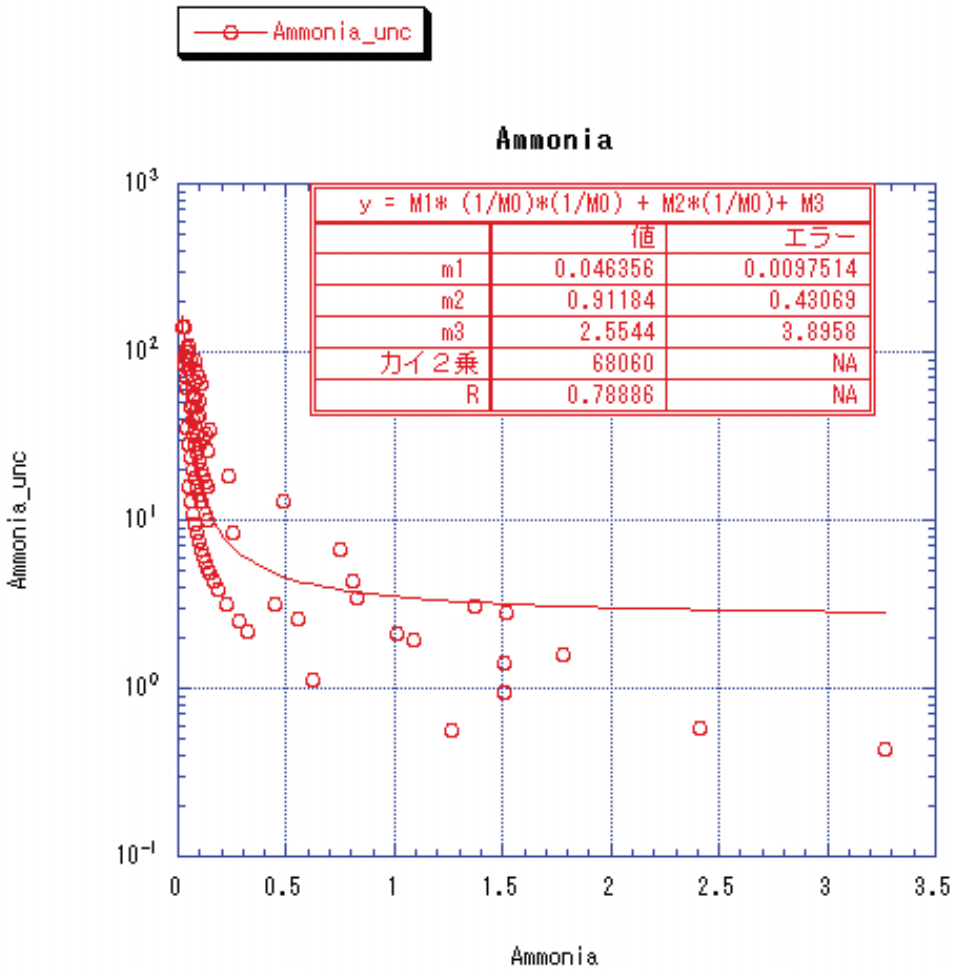
$$\text{Unc}\ (\%) = -0.08 + 0.703 / C_{po4} \qquad (4)$$




We can also evaluate concentration dependent uncertainty for ammonia based on duplicate measurements of the samples.

For ammonia, uncertainty in terms of % is expressed by eq. (5)

$$\text{Unc}\ (\%) = 2.554 + 0.912 / C_{NH4} + 0.046 / C_{NH4} / C_{NH4} \qquad (5)$$




For ammonia, uncertainty in terms of % is expressed by eq. (4)

$$Unc\ (\%) = a + b / C_{sil} \qquad (4)$$

(9) Problems/improvements occurred and solutions.

a. Precipitation at ammonia line

There was a precipitation at the point of mixed seawater sample, EDTA and NaOH in ammonia line. We changed the concentration of EDTA by twice due to avoid the production of the precipitation. We need to examine the quantity of EDTA.

c. Over range samples

We obtained over range samples in Chukchi Sea. These samples were measured by extrapolating calibration curve. Over range sample list was shown in Table 4.2.7.

**Table 4.2-7.** Over range samples

| Parameter | Station and Sample No. |
|---|---|
| Ammonia | Stn. 037 cast1 # 1 |
| | Stn. 041 cast1 # 1 |

(10) Station list

The sampling station list for nutrients is shown in Table 4.2.7.

Station 87 cast1 and cast2 collected RMNS originwater.

**Table 4.2-7.** List of stations

| Station | Cast | Latitude | Longitude |
|---|---|---|---|
| 1 | 1 | 65.7697 | 191.2483 |
| 3 | 1 | 65.6573 | 191.7475 |
| 4 | 1 | 66.004 | 191.2512 |
| 5 | 1 | 66.5032 | 191.2482 |
| 6 | 1 | 67.0032 | 191.2552 |
| 7 | 1 | 67.5015 | 191.2505 |
| 8 | 1 | 68.0042 | 191.2363 |
| 9 | 1 | 68.5033 | 191.2537 |
| 10 | 1 | 69.0025 | 191.2502 |
| 11 | 1 | 71.343 | 202.3903 |
| 12 | 1 | 71.5808 | 202.1557 |
| 14 | 1 | 71.2452 | 202.8288 |
| 16 | 1 | 71.3263 | 202.6492 |
| 18 | 1 | 71.4112 | 202.4923 |
| 20 | 1 | 71.4975 | 202.324 |
| 21 | 1 | 71.4923 | 203.0473 |

| Station | Cast | Latitude | Longitude |
|---|---|---|---|
| 22 | 1 | 71.5468 | 203.6457 |
| 23 | 1 | 71.627 | 204.2397 |
| 24 | 1 | 71.6087 | 205.1485 |
| 25 | 1 | 71.6832 | 205.0243 |
| 26 | 1 | 71.7365 | 204.89 |
| 27 | 1 | 71.813 | 204.7033 |
| 28 | 1 | 71.9348 | 204.3435 |
| 29 | 1 | 72.6803 | 205.2008 |
| 31 | 1 | 74.5305 | 198.088 |
| 33 | 1 | 74.1678 | 197.9943 |
| 34 | 1 | 73.9972 | 191.2578 |
| 35 | 1 | 73.0035 | 191.2513 |
| 36 | 1 | 72.7498 | 191.2518 |
| 37 | 1 | 72.501 | 191.2505 |
| 38 | 1 | 72.5012 | 192.252 |
| 39 | 1 | 72.75 | 192.2578 |
| 40 | 1 | 73.0003 | 192.2528 |
| 41 | 1 | 72.7532 | 191.7587 |
| 41 | 2 | 72.7495 | 191.7485 |
| 41 | 3 | 72.7503 | 191.7575 |
| 41 | 4 | 72.7487 | 191.75 |
| 41 | 5 | 72.7505 | 191.7493 |
| 41 | 6 | 72.751 | 191.7483 |
| 41 | 7 | 72.7492 | 191.7535 |
| 41 | 8 | 72.7498 | 191.7477 |
| 41 | 9 | 72.7498 | 191.7388 |
| 41 | 10 | 72.7498 | 191.7548 |
| 41 | 11 | 72.7503 | 191.7528 |
| 41 | 12 | 72.7497 | 191.7528 |

| Station | Cast | Latitude | Longitude |
|---|---|---|---|
| 41 | 13 | 72.7513 | 191.7468 |
| 41 | 14 | 72.7508 | 191.753 |
| 41 | 15 | 72.7495 | 191.7492 |
| 41 | 16 | 72.7495 | 191.7492 |
| 41 | 17 | 72.7482 | 191.7543 |
| 41 | 18 | 72.7512 | 191.7565 |
| 41 | 19 | 72.7488 | 191.7515 |
| 41 | 20 | 72.749 | 191.7487 |
| 41 | 21 | 72.7512 | 191.7458 |
| 41 | 22 | 72.7503 | 191.7465 |
| 41 | 23 | 72.7497 | 191.7528 |
| 41 | 24 | 72.7468 | 191.7572 |
| 41 | 25 | 72.7515 | 191.7467 |
| 41 | 26 | 72.7503 | 191.7508 |
| 41 | 27 | 72.7487 | 191.7517 |
| 41 | 28 | 72.7502 | 191.7508 |
| 41 | 29 | 72.7495 | 191.7513 |
| 41 | 30 | 72.7512 | 191.7517 |
| 41 | 31 | 72.7493 | 191.7487 |
| 41 | 32 | 72.7552 | 191.7558 |
| 41 | 33 | 72.7487 | 191.7497 |
| 41 | 34 | 72.7513 | 191.7495 |
| 41 | 35 | 72.7485 | 191.7448 |
| 41 | 36 | 72.753 | 191.7443 |
| 41 | 37 | 72.748 | 191.7478 |
| 41 | 38 | 72.7508 | 191.7452 |
| 41 | 39 | 72.7433 | 191.7462 |
| 41 | 40 | 72.7465 | 191.7515 |
| 41 | 41 | 72.7488 | 191.7592 |

| Station | Cast | Latitude | Longitude |
|---|---|---|---|
| 41 | 42 | 72.7537 | 191.7425 |
| 41 | 43 | 72.7517 | 191.7605 |
| 41 | 44 | 72.7507 | 191.7528 |
| 41 | 45 | 72.7498 | 191.7488 |
| 41 | 46 | 72.7503 | 191.7478 |
| 41 | 47 | 72.75 | 191.75 |
| 41 | 48 | 72.7495 | 191.7523 |
| 41 | 49 | 72.7498 | 191.7508 |
| 41 | 50 | 72.7497 | 191.7478 |
| 41 | 51 | 72.7497 | 191.7532 |
| 41 | 52 | 72.7492 | 191.7487 |
| 41 | 53 | 72.7488 | 191.7528 |
| 41 | 54 | 72.7498 | 191.7502 |
| 41 | 55 | 72.75 | 191.7498 |
| 41 | 56 | 72.749 | 191.745 |
| 41 | 57 | 72.7505 | 191.7507 |
| 41 | 58 | 72.7493 | 191.7537 |
| 41 | 59 | 72.7548 | 191.7513 |
| 41 | 60 | 72.7508 | 191.7513 |
| 41 | 61 | 72.7518 | 191.752 |
| 41 | 62 | 72.7518 | 191.743 |
| 41 | 63 | 72.751 | 191.7528 |
| 41 | 64 | 72.7497 | 191.7482 |
| 41 | 65 | 72.7485 | 191.751 |
| 42 | 5 | 72.8988 | 191.7495 |
| 42 | 15 | 72.9 | 191.75 |
| 42 | 16 | 72.9002 | 191.7503 |
| 43 | 5 | 72.6002 | 191.7517 |
| 43 | 11 | 72.6023 | 191.7433 |

| Station | Cast | Latitude | Longitude |
|---|---|---|---|
| 43 | 12 | 72.6007 | 191.7492 |
| 43 | 13 | 72.6018 | 191.7557 |
| 43 | 14 | 72.6003 | 191.7543 |
| 43 | 15 | 72.6033 | 191.7523 |
| 43 | 16 | 72.5997 | 191.7535 |
| 44 | 4 | 72.7503 | 192.2502 |
| 44 | 16 | 72.751 | 192.2647 |
| 45 | 4 | 72.7522 | 191.2393 |
| 45 | 15 | 72.7498 | 191.2455 |
| 45 | 16 | 72.751 | 191.2447 |
| 46 | 1 | 72.8072 | 192.224 |
| 47 | 1 | 72.986 | 191.0708 |
| 48 | 1 | 74.0025 | 191.2492 |
| 49 | 1 | 73.5008 | 191.2378 |
| 50 | 1 | 73.4982 | 192.2473 |
| 51 | 1 | 72.9985 | 192.2497 |
| 52 | 1 | 73.0625 | 195.381 |
| 53 | 1 | 73.3827 | 196.701 |
| 54 | 1 | 73.693 | 197.3483 |
| 55 | 1 | 74.0007 | 198.0062 |
| 56 | 1 | 73.8005 | 200.0103 |
| 57 | 1 | 73.3033 | 199.1663 |
| 58 | 1 | 73.1498 | 197.6878 |
| 59 | 1 | 72.7387 | 197.5258 |
| 60 | 1 | 72.5028 | 191.2492 |
| 61 | 1 | 72.0007 | 191.2562 |
| 62 | 1 | 71.5003 | 191.2533 |
| 63 | 1 | 70.9995 | 191.2503 |
| 64 | 1 | 70.5 | 191.251 |

| Station | Cast | Latitude | Longitude |
|---|---|---|---|
| 65 | 1 | 70.001 | 191.2507 |
| 66 | 1 | 69.5 | 191.2547 |
| 67 | 1 | 69.0013 | 191.2527 |
| 68 | 1 | 68.3013 | 192.9542 |
| 70 | 1 | 68.202 | 192.6662 |
| 72 | 1 | 68.0025 | 191.9963 |
| 74 | 1 | 67.7483 | 191.4995 |
| 75 | 1 | 68.5012 | 191.2503 |
| 76 | 1 | 68.2502 | 191.2493 |
| 77 | 1 | 68.0008 | 191.2438 |
| 78 | 1 | 67.7507 | 191.2495 |
| 79 | 1 | 67.4995 | 191.2507 |
| 80 | 1 | 67.2508 | 191.2492 |
| 81 | 1 | 67.0005 | 191.2445 |
| 82 | 1 | 66.5012 | 191.237 |
| 83 | 1 | 65.9998 | 191.2495 |
| 84 | 1 | 65.7633 | 191.2427 |
| 86 | 1 | 65.6508 | 191.7483 |
| 87 | 1 | 48.8752 | 166.6145 |
| 87 | 2 | 48.8607 | 166.5892 |

(11) Data archive

These data obtained in this cruise will be submitted to the Data Integration and Analysis Group (DIAG) of JAMSTEC, and will be opened to the public via “Data Research for Whole Cruise Information in JAMSTEC” in JAMSTEC home page.

(12) Acknowledgment

We would like to express our sincere thanks to Dr. Michio Aoyama in Geochemical Research Department, Meteorological Research Institute, who largely contributed to

the quality control of the data with valuable suggestions from his laboratory.

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## 4.3. Dissolved Inorganic Carbon

(1) Personnel

Shigeto Nishino (JAMSTEC): Principal Investigator

Makoto Takada (MWJ): Operation Leader

Atsushi Ono (MWJ)

(2) Objective

The Arctic Ocean has a feature that Dissolved Inorganic Carbon (DIC) concentration is low because of the influence of inflow of the large amount of river water, dilution by sea-ice melt water and high biological productivity. Recently, the undersaturation of the calcium carbonate and a change of $pCO_2$ have been observed in the Arctic Ocean. It is considered that the change of seawater pH and decrease of calcium carbonate affect a growth of the species which forms shells of calcium carbonate. Therefore, quantitative understanding of the cause of these changes is necessary for better assessments and future predictions. The percentage saturation of seawater in respect to calcium carbonate can be computed from DIC and Total Alkalinity (TA; ref. Section 4.4.). Accordingly, we measured DIC on-board during the MR13-06 cruise.

(3) Parameters

Dissolved Inorganic Carbon (DIC)

(4) Instruments and Methods

I. Seawater sampling

Seawater samples were collected by 12 L Niskin bottles and a bucket at 75 stations (total 1823 samples). Seawater was transported into a 300 mL glass bottle (SCHOTT DURAN) which was previously soaked in 5% non-phosphoric acid detergent (pH13) solution at least 3 hours, and rinsed with fresh water for 5 times and Milli-Q deionized water for 3 times. A sampling tube was connected to the Niskin bottle when the sampling was conducted. The glass bottles were filled from the bottom, without rinsing, and were overflowed for 20 seconds. They were sealed using the 29 mm polyethylene inner lids with care not to leave any bubbles in the bottle. After collecting the samples on the deck, the sampling bottles were moved to the laboratory. Prior to the analysis, 3 mL of the samples (1% of the bottle volume) was removed from the glass bottles to make a headspace. The samples were then poisoned with 100 $\mu$L of over saturated solution of mercury chloride within one hour after samplings. The samples

were sealed with 31.9 mm polyethylene inner lids and stored in a refrigerator at approximately 5 ˚C until the analysis.

II. Seawater analysis

Measurements of DIC were made with total $CO_2$ measuring system (System D; Nippon ANS, Inc.). The system comprises of seawater dispensing system, a $CO_2$ extraction system and a coulometer (Model 3000, Nippon ANS, Inc.).

The seawater dispensing system has an auto-sampler (6 ports), which takes seawater from a glass bottle to a pipette of nominal 15 mL volume by PC control. The pipette was kept at 20 ± 0.05 ˚C by a water jacket, in which water is circulated from a thermostatic water bath (RTE10, Thermo) set at 20 ˚C.

The $CO_2$ dissolved in a seawater sample is extracted in a stripping chamber of the $CO_2$ extraction system by phosphoric acid (10% v/v). The stripping chamber is made approximately 25 cm long and has a fine frit at the bottom. A constant volume of acid is added to the stripping chamber from its bottom by pressurizing an acid bottle with nitrogen gas (99.9999%). A seawater sample kept in a constant volume pipette is introduced to the stripping chamber by the same method. Nitrogen gas is bubbled through a fine frit at the bottom of the stripping chamber to make the reaction well. The stripped $CO_2$ is carried by the nitrogen gas (flow rate of 140 mL $min^{-1}$) to the coulometer through a dehydrating module consists of two electronic dehumidifiers (kept at 2 ˚C) and a chemical desiccant ($Mg(ClO_4)_2$).

Measurements of 1.5% $CO_2$ standard gas in a nitrogen base, system blank (phosphoric acid blank) and seawater samples (6 samples) were programmed to repeat. The variation of our own made JAMSTEC DIC reference material or 1.5% $CO_2$ standard gas signal was used to correct the signal drift results from chemical alternation of coulometer solution.

(5) Observation log

The sampling stations for DIC were shown in Figure 4.3-1.

(6) Preliminary results

During the cruise, 1823 samples were analyzed for DIC. A few replicate samples were taken at most of the stations and difference between each pair of analyses was plotted on a range control chart (Figure 4.3-2). The average of the differences was 1.01 μmol $kg^{-1}$ (n = 315), and the standard deviation was 1.07 μmol $kg^{-1}$ (n = 315), which indicates the analysis was accurate enough according to the Guide to the best practices

for ocean $CO_2$ measurements (Dickson et al., 2007).

(7) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC web site.

(8) References

Dickson, A. G., Sabine, C. L.., Christian J. R. (2007) Guide to the best practices for ocean $CO_2$ measurements; PICES Special Publication 3, 199pp

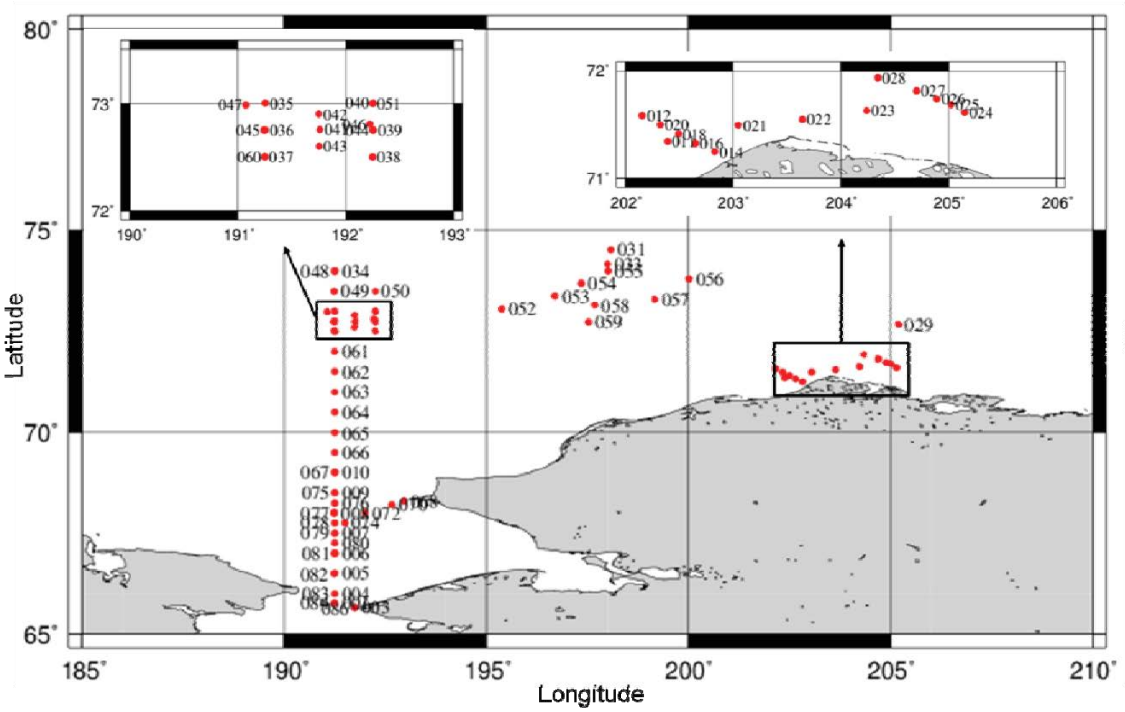



**Figure 4.3-1.** DIC sampling stations.

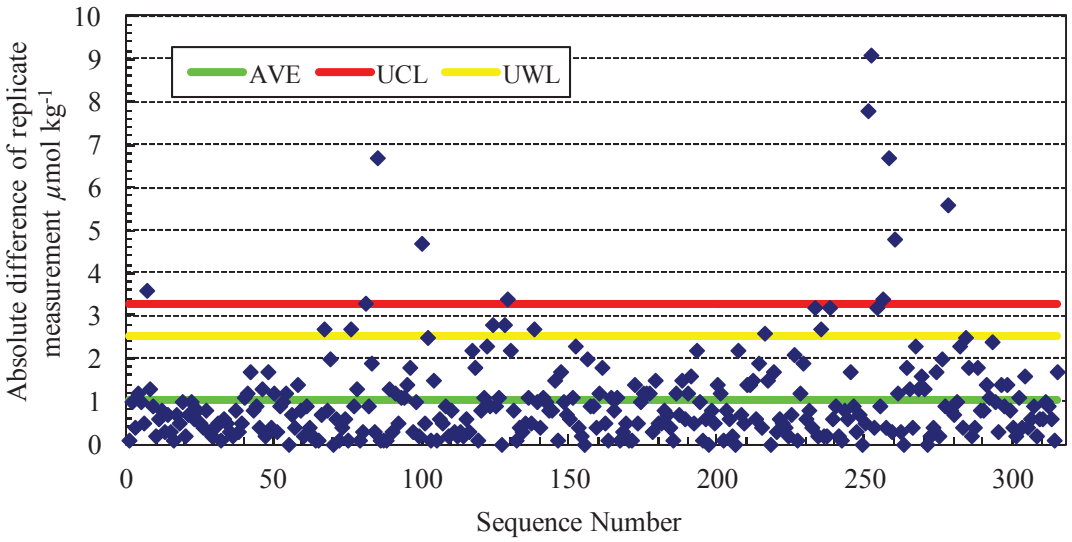



**Figure 4.3-2.** Range control chart of the absolute differences of replicate measurements carried out in the analysis of DIC during the MR13-06.

## 4.4. Total Alkalinity

(1) Personnel

Shigeto Nishino (JAMSTEC): Principal Investigator
Tomonori Watai (MWJ): Operation Leader
Emi Deguchi (MWJ)

(2) Objective

As described in the Section 4.3. (DIC), total Alkalinity (TA) is an essential parameter in carbonate system in the ocean. We have measured TA during the MR13-06 cruise to estimate pH, calcium carbonate saturation state and $pCO_2$. Furthermore, TA is a useful tracer for river water in the Arctic Ocean: TA is high in river runoff (especially in North American rivers) and low in sea ice meltwater. Because river water carries freshwater, carbon, nutrients, contaminants etc., changes in distribution of river water in the Arctic Ocean may affect regional and global climate, productivity and human health. Distribution of river water in the Chukchi Sea/Canada Basin region during the MR13-06 cruise will be estimated from TA and results will be compared with those observed in previous years.

(3) Parameters

Total Alkalinity, TA

(4) Instruments and Methods

(4)-1 Seawater sampling

Seawater samples were collected at 75 stations / 150 casts in 12 L Niskin bottles mounted on the CTD-rosette system. A sampling silicone rubber with PFA tip was connected to the Niskin bottle when the sampling was carried out. The 125 ml borosilicate glass bottles (SHOTT DURAN) were filled from the bottom smoothly, without rinsing, and were overflowed for 2 times bottle volume (10 seconds) with care not to leave any bubbles in the bottle. These bottles were pre-washed by soaking in 5 % non-phosphoric acid detergent (pH = 13) for more than 3 hours and then rinsed 5 times with tap water and 3 times with Milli-Q deionized water. After collecting the samples on the deck, the bottles were carried into the lab and put in the water bath kept about 25° C for one hour before the measurement.

(4)-2 Seawater analysis

Measurement of alkalinity was made using a spectrophotometric system (Nippon ANS, Inc.) using a scheme of Yao and Byrne (1998). The sampled seawater in the glass bottle is transferred to a sample cell in the spectrophotometer (Carry 50 Scan, Varian) via dispensing unit. The length and volume of the cell are 8 cm and 13 mL, respectively, and its temperature is kept at 25° C in a thermostated compartment. The TA is calculated by measuring two sets of absorbance at three wavelengths (750, 616 and 444 nm). One is the absorbance of seawater sample before injecting an acid with indicator solution (bromocresol green) and another is the one after the injection. For mixing the acid with indicator solution and the seawater sufficiently, they are circulated through the line by a peristaltic pump 8 and half minutes before the measurement.

The TA is calculated based on the following equation:

$$pH_T = 4.2699 + 0.002578 \times (35 - S) + \log((R(25) - 0.00131) / (2.3148 - 0.1299 \times R(25))) - \log(1 - 0.001005 \times S), \quad (1)$$

$$A_T = (N_A \times V_A - 10^{-pH_T} \times DensSW(T, S) \times (V_S + V_A)) \times (DensSW(T, S) \times V_S)^{-1}, \quad (2)$$

where R(25) represents the difference of absorbance at 616 and 444 nm between before and after the injection. The absorbance of wavelength at 750 nm is used to subtract the variation of absorbance caused by the system. DensSW (T, S) is the density of seawater at temperature (T) and salinity (S), $N_A$ the concentration of the added acid, $V_A$ and $V_S$ the volume of added acid and seawater, respectively.

To keep the high analysis precision, some treatments were carried out during the cruise. The acid with indicator solution stored in 1 L DURAN bottle is kept in a bath with its temperature of 25° C, and about 10 mL of it is discarded at first before the batch of measurement. Furthermore, we injected the acid so that $pH_T$ of a sample might become the range of 3.6 to 4.6 values. For mixing the seawater and the acid with indicator solution sufficiently, TYGON tube used on the peristaltic pump was periodically renewed. Absorbance measurements were done 10 times during each analysis, and the stable last five and three values are averaged and used for above listed calculation for before and after the injection, respectively.

(5) Station list or Observation log

Seawater samples were collected at 75 stations / 150 casts (Figure 4.4-1).

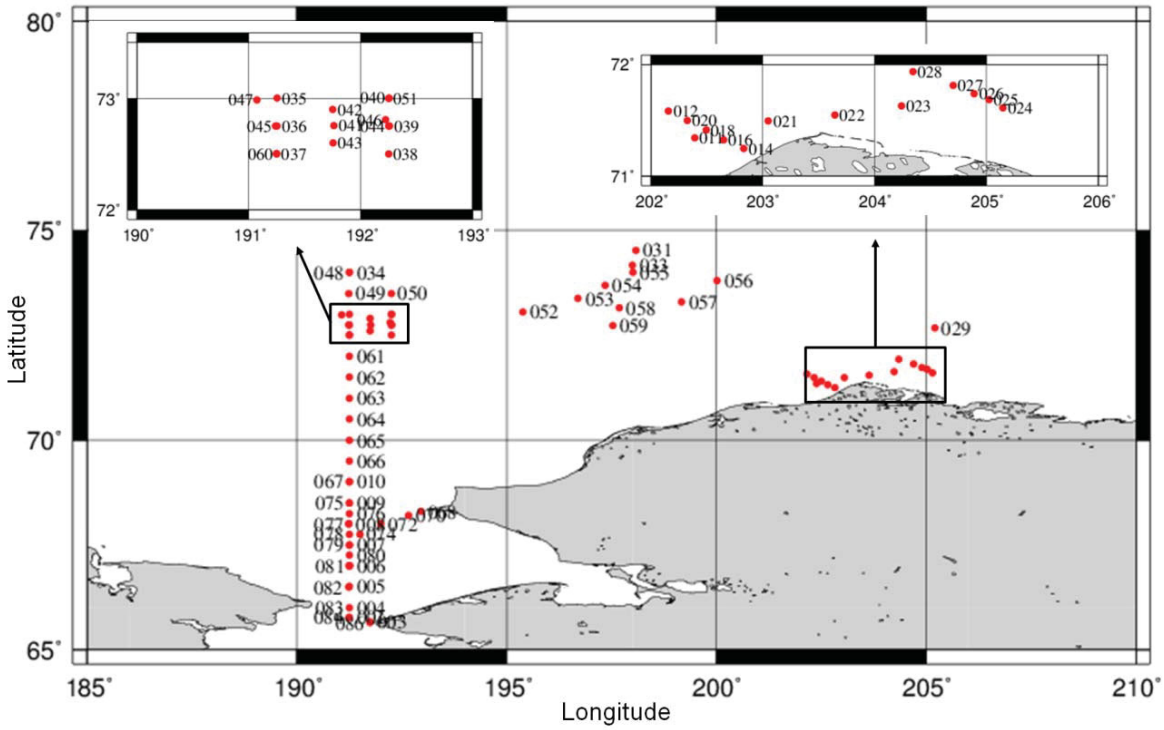



**Figure 4.4-1.** Map of sampling station.

(6) Preliminary results

At each station, samples were taken in duplicate for waters of the following table 4.4-1. The difference between each pair of analyses was plotted on a range control chart (Figure 4.4-2). The average of the difference was 0.88 $\mu$mol kg$^{-1}$ (n = 299 pair) with its standard deviation of 0.80 $\mu$mol kg$^{-1}$, which indicates that the analysis was accurate enough according to Guide to best practices for ocean $CO_2$ measurements (Dickson et al., 2007).

**Table 4.4-1.** The layer taken in duplicate for waters

| Bottom depth | Duplicate layer |
|---|---|
| < 100 m | 10 m, Bottom |
| 100 - 400 m | 50 m, 100 m, Bottom |
| > 400 m | 100 m, 400 m, Bottom |

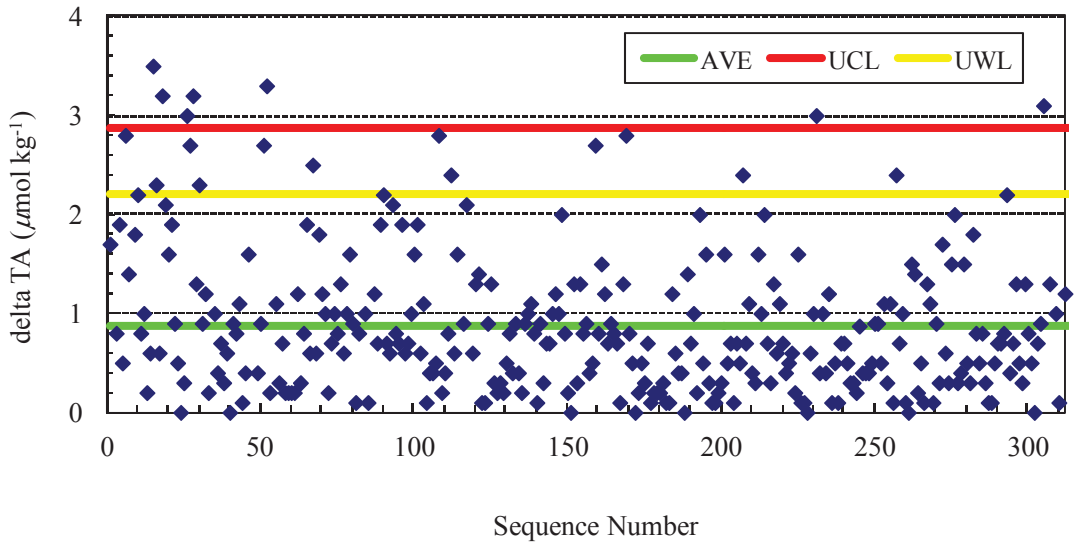



**Figure 4.4-2.** Range control chart of the absolute differences of duplicate measurements of TA carried out during this cruise.

(7) Data Archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC web site.

(8) References

Yao, W. and Byrne, R. H. (1998), Simplified seawater alkalinity analysis: Use of linear array spectrometers. *Deep-Sea Research Part I, Vol. 45,* 1383-1392.

Dickson, A. G., Sabine, C. L. & Christian, J. R. (2007), Guide to best practices for ocean CO2 measurements; PICES Special Publication 3, 199

## 4.5. Chlorophyll *a* Measurements of Total and Size-fractionated Phytoplankton

(1) Personnel

Shigeto Nishino (JAMSTEC): Principal Investigator (PI)
Amane Fujiwara (National Institute of Polar Research)
Ryosuke Futuki (School of Fisheries Sciences, Hokkaido University)
Hideki Yamamoto (MWJ)
Misato Kuwahara (MWJ)

(2) Objective

Phytoplankton distributes in various species and sizes in the ocean were examined. Phytoplankton species are roughly characterized by the cell size. The object of this study is to investigate the vertical and horizontal distributions of phytoplankton in the Arctic Ocean by using the size-fractionated filtration method.

(3) Parameters

Total chlorophyll *a*
Size-fractionated chlorophyll *a*

(4) Instruments and methods

We collected samples for chlorophyll *a* (chl-*a*) from 12 depths between the surface and 200 m depth including a chl-*a* maxmum layer at routine casts. The chl-*a* maximum layer was determined by a fluorometer (Seapoint Sensors, Inc.) attached to the CTD system.

At the casts where the primary productivity measurements were conducted, we collected samples (0.25L) for total chl-*a* from 12 depths and size-fractionated chl-*a* from two depths, which correspond to the surface and a chl-*a* maximum layer, within the euphotic layer and the layer below down to 200 m. The euphotic layer was determined by a downward irradiance sensor for the experiments of primary productivity, and the sampling depths were determined as light intensities of 38, 13, 7, 4, 1 and 0.6% for the surface incident irradiance.

Water samples for total chl-*a* were vacuum-filtrated (<0.02MPa) through 25mm-diameter Whatman GF/F filter. Water samples for size-fractionated chl-*a* were sequentially vacuum-filtrated (<0.02MPa) through the four types of 47mm-diameter Nylone filters (pore size of 20.0μm) , 47mm-diameter nuclepore filters (pore size of

10μm and 2.0μm) and the 25mm-diameter Whatman GF/F filter. Phytoplankton pigments retained on the filters were immediately extracted in a polypropylene tube with 7 ml of N,N-dimethylformamide. The tubes were stored at –20°C under the dark condition to extract chl-*a* for 24 hours or more.

Fluorescences of each sample were measured by Turner Design fluorometer (10-AU-005), which was calibrated against a pure chl-*a* (Sigma chemical Co.). We applied fluorometric determination for the samples of chl-*a*: "Non-acidification method" (Welschmeyer, 1994). Analytical conditions of this method were listed in Table 4.5-1.

(5) Results

Samples for total and size-fractionated chl-*a* were collected at 144 and 43 stations, respectively (see Figure 4.5-1). The numbers of samples for total and size-fractionated chl-*a* were 1407 and 502, respectively.

(6) Data archive

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC web site.

(7) Reference

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

**Table 4.5-1.** Analytical conditions of non-acidification method for chlorophyll *a* with Turner Design fluorometer (10-AU-005)

| | Non-acidification method |
|---|---|
| Excitation filter (nm) | 436 |
| Emission filter (nm) | 680 |
| Lamp | Blue F4T5,B2/BP |

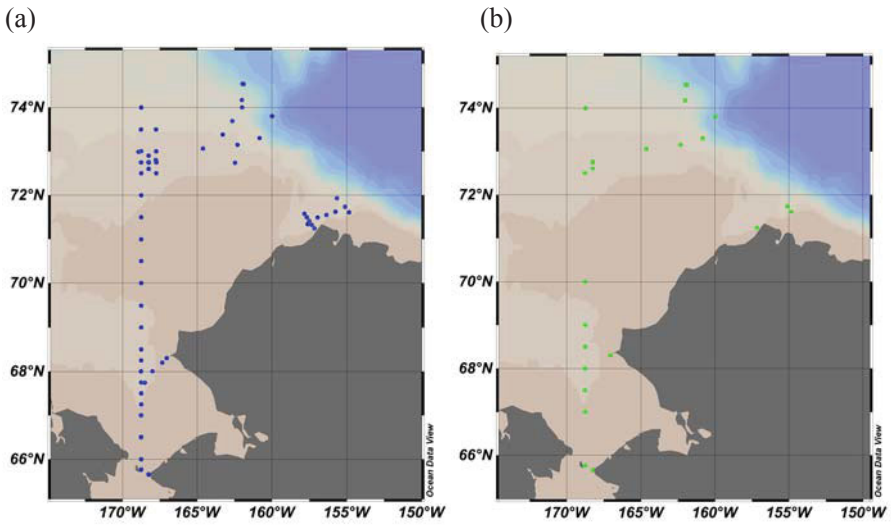



**Figure 4.5-1.** Maps of stations for (a) total and (b) size-fractionated chlorophyll *a* measurements.

## 4.6. Primary Production

(1) Personnel

Shigeto Nishino (JAMSTEC): Principal Investigator
Toru Hirawake (Hokkaido University)
Amane Fujiwara (National Institute of Polar Research /Hokkaido University)
Ryosuke Futuki (Hokkaido University)
Kanako Yoshida (MWJ): Operation Leader
Keitaro Matsumoto (MWJ)

(2) Objective

Primary production was measured to estimate underwater photosynthesis by phytoplankton in the Arctic Ocean.

(3) Parameter

Primary production

(4) Instruments and methods

a. Instruments

Stable isotope analyzer

ANCA-SL by Europa Scientific Ltd.; now SerCon Ltd.

Software

ANCA Ver.3.6

b. Methods

Primary production was measured at 10 stations (Sts. 001, 008, 024, 034, 041, 052, 057, 060, 077 and 084) by simulated in situ incubation method (see Figure 4.6-1 and Table 4.6-1). We sampled seawater using shading and acid-treatment bottles and tubes connected to the Niskin bottles, which are derived from 7 optical depths, 100%, 38%, 14%, 7%, 4%, 1% and 0.6% of surface irradiance.

After sampling, the seawater was dispensed into 1L Nalgene polycarbonate bottles for incubation in a dark room. The Nalgene bottles were used after acid treatment. These seawater samples were inoculated with labeled carbon substrate ($NaH^{13}CO_3$) for the measurements of primary production. The concentration of labeled carbon ($NaH^{13}CO_3$) was 200 μM that was ca. 10 % enrichment to the total inorganic carbon in the ambient water. The bottles were placed into incubators with neutral density filters

corresponding to light levels at the seawater sampling depths. Incubations using dark bottles were also conducted at each light level.

Samples for the measurements of primary production were incubated in a bath on the deck for 24 hours. At the end of the incubation period, samples were filtered through glass fiber filters (Whatman GF/F 25mm, pre-combusted under 450 degC over 4 hours). The filters were kept to freeze -20 degC until measurements. Before the measurements, the filters were oven-dried at 45 degC for at least 20 hours and treated with hydrochloric acid to remove the inorganic carbon. The measurements were performed on board the ship using a stable isotope analyzer (ANCA-SL, Europa Scientific Ltd.; now SerCon Ltd.).

(5) Station list

Table 4.6-1 shows a station list including optical depths, incubation times, and measured parameters with or without zero time (natural abundance) measurements.

(6) Data archive

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via “Data Research for Whole Cruise Information in JAMSTEC” in JAMSTEC web site.

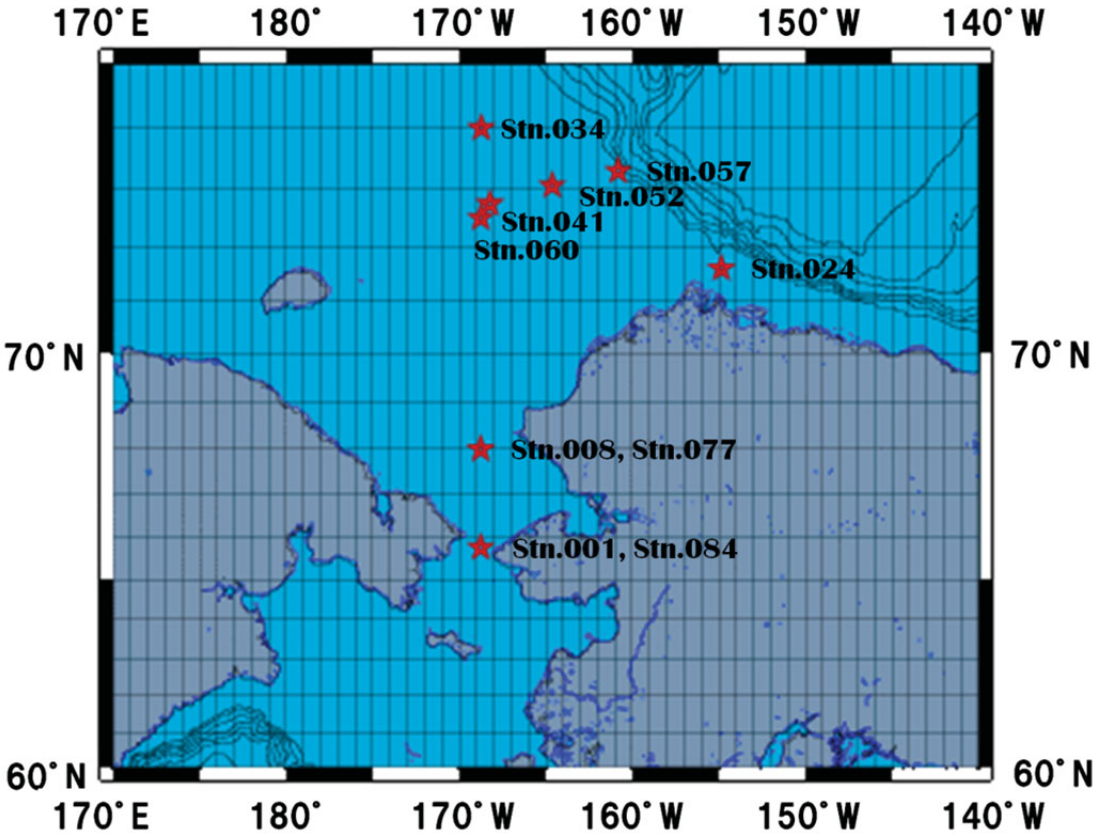



**Figure 4.6-1.** Map of stations with station numbers for the measurements of primary production (red stars).

**Table 4.6-1.** List of stations, optical depths, incubation times, and measured parameters with or without zero time (natural abundance) measurements

| Stations | Optical depths (%) | Incubation time (hrs) | Primary Production |
|---|---|---|---|
| 001Cast.1 | 0.6, 1, 4, 7, 13, 38, 100 | 24 | x&0 |
| 008Cast.1 | 0.6, 1, 4, 7, 13, 38, 100 | 24 | x&0 |
| 024Cast.1 | 0.6, 1, 4, 7, 13, 38, 100 | 24 | x&0 |
| 034Cast.1 | 0.6, 1, 4, 7, 13, 38, 100 | 24 | x&0 |
| 041Cast.1 | 1, 4, 7, 13, 38, 100 | 24 | x&0 |
| 041Cast.9 | 0.6, 1, 4, 7, 13, 38, 100 | 24 | x |
| 041Cast.17 | 0.6, 1, 4, 7, 13, 38, 100 | 24 | x |
| 041Cast.25 | 0.6, 1, 4, 7, 13, 38, 100 | 24 | x |
| 041Cast.33 | 0.6, 1, 4, 7, 13, 38, 100 | 24 | x |
| 041Cast.41 | 0.6, 1, 4, 7, 13, 38, 100 | 24 | x |
| 041Cast.49 | 0.6, 1, 4, 7, 13, 38, 100 | 24 | x |
| 041Cast.57 | 0.6, 1, 4, 7, 13, 38, 100 | 24 | x |
| 052 Cast.1 | 0.6, 1, 4, 7, 13, 38, 100 | 24 | x&0 |
| 057 Cast.1 | 0.6, 1, 4, 7, 13, 38, 100 | 24 | x&0 |
| 041Cast.62 | 0.6, 1, 4, 7, 13, 38, 100 | 24 | x |
| 060 Cast.1 | 0.6, 1, 4, 7, 13, 38, 100 | 24 | x |
| 077 Cast.1 | 0.6, 1, 4, 7, 13, 38, 100 | 24 | x&0 |
| 084 Cast.1 | 0.6, 1, 4, 7, 13, 38, 100 | 24 | x&0 |

x: measurements without zero time

x&0: measurements with zero time

## 4.7. Bio-optical Observations

(1) Personnel

Toru Hirawake (Faculty of Fisheries Sciences, Hokkaido University; not onboard): PI
Amane Fujiwara (National Institute of Polar Research)
Ryosuke Futuki (School of Fisheries Sciences, Hokkaido University)

(2) Objectives

A) To carry out validation of optical algorithms to derive inherent optical properties, pigments concentration, size structure and primary productivity.
B) To estimate effect of phytoplankton productivity at subsurface chlorophyll maximum on satellite derived primary productivity.
C) To investigate differences of grazing properties between mesozooplankton species from the Pacific and Arctic Ocean.
D) To investigate phytoplankton community structure

(3) Parameters

A) Underwater spectral irradiance and radiance (PRR-800/810)
B) Incident photosynthetic available radiation (PAR)
C) Light absorption coefficients of particles and colored dissolved organic materials (CDOM)
D) Phytoplankton pigments (HPLC)
E) Grazing experiment
F) Daily net primary productivity of phytoplankton (NPP) (*see description of '4.6 Primary production' by Nishino (JAMSTEC) et al. in this report*)
G) Bulk and size fractionated chlorophyll *a* concentration (*see description of '4.5 Chlorophyll a' by Nishino (JAMSTEC) et al. in this report*)

(4) Instruments and Methods

Sampling stations for each measurement and experiment are shown in Table 4.7-1.

A) Underwater spectral irradiance and radiance (PRR-800/810)

Underwater spectral downwelling irradiance $E_d(\lambda, z)$ (μW cm$^{-2}$ nm$^{-1}$) and upwelling radiance $L_u(\lambda, z)$ (μW cm$^{-2}$ nm$^{-1}$ str$^{-1}$) at 17 wavelengths over 380-765 nm were measured with a spectroradiometer, PRR-800 (Biospherical Instrument Inc.). The PRR-800 was deployed in free-fall mode up to 80-120 m deep distancing from the stern of ship to avoid her shadow. Incident downwelling irradiance to sea surface $E_d(\lambda, 0+)$ (μW cm$^{-2}$ nm$^{-1}$) was monitored by reference spectroradiometer, PRR-810 (Biospherical Instrument Inc.) with same specification as the underwater sensor. Before each deployment of the instrument, 10 minutes averaged dark values were recorded. For NPP measurements, underwater photosynthetic available radiation (PAR), $E_q(z)$, was also calculated by converting the $E_d(\lambda, z)$ to quantum unit, $E_q(\lambda, z)$ (μmol photons m$^{-2}$ s$^{-1}$), and integrating the $E_q(\lambda, z)$ from 412 to 710 nm.

B) Incident photosynthetically available radiation (PAR)

Incident PAR, $E_q$ (0+), was monitored with a LI-190SB air quantum sensor. Mean value for five minutes was recorded to a LI-1400 data logger (LI. COR Inc.) during the cruise.

C) Light absorption coefficients of particles and colored dissolved organic materials (CDOM)

Seawater samples for absorption coefficients measurement were collected from the sea surface and depths corresponding to 13% of incident PAR and subsurface chlorophyll maximum using Niskin-X bottles on a CTD/Carousel Multi Sampler (Sea-Bird Electronics Inc.).

For measurements of spectral absorption coefficient of particles, particles in 1-4 liter(s) of water sample were concentrated on a glass fiber filter (Whatman GF/F, 25 mm). Optical density (*OD*) of particles on the filter pad was measured with a spectrophotometer, UV-2400 (Shimadzu) equipped an end-on type detector, and absorption coefficient of particles ($a_p(\lambda, z)$) was determined from the *OD* according to the Quantitative Filter Technique (QFT) (Mitchell, 1990). The filter was then soaked in methanol to extract and remove the pigments (Kishino *et al.*, 1985) and absorption coefficient of detritus ($a_d(\lambda, z)$) was quantified again. Absorption coefficient of phytoplankton, $a_{ph}(\lambda, z)$, was determined subscribing $a_d(\lambda, z)$ from $a_p(\lambda, z)$.

For measurements of spectral absorption coefficient of CDOM ($a_{CDOM}(\lambda, z)$), 250 ml of water sample was filtrated through a 0.2 μm Nuclepore filter (Whatman, 47 mm). *OD* of the filtrated water against pure water (Milli-Q) was measured with 10 cm cylindrical quartz cell and spectrophotometer, UV-2400 (Shimadzu), and calculated $a_{CDOM}(\lambda, z)$.

D) Phytoplankton pigments (HPLC)

Seawater samples for phytoplankton pigments were collected from the sea surface and depths corresponding to 13% of incident PAR and subsurface chlorophyll maximum using Niskin-X bottles on a CTD/Carousel Multi Sampler (Sea-Bird Electronics Inc.).

Phytoplankton in 2 liters of water sample were concentrated on a glass fiber filter (Whatman GF/F, 25 mm) and stored in liquid $N_2$. Pigments concentration will be determined with a high performance liquid chromatography (HPLC) according to a method of Van Heukelem and Thomas (2001) at a laboratory after the cruise.

E) Grazing experiment (Incubation)

Seawater sample for grazing experiment was collected from the depth of subsurface chlorophyll maximum using Niskin-X bottles on a CTD/Carousel Multi Sampler (Sea-Bird Electronics Inc.). Copepods sample was collected with 80 cm ring net.

Seawater sample was transferred into 2500 ml clear polycarbonate bottles. Copepods sample was sorted and several species of copepod from the Arctic and Pacific were isolated and put into the seawater sample separately. The samples were covered by black plastic bag and incubated in a water bath for 24 hours. Temperature in the water bath was maintained with running water from the sea surface.

Total and size fractionated chlorophyll *a* concentrations of water samples before and after the incubation were measured. Filtering rate of each species will be calculated from the chlorophyll *a* concentrations.

F) Daily net primary productivity of phytoplankton (NPP)

Net primary productivity of phytoplankton was determined using the stable $^{13}C$ isotope method (Hama *et al.*, 1983). The details were described in the section '4.9 Primary production' in this report by Yoshida (MWJ) et al.

G) Bulk and size fractionated chlorophyll a concentration

Bulk and size fractionated chlorophyll *a* concentration was measured fluorometrically. The details were described in the section '4.8 Chlorophyll *a*' in this report by Nishino (JAMSTEC) et al.

(5) Data archive

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC web site.

**Table 4.7-1.** Sampling summary

| Stn ID | Cast | Stn type | Lat. | Lon. | Date (UTC) | Time (UTC) | Weather* | Depth(m) | SST(℃) | samples collected | | | | | | | operation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | total chla | size chla | CDOM | QFT | PP | HPLC | incubation | PRR800 |
| 1 | 1 | Vertical | 65.7697 | -168.752 | 08/31/2013 | 19:51 | b | 54 | 6.95 | X | X | X | X | X | X | X | X |
| 3 | 1 | Surface | 65.6573 | -168.253 | 08/31/2013 | 22:58 | b | 43 | 11.12 | X | X | X | X | | X | | X |
| 8 | 1 | Vertical | 68.0042 | -168.764 | 09/01/2013 | 18:48 | b | 58 | 5.30 | X | X | X | X | X | X | X | X |
| 9 | 1 | Surface | 68.5033 | -168.746 | 09/01/2013 | 22:17 | b | 53 | 7.98 | X | X | X | X | | X | | X |
| 14 | 1 | Vertical | 71.2452 | -157.171 | 09/04/2013 | 0:29 | s | 46 | 2.47 | X | X | X | X | | X | | X |
| 18 | 1 | Surface | 71.4112 | -157.508 | 09/04/2013 | 6:50 | - | 122 | 2.40 | | | | | | | X | |
| 24 | 1 | Vertical | 71.6087 | -154.852 | 09/04/2013 | 19:21 | o | 44 | 2.74 | X | X | X | X | X | X | | X |
| 26 | 1 | Surface | 71.7365 | -155.1100 | 09/04/2013 | 22:51 | o | 257 | 3.13 | X | X | X | X | | X | | X |
| 32 | 1 | Surface | 74.5373 | -161.9670 | 09/09/2013 | 2:27 | s | 1685 | 0.49 | X | X | X | X | | X | | X |
| 34 | 1 | Vertical | 73.9972 | -168.742 | 09/09/2013 | 21:39 | o | 178 | 0.01 | X | X | X | X | X | X | | X |
| 41 | 1 | Vertical | 72.7532 | -168.2413 | 09/10/2013 | 21:13 | o | 56 | 3.20 | X | X | X | X | X | X | | X |
| 41 | 5 | Vertical | 72.7505 | -168.2507 | 09/11/2013 | 20:42 | o | 56 | 3.19 | X | X | X | X | | X | | X |
| 41 | 9 | Vertical | 72.7498 | -168.2612 | 09/12/2013 | 20:41 | o | 56 | 3.22 | X | X | X | X | X | X | | X |
| 41 | 13 | Vertical | 72.7513 | -168.2532 | 09/13/2013 | 20:42 | o | 56 | 3.22 | X | X | X | X | | X | | X |
| 41 | 17 | Vertical | 72.7482 | -168.2457 | 09/14/2013 | 20:44 | s | 56 | 2.78 | X | X | X | X | X | X | | X |
| 41 | 21 | Vertical | 72.7512 | -168.2542 | 09/15/2013 | 20:42 | 0 | 56 | 2.56 | X | X | X | X | | X | | X |
| 41 | 25 | Vertical | 72.7515 | -168.2533 | 09/16/2013 | 20:42 | s | 56 | 2.60 | X | X | X | X | X | X | | X |
| 41 | 29 | Vertical | 72.7495 | -168.2487 | 09/17/2013 | 20:41 | o | 56 | 2.78 | X | X | X | X | | X | | X |
| 41 | 33 | Vertical | 72.7487 | -168.2503 | 09/18/2013 | 20:41 | o | 56 | 2.50 | X | X | X | X | X | X | | X |
| 41 | 37 | Vertical | 72.7480 | -168.2522 | 09/19/2013 | 20:43 | o | 56 | 2.38 | X | X | X | X | | X | | X |
| 41 | 41 | Vertical | 72.7488 | -168.2408 | 09/20/2013 | 20:45 | o | 56 | 2.00 | X | X | X | X | X | X | | X |
| 41 | 45 | Vertical | 72.7498 | -168.2512 | 09/21/2013 | 20:41 | o | 56 | 1.71 | X | X | X | X | | X | | X |
| 41 | 49 | Vertical | 72.7498 | -168.2492 | 09/22/2013 | 20:42 | o | 56 | 1.51 | X | X | X | X | X | X | | X |
| 41 | 53 | Vertical | 72.7488 | -168.2472 | 09/23/2013 | 20:41 | o | 56 | 1.73 | X | X | X | X | | X | | X |
| 41 | 57 | Vertical | 72.7505 | -168.2493 | 09/24/2013 | 20:42 | bc | 56 | 1.58 | X | X | X | X | X | X | | X |
| 41 | 59 | incubation | 72.7548 | -168.2487 | 09/25/2013 | 8:48 | - | 56 | 1.95 | | | | | | | X | |
| 41 | 61 | Vertical | 72.7518 | -168.2480 | 09/25/2013 | 20:41 | c | 56 | 2.00 | X | X | X | X | | X | | X |
| 52 | 1 | Vertical | 73.0625 | -164.6190 | 09/26/2013 | 22:03 | bc | 84 | -0.59 | X | X | X | X | X | X | | X |
| 57 | 1 | Vertical | 73.3033 | -160.8337 | 09/27/2013 | 22:32 | bc | 410 | 0.71 | X | X | X | X | X | X | | X |
| 58 | 1 | Vertical | 73.1498 | -162.3122 | 09/28/2013 | 2:13 | bc | 200 | 0.90 | X | X | X | X | | X | | X |
| 41 | 62 | Vertical | 72.7518 | -168.2570 | 09/30/2013 | 21:00 | o | 56 | 0.42 | X | X | X | X | X | X | | X |
| 41 | 64 | incubation | 72.7497 | -168.2518 | 10/01/2013 | 8:43 | - | 56 | 1.00 | | | | | | | X | |
| 60 | 1 | Vertical | 72.5028 | -168.7508 | 10/01/2013 | 19:31 | bc | 58 | 1.25 | X | X | X | X | X | X | | X |
| 68 | 1 | Vertical | 68.3013 | -167.0458 | 10/02/2013 | 22:56 | o | 38 | 4.51 | X | X | X | X | | X | | X |
| 77 | 1 | Vertical | 68.0008 | -168.7562 | 10/03/2013 | 20:31 | o | 58 | 2.16 | X | X | X | X | X | X | X | X |
| 84 | 1 | Vertical | 65.7633 | -168.7573 | 10/04/2013 | 18:23 | c | 52 | 1.69 | X | X | X | X | X | X | | X |

## 4.8. Microbes and DOC/N

(1) Personnel

Toshi Nagata (Atmosphere and Ocean Research Institute, Univ. of Tokyo; not onboard): PI
Mario Uchimiya (National Institute of Polar Research)
Chiaki Motegi (Université Laval)

(2) Objective

To clarify the spatial variations in and regulation of microbes and dissolved organic matter in the Chukchi Sea, western Arctic.

(3) Parameters

i) Microbes

a) Prokaryote abundance
b) Heterotrophic prokaryote production
c) Prokaryote and viral community composition

ii) Dissolved organic matter

d) Dissolved organic carbon and nitrogen (DOC/N)

(4) Methods and Instruments

i) Microbes

a) Prokaryote abundance

2 mL of seawater sample was fixed by glutaraldehyde (final concentration of 1%), frozen in liquid nitrogen, and then stored in a deep freezer (-80°C). Prokaryote abundance will be determined by flow cytometry in a land laboratory.

b) Heterotrophic prokaryote production

1.5 mL of seawater sample was amended with $^{3}$H-leucine (final concentration of 10 nM) and incubated for 2–24 h in the dark at *in situ* temperature. After the incubation, the sample was centrifuged and precipitates were extracted. The radioactivity will be determined using a liquid scintillation counter in a land laboratory.

c) Prokaryote and viral community composition

6–9 L of seawater sample was filtered through a 3 µm polycarbonate filter and then through a 0.22 µm Sterivex filter. Filters were kept in a freezer (-20°C). Prokaryotes community composition will be determined by 454 Pyrosequence in a land laboratory. For viral community, 3–5 L of filtrate (<0.22 µm) was concentrated with 100 kDa cartridge (final volume 30 mL, Vivaflow200). Viral community composition

will be determined by 454 Pyrosequence in a land laboratory.

ii) Dissolved organic matter

e) DOC/N

Seawater sample was filtered through a pre-combusted GF/F filter and the filtrate was collected in a glass bottle. The aliquot was transferred to glass ampoules and stored in a freezer (-20°C). The concentration of DOC and total dissolved nitrogen (TDN) will be determined by high temperature catalytic oxidation method in a land laboratory. The concentration of DON will be calculated by subtracting the concentration of dissolved inorganic nitrogen from that of TDN.

(5) Observation log

Information about sample and data collection is summarized in Table 4.8-1.

(6) Data archive

All the data obtained during MR13-06 cruise will be submitted to the Data Management Group (DMG) of JAMSTEC after the sample analysis and validation.

**Table 4.8-1.** Observation log. Sta.#, station number; FCM, flow cytometry for prokaryote abundance; HPP, heterotrophic prokaryote production; CC, community composition of prokaryote and virus; DOC/N, dissolved organic carbon and nitrogen. For each parameter, the information is indicated by "1" when the sample (or data) collection was conducted, whereas indicated by "-" when not conducted.

| Sta. # | Cast # | Date | FCM | ProkP | CC | DOC/N |
|---|---|---|---|---|---|---|
| 1 | 1 | 2013.8.31 | 1 | 1 | 1 | 1 |
| 3 | 1 | 2013.8.31 | 1 | 1 | 1 | 1 |
| 8 | 1 | 2013.9.1 | 1 | 1 | 1 | 1 |
| 9 | 1 | 2013.9.1 | 1 | 1 | | 1 |
| 26 | 1 | 2013.9.4 | 1 | 1 | 1 | 1 |
| 31 | 1 | 2013.9.7 | 1 | 1 | 1 | 1 |
| 34 | 1 | 2013.9.9 | 1 | 1 | 1 | 1 |
| 35 | 1 | 2013.9.9 | 1 | 1 | 1 | 1 |
| 37 | 1 | 2013.9.10 | 1 | 1 | 1 | 1 |
| 41 | 1 | 2013.9.10 | 1 | 1 | | 1 |
| 41 | 5 | 2013.9.11 | 1 | 1 | | 1 |
| 41 | 9 | 2013.9.12 | 1 | 1 | | 1 |
| 41 | 13 | 2013.9.13 | 1 | 1 | 1 | 1 |
| 41 | 15 | 2013.9.14 | 1 | 1 | | |
| 41 | 17 | 2013.9.14 | 1 | 1 | 1 | 1 |
| 41 | 19 | 2013.9.14 | 1 | 1 | | |
| 41 | 21 | 2013.9.15 | 1 | 1 | | 1 |
| 41 | 23 | 2013.9.16 | 1 | 1 | | |
| 41 | 25 | 2013.9.16 | 1 | 1 | 1 | 1 |
| 41 | 26 | 2013.9.17 | 1 | 1 | | |
| 41 | 27 | 2013.9.17 | 1 | 1 | | |
| 41 | 28 | 2013.9.17 | 1 | 1 | | |
| 41 | 29 | 2013.9.17 | 1 | 1 | | 1 |
| 41 | 30 | 2013.9.18 | 1 | 1 | | |
| 41 | 31 | 2013.9.18 | 1 | 1 | | |
| 41 | 32 | 2013.9.18 | 1 | 1 | | |
| 41 | 33 | 2013.9.18 | 1 | 1 | 1 | 1 |
| 41 | 34 | 2013.9.19 | 1 | 1 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 41 | 35 | 2013.9.19 | 1 | 1 | | |
| 41 | 36 | 2013.9.19 | 1 | 1 | | |
| 41 | 37 | 2013.9.19 | 1 | 1 | | 1 |
| 41 | 38 | 2013.9.20 | 1 | 1 | | |
| 41 | 39 | 2013.9.20 | 1 | 1 | | |
| 41 | 40 | 2013.9.20 | 1 | 1 | | |
| 41 | 41 | 2013.9.20 | 1 | 1 | 1 | 1 |
| 41 | 42 | 2013.9.21 | 1 | 1 | | |
| 41 | 43 | 2013.9.21 | 1 | 1 | | |
| 41 | 44 | 2013.9.21 | 1 | 1 | | |
| 41 | 45 | 2013.9.21 | 1 | 1 | | 1 |
| 41 | 46 | 2013.9.22 | 1 | 1 | | |
| 41 | 47 | 2013.9.22 | 1 | 1 | | |
| 41 | 48 | 2013.9.22 | 1 | 1 | | |
| 41 | 49 | 2013.9.22 | 1 | 1 | 1 | 1 |
| 41 | 50 | 2013.9.23 | 1 | 1 | | |
| 41 | 51 | 2013.9.23 | 1 | 1 | | |
| 41 | 52 | 2013.9.23 | 1 | 1 | | |
| 41 | 53 | 2013.9.23 | 1 | 1 | | 1 |
| 41 | 54 | 2013.9.24 | 1 | 1 | | |
| 41 | 55 | 2013.9.24 | 1 | 1 | | |
| 41 | 56 | 2013.9.24 | 1 | 1 | | |
| 41 | 57 | 2013.9.24 | 1 | 1 | 1 | 1 |
| 41 | 58 | 2013.9.25 | 1 | 1 | | |
| 41 | 59 | 2013.9.25 | 1 | 1 | | |
| 46 | 1 | 2013.9.25 | 1 | 1 | 1 | 1 |
| 47 | 1 | 2013.9.26 | 1 | 1 | 1 | 1 |
| 48 | 1 | 2013.9.26 | 1 | | 1 | |
| 52 | 1 | 2013.9.26 | 1 | 1 | 1 | 1 |
| 56 | 1 | 2013.9.27 | 1 | 1 | 1 | 1 |
| 58 | 1 | 2013.9.28 | 1 | 1 | 1 | 1 |
| 41 | 62 | 2013.9.30 | 1 | 1 | | 1 |
| 41 | 63 | 2013.10.1 | 1 | 1 | | |
| 41 | 64 | 2013.10.1 | 1 | 1 | | |
| 41 | 65 | 2013.10.1 | 1 | 1 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 61 | | 2013.10.1 | 1 | 1 | 1 | 1 |
| 65 | | 2013.10.2 | 1 | 1 | 1 | 1 |
| 77 | | 2013.10.3 | 1 | 1 | 1 | 1 |
| 84 | | 2013.10.4 | 1 | 1 | | |
| 86 | | 2013.10.4 | 1 | 1 | 1 | 1 |

## 4. 9. Trace Metals

(1) Personnel

Ana M. Aguilar-Islas (University of Alaska Fairbanks): Principal Investigator
Shigeto Nishino (JAMSTEC): Co-PI
Kenichiro Sato (MWJ)
Robert Rember (International Arctic Research Center, not on board)

(2) Objectives

Investigate the distribution and partitioning of iron (Fe) and other trace metals.

(3) Parameters

A. Dissolved Fe, Cu, Zn, Cd, Pb
B. Leachable particulate Al, Mn, Fe, Cu,
C. Total particulate Al, Mn, Fe, Cu
D. Organic Fe speciation

(4) Instruments and Methods

Seawater samples were collected using a "clean" 12-position rosette water sampling system. The system consists of a powder-coated aluminum frame, titanium exposed metal surfaces, a Sea-Bird Electronics, Inc. 19plus unit, a Wet Labs EcoView fluorometer, a Wet Labs C-Star transmissometer , and a Sea-Bird Electronics Inc. auto fire module (AFM) which is programmed to fire bottles at the desired depths. The 5-liter bottles used are Teflon-coated with external-spring. These were washed with phosphate-free detergent and 0.5 M Trace-Metal Grade hydrochloric acid, and were rinsed and stored with Milli-Q water prior to use. The rosette was deployed using the ship's Kevlar wire. A maximum of 9 bottles were deployed during casts due to weight restrictions on the Kevlar wire. During rough sea conditions, bottles were hung directly on the Kevlar wire, and messengers were used to fire the bottles. Upon recovery bottles were taken to a wet lab and water was subsampled in line using acid cleaned Teflon tubing and ultra-pure nitrogen gas to pressurize the bottles. Seawater samples were filtered inside a plastic enclosure under a positive pressure atmosphere through 0.4 um polycarbonate track-etched filters (Nuclepore). Filtered seawater samples were collected into acid-washed polyethylene bottles and stored at room temperature. Filters were folded, placed into 7 ml vials and stored frozen.

Snow events were sampled from above the wheel house. Snow was collected using polyethylene bottles attached to a plastic-covered bamboo pole and facing into the wind. This method resulted in low recovery due to changing wind direction, and was abandoned for the use of a large polyethylene funnel attached to a 500 ml polyethylene bottle. After collection, snow was allowed to melt inside a plastic enclosure under a positive pressure atmosphere. In general melted snow yielded less than 30 ml, and samples were not filtered. When snow events yielded more than 30 ml, samples were filtered through 0.4 um polycarbonate track-etched filter, and an unfiltered subsample was also collected. When snow events yielded less than 3 ml, the sample was discarded.

One sea ice sample was collected using a net, and was stored frozen.

Samples will be analyzed onshore using a high-resolution inductively-coupled plasma mass spectrometer (HR-ICPMS) at the International Arctic Research Center of the University of Alaska, Fairbanks.

(5) List of Stations and Samples

A total of 21 vertical profiles were collected from 11 stations (Figure 4.9-1). Eleven of the 21 profiles were collected from the stationary point observation main station (Stn 41) (Table 4.9-1). Station 48 was a re-occupation of Station 34. Collected seawater samples (120) are listed on Table 4.9-1. Subsamples collected for organic iron speciation are denoted with an asterisk. A total of 11 snow samples were collected and are listed on Table 4.9-2. One sea ice sample was collected.

(6) Preliminary Results

The two-layer system at the stationary observation point main station (Stn 41) exhibited a narrow (c.a. 10 m) and variable benthic boundary layer (BBL) as determined by the change in beam transmission data of the bottom 20 m (Figure 4.9-2). Sedimentary input is likely the main source of trace metals over the Chukchi shelf, and this variability in the BBL is expected to affect primarily the dissolved and particulate distribution of trace metals in the bottom layer at this station. The resuspended sediment was mainly composed of organic aggregates (Figure 4.9-3), and it is expected that these will yield a high percentage of leachable particulate iron similar to the resuspended sediment over the Bering Sea shelf (Hurst et al., 2010). Within the narrow BBL a linear relationship was found for the concentration of oxygen (CTD sensor data) as a function of % beam transmission (CTD transmissometer data) (Figure 4.9-4) suggesting that coupling between resuspension of particles and the mixing of dissolved constituents from the surface sediment. Indeed, similar relationships were found between % beam transmission and nutrients within the BBL, with the best correlation obtained for nitrite (Figure 4.9-5). This relationship was disrupted during a 2 day period, likely as a result of a mixing event that brought high-dissolved oxygen, low-nutrient, low particle water down into the BBL (Figures 4.9-2, 4.9-4, and 4.9-5). It is expected that the dissolved and particulate trace metal distributions were also affected by this mixing event. Surprisingly the relationship between dissolved oxygen and % beam transmission was unique for each of the closely clustered stationary point observation stations (Stn 41-45) (Figure 4.9-6), suggesting that sedimentary inputs/sinks of trace elements are possibly quite variable over the Chukchi shelf.

(7) Data Archive

The data obtained from samples collected during this cruise will be submitted to the Data Management Office (DMO) of JAMSTEC, and will be opened to the public via “Data Research for Whole Cruise Information in JAMSTEC” in JAMSTEC home page.

(8) References

Hurst, M. P., A.M. Aguilar-Islas, K.W. Bruland, 2010. Iron in the southeastern Bering Sea: Elevated leachable particulate Fe in shelf bottom waters as an important source for surface waters. *Continental Shelf Research*, doi: 10.1016/j.csr.2010.01.001

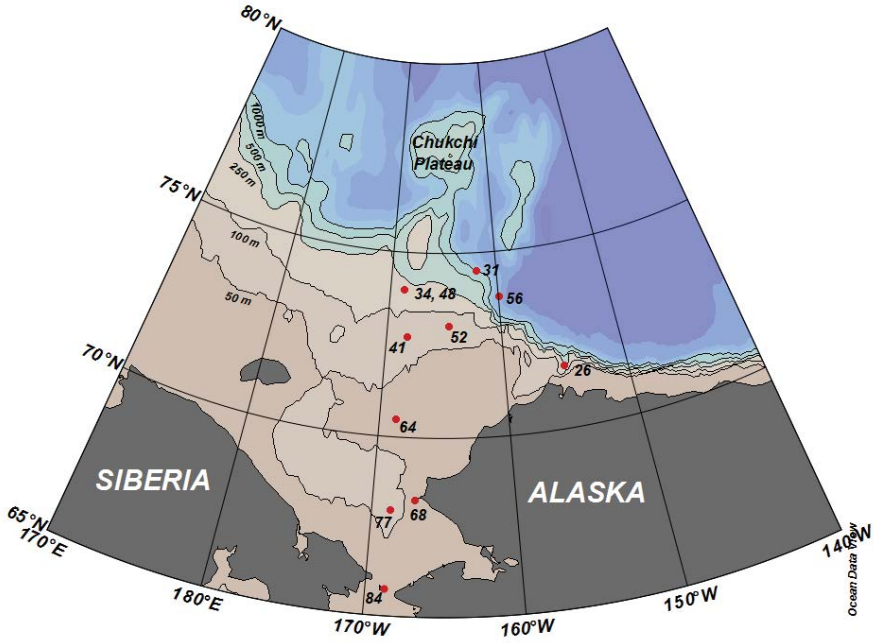



**Figure 4.9-1.** Trace metal station locations.

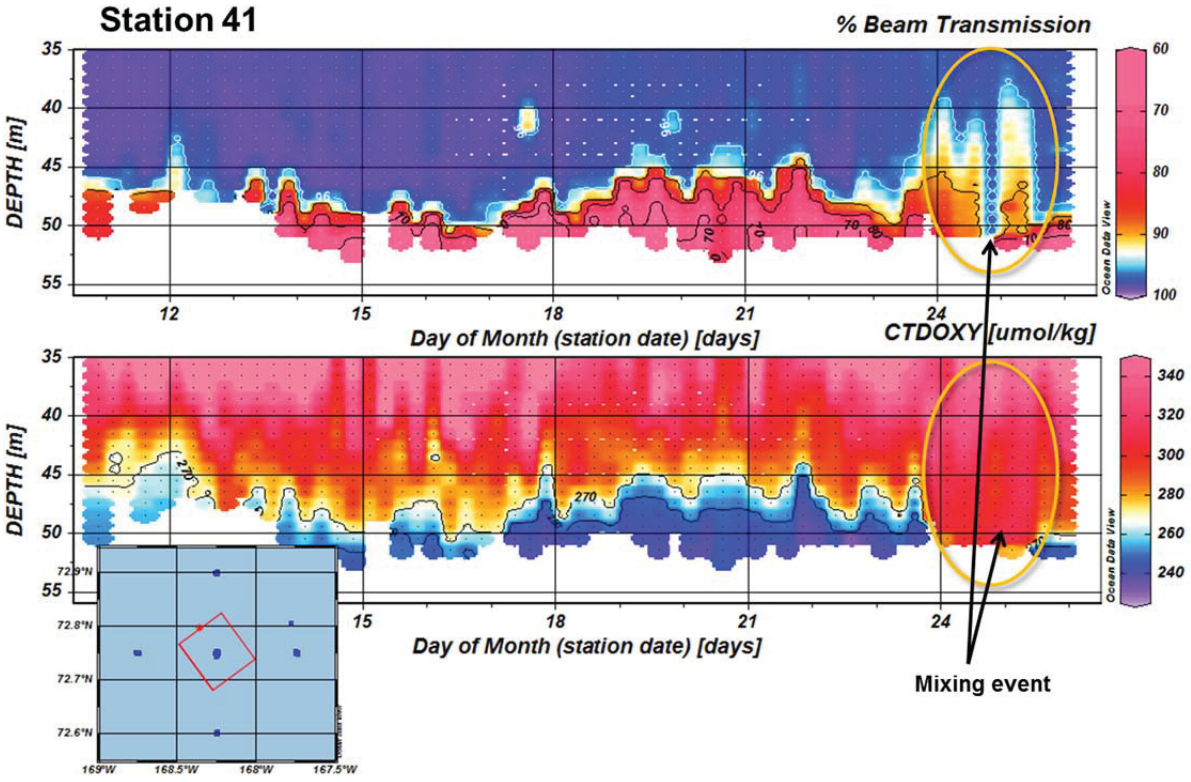



**Figure 4.9-2.** Variability in % beam transmission and dissolved oxygen within the bottom 20 m at Station 41.

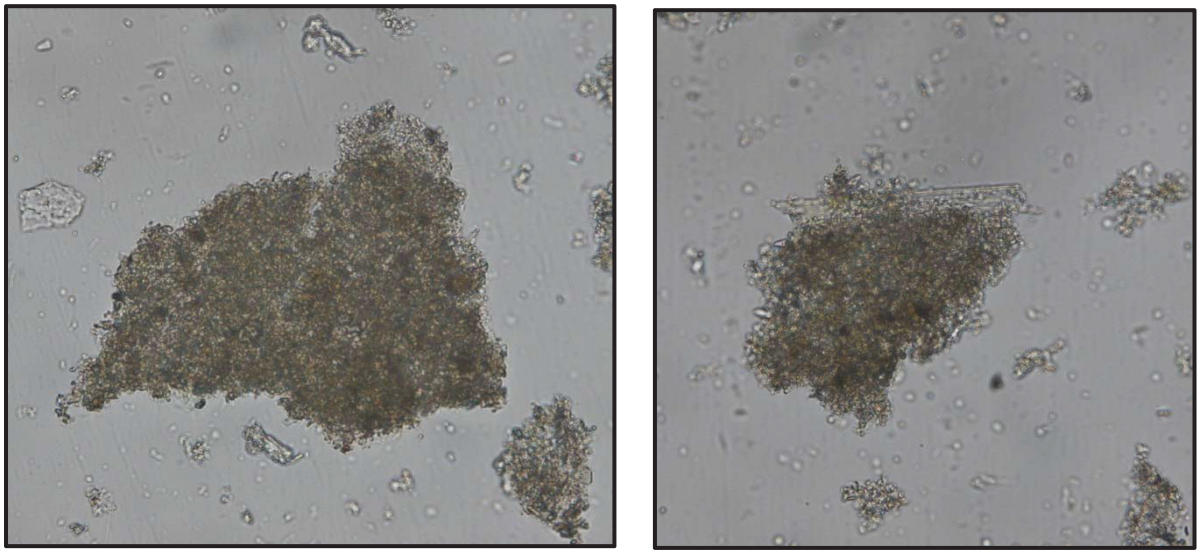


**Figure 4.9-3.** Suspended sediment from 50 m at Station 041, cast 45 (22 September). Photos by Katsunori Kimoto.

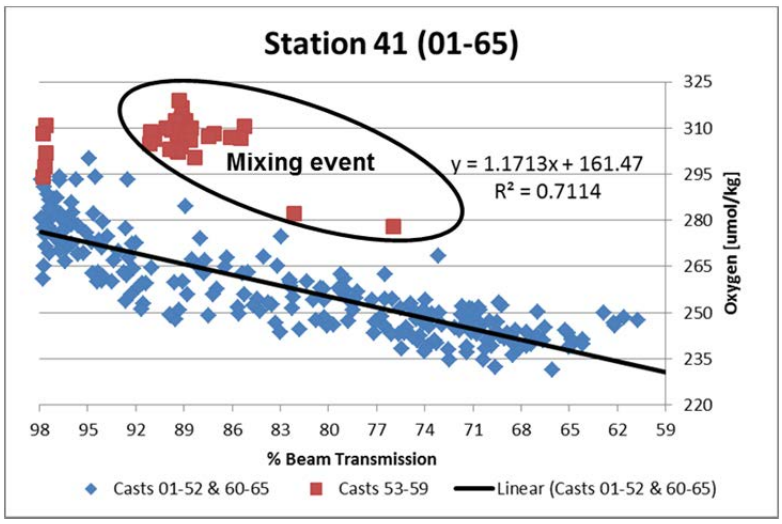



**Figure 4.9-4.** Dissolved oxygen as a function of % beam transmission at the Station 41. Data was taken from 47 m and below. The data from the mixing event (casts 53 to 59) are not included in the linear regression.

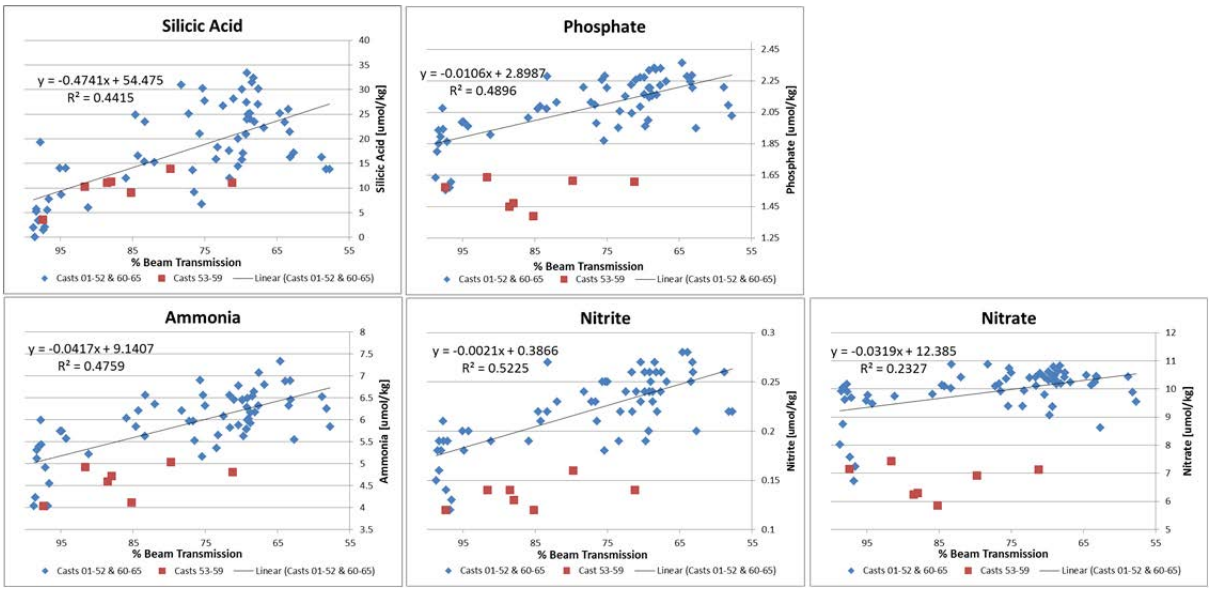



**Figure 4.9-5.** Dissolved nutrients as a function of % beam transmission at the Station 41. Data was taken from 46 m and below. The data from the mixing event (casts 53 to 59) are not included in the linear regression.

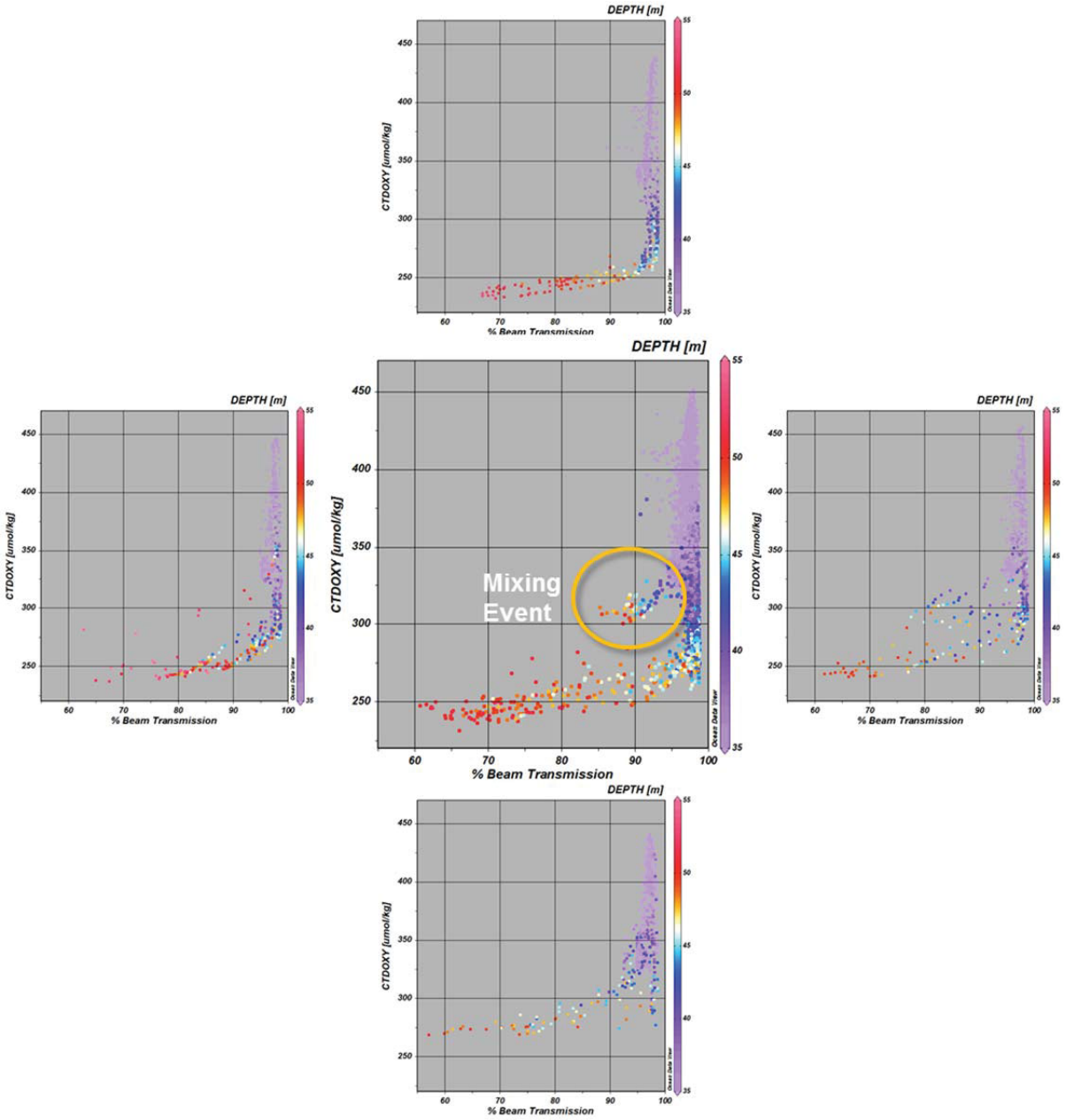



**Figure 4.9-6.** Dissolved oxygen as a function of % beam transmission at the Stations 41-45. Unique signature at each of the fix point observation stations.

**Table 4.9-1.** Seawater and Suspended Particles Sample List. ** Denotes duplicate sample

| Date | Station # | "Clean" Cast ID | Depth | Sample # | Date | Station # | "Clean" Cast ID | Depth | Sample # |
|---|---|---|---|---|---|---|---|---|---|
| 5/09/13 | 026 | TM01-26r | 15 m | 1 | 23/09/13 | 041-53 | TM11-41-53 | 15 m | 60 |
| | | | 25 m | 2 | | | | 25 m | 61 |
| | | | 40 m | 3 | | | | 30 m | 62 |
| | | | 65 m | 4 | | | | 40 m | 63 |
| | | | 90 m | 5 | | | | 45 m | 64 |
| | | | 120 m | 6 | | | | 50 m | 65 |
| | | | 150 m | 7 | 24/09/13 | 041-57 | TM12-41-57 | 15 m | 66 |
| | | | 200 m | 8 | | | | 25 m | 67 |
| | | | 240 m | 9 | | | | 30 m | 68 |
| 8/09/13 | 031 | TM02-31 | 15 m | 10* | | | | 40 m | 69 |
| | | | 55 m | 11* | | | | 45 m | 70 |
| | | | 125 m | 12* | | | | 50 m | 71 |
| | | | 200 m | 13* | 25/09/13 | 041-61 | TM13-41-61 | 15 m | 72* |
| | | | 250 m | 14* | | | | 25 m | 73* |
| | | | 400 m | 15* | | | | 30 m | 74 |
| | | | 600 m | 16* | | | | 40 m | 75 |
| | | | 800 m | 17* | | | | 45 m | 76 |
| | | | 1000 m | 18* | | | | 50 m | 77 |
| 9/09/13 | 034 | TM03-34 | 15 m | 19* | 25/09/13 | 048 | TM14-48 | 15 m | 78 |
| | | | 25 m | 20* | | | | 25 m | 79 |
| | | | 40 m | 21* | | | | 40 m | 80 |
| | | | 90 m | 22* | | | | 60 m | 81 |
| | | | ** 90 m | 23 | | | | 120 m | 82 |
| | | | 150 m | 24* | 26/09/13 | 052 | TM15-52 | 15 m | 83 |
| | | | 165 m | 25* | | | | 25 m | 84 |
| 110/9/13 | 041-05 | TM04-41-05 | 15 m | 26* | | | | 45 m | 85 |
| | | | 25 m | 27* | | | | 50 m | 86 |
| | | | 30 m | 28* | | | | 60 m | 87 |
| | | | 40 m | 29* | | | | 70 m | 88 |
| | | | 50 m | 30* | 27/09/13 | 056 | TM16-56 | 15 m | 89* |
| 13/09/13 | 041-13 | TM05-41-13 | 15 m | 31 | | | | 40 m | 90* |
| | | | 25 m | 32 | | | | 100 m | 91 |
| | | | 30 m | 33 | | | | 150 m | 92 |
| | | | 40 m | 34 | | | | 200 m | 93 |
| | | | 50 m | 35 | | | | 430 m | 94 |
| 15/09/13 | 041-21 | TM06-41-21 | 15 m | 36 | | | | 600 m | 95 |
| | | | 25 m | 37 | | | | 800 m | 96 |
| | | | 30 m | 38 | | | | 1000 m | 97 |
| | | | 40 m | 39 | 30/09/13 | 041-62 | TM17-41-62 | 15 m | 98 |
| | | | 50 m | 40 | | | | 25 m | 99 |
| 17/09/13 | 041-29 | TM07-41-29 | 15 m | 41 | | | | 30 m | 100 |
| | | | 25 m | 42 | | | | 40 m | 101 |
| | | | 30 m | 43 | | | | 45 m | 102 |
| | | | 40 m | 44 | | | | 50 m | 103 |
| | | | 50 m | 45 | 01/10/13 | 064 | TM18-64 | 15 m | 104 |
| 19/09/13 | 041-37 | TM08-41-37 | 15 m | 46 | | | | 20 m | 105 |
| | | | 31 m | 47 | | | | 30 m | 106 |
| 21/09/13 | 041-45 | TM09-41-45 | 15 m | 48 | | | | 34 m | 107 |
| | | | 25 m | 49 | 02/10/13 | 068 | TM19-68 | 15 m | 108 |
| | | | 30 m | 50 | | | | 25 m | 109 |
| | | | 40 m | 51 | | | | 34 m | 110 |
| | | | 45 m | 52 | 03/10/13 | 077 | TM20-77 | 15 m | 111 |
| | | | 50 m | 53 | | | | 25 m | 112 |
| 22/09/13 | 041-49 | TM10-41-49 | 15 m | 54 | | | | 35 m | 113 |
| | | | 25 m | 55 | | | | 45 m | 114 |
| | | | 30 m | 56 | | | | 50 m | 115 |
| | | | 40 m | 57 | | | | 54 m | 116 |
| | | | 45 m | 58 | 04/10/13 | 084 | TM21-84 | 15 m | 117 |
| | | | 50 m | 59 | | | | 25 m | 118 |
| | | | | | | | | 35 m | 119 |
| | | | | | | | | 46 m | 120 |

**Table 4.9-2.** Snow Sample List

| Date | Notes | Sample # | Date | Notes | Sample # |
|---|---|---|---|---|---|
| 8 September | < 3 ml Discarded | 0 | 24-25 September | < 3 ml Discarded | 0 |
| 13 September | < 3 ml Discarded | 0 | 27-28 September | 30 ml Filtered | 8 |
| 15-16 September | 7.5 ml Unfiltered | 1 | | 30 ml Unfiltered | 9 |
| 16 September | 18 ml Unfiltered | 2 | 30 September | 30 ml Unfiltered | 10 |
| 16-18 September | 13.5 ml Unfiltered | 3 | | 75 ml Filtered | 11 |
| 18-19 September | 5.5 ml Unfiltered | 4 | 1-2 October | < 3 ml Discarted | 0 |
| 21-22 September | 24.5 ml Unfiltered | 5 | | | |
| 22-24 September | 30 ml Filtered | 6 | | | |
| | 12 ml Unfiltered | 7 | | | |

## 4.10. Underway Surface Water Monitoring

(1) Personnel

Shigeto NISHINO (JAMSTEC): Principal Investigator
Hiroshi Uchida (JAMSTEC)
Shinichiro YOKOGAWA (Marine Works Japan Co. Ltd): Leg1 Operation Leader
Katsunori SAGISHIMA (Marine Works Japan Co. Ltd): Leg1
Masahiro ORUI (Marine Works Japan Co. Ltd): Leg1
Keitaro MATSUMOTO (Marine Works Japan Co. Ltd): Leg2 Operation Leader
Kanako YOSHIDA (Marine Works Japan Co. Ltd): Leg2

(2) Objective

Our purpose is to obtain temperature, salinity, dissolved oxygen, and fluorescence data continuously in near-sea surface water.

(3) Parameters

Temperature (surface water)
Salinity (surface water)
Dissolved oxygen (surface water)
Fluorescence (surface water)

(4) Instruments and Methods

The Continuous Sea Surface Water Monitoring System (Marine Works Japan Co. Ltd.) has five sensors and automatically measures temperature, salinity, dissolved oxygen and fluorescence in near-sea surface water every one minute. This system is located in the "*sea surface monitoring laboratory*" and connected to shipboard LAN-system. Measured data, time, and location of the ship were stored in a data management PC. The near-surface water was continuously pumped up to the laboratory from about 4.5 m water depth and flowed into the system through a vinyl-chloride pipe. The flow rate of the surface seawater was adjusted to be 5 $dm^3$ $min^{-1}$.

a. Instruments

Software

Seamoni-kun Ver.1.50

Sensors

Specifications of the each sensor in this system are listed below.

Temperature and Conductivity sensor

| | |
|---|---|
| Model: | SBE-45, SEA-BIRD ELECTRONICS, INC. |
| Serial number: | 4552788-0264 |
| Measurement range: | Temperature -5 to +35 $^{o}$C |
| | Conductivity 0 to 7 S $m^{-1}$ |
| Initial accuracy: | Temperature 0.002 $^{o}$C |
| | Conductivity 0.0003 S $m^{-1}$ |
| Typical stability (per month): | Temperature 0.0002 $^{o}$C |
| | Conductivity 0.0003 S $m^{-1}$ |
| Resolution: | Temperatures 0.0001 $^{o}$C |
| | Conductivity 0.00001 S $m^{-1}$ |

Bottom of ship thermometer

| | |
|---|---|
| Model: | SBE 38, SEA-BIRD ELECTRONICS, INC. |
| Serial number: | 3852788-0457 |
| Measurement range: | -5 to +35 $^{o}$C |
| Initial accuracy: | ±0.001 $^{o}$C |
| Typical stability (per 6 month): | 0.001 $^{o}$C |
| Resolution: | 0.00025 $^{o}$C |

Dissolved oxygen sensor

| | |
|---|---|
| Model: | OPTODE 3835, AANDERAA Instruments. |
| Serial number: | 1519 |
| Measuring range: | 0 - 500 μmol $dm^{-3}$ |
| Resolution: | < 1 μmol $dm^{-3}$ |
| Accuracy: | < 8 μmol $dm^{-3}$ or 5 % whichever is greater |
| Settling time: | < 25 s |

Dissolved oxygen sensor

| | |
|---|---|
| Model: | RINKO II, ARO-CAR/CAD |
| Serial number: | 13 |
| Measuring range: | 0 - 540 μmol $dm^{-3}$ |
| Resolution: | < 0.1 μmol $dm^{-3}$ |

| | |
|---|---|
| | or 0.1 % of reading whichever is greater |
| Accuracy: | < 1 μmol $dm^{-3}$ |
| | or 5 % of reading whichever is greater |

Fluorometer

| | |
|---|---|
| Model: | C3, TURNER DESIGNS |
| Serial number: | 2300384 |

b. Measurements

Periods of measurement, maintenance, and problems during MR13-06 are listed in Table 4.10-1.

**Table 4.10-1.** Events list of the Sea surface water monitoring during MR13-06

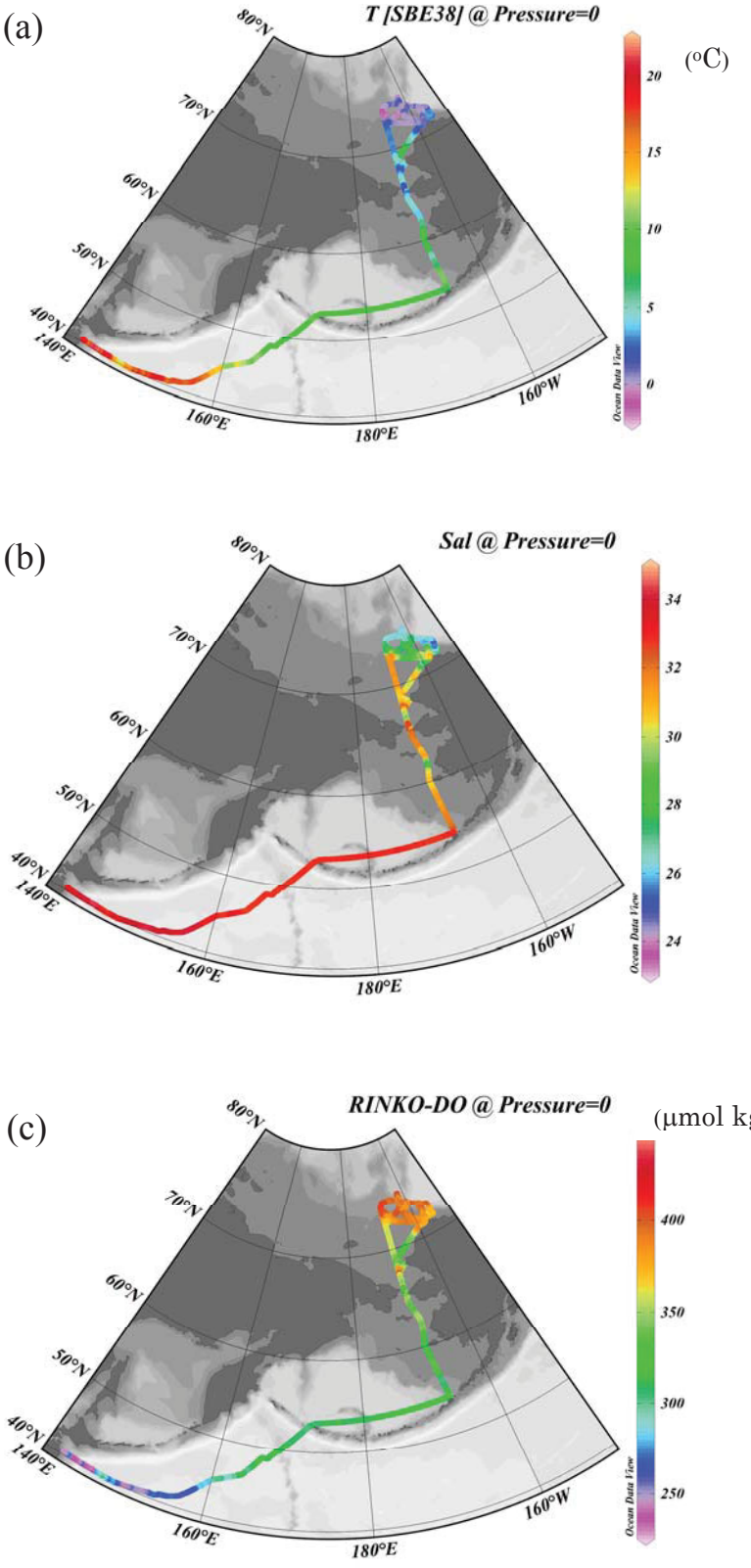
| System Date [UTC] | System Time [UTC] | Events | Remarks |
|---|---|---|---|
| 2013/08/28 | 23:31 | All the measurements started and data was available. | Cruise start |
| 2013/09/08 | 21:08 | All the measurements stopped. | Filter cleaning |
| 2013/09/08 | 22:31 | All the measurements started. | Logging restart |
| 2013/10/06 | 10:06 | All the measurements stopped. | Leg1 end |
| 2013/10/09 | 19:55 | All the measurements started. | Leg2 start |
| 2013/10/19 | 07:00 | All the measurements stopped. | Cruise end |

(5) Preliminary Results

We took the surface water samples once a day to compare sensor data with bottle data of salinity, dissolved oxygen and fluorescence. The results are shown in Figures 4.10-1 to -3. All the salinity samples were analyzed by the Guideline 8400B "AUTOSAL" (see Section 3.6), and dissolve oxygen samples were analyzed by Winkler method (see Section 4.1), and fluorescence were analyzed by 10-AU (see Section 4.5).

(6) Data archive

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC web site.


(a)
T [SBE38] @ Pressure=0
(°C)
80°N
70°N
60°N
50°N
40°N
140°E
160°E
180°E
160°W
20
15
10
5
0
Ocean Data View
(b)
Sal @ Pressure=0
34
32
30
28
26
24
Ocean Data View
(c)
RINKO-DO @ Pressure=0
(μmol kg-1)
400
350
300
250
Ocean Data View

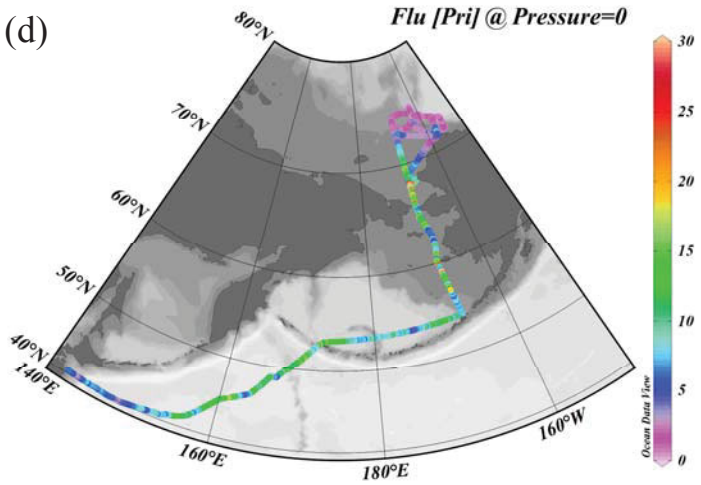



**Figure 4.10-1.** Spatial and temporal distribution of (a) temperature, (b) salinity, and (c) dissolved oxygen and (d) fluorescence in MR13-06 cruise.

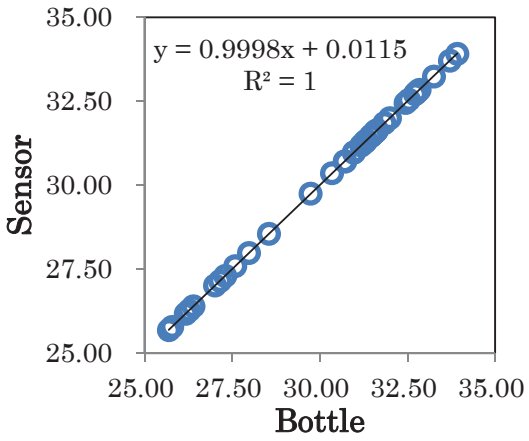



**Figure 4.10-2.** Correlation of salinity between sensor data and bottle data.

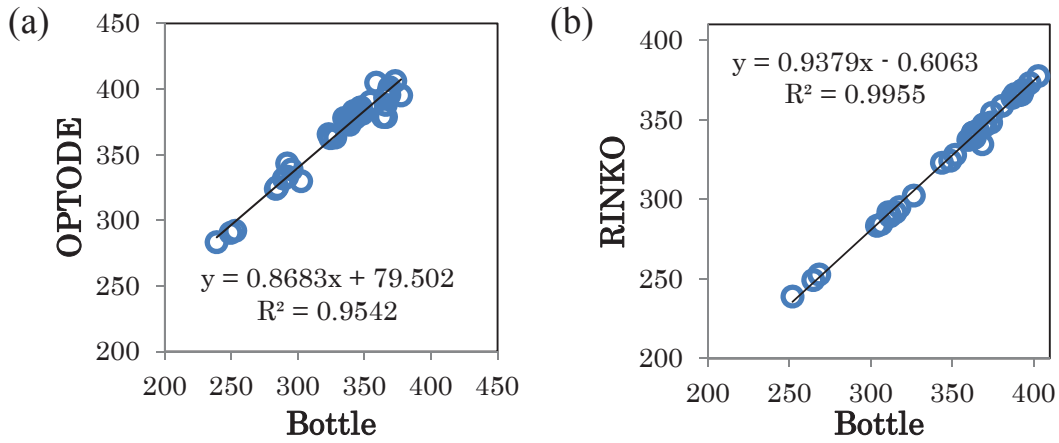



**Figure 4.10-3.** Correlation of dissolved oxygen between sensor data and bottle data. (a: OPTODE, b: RINKO)

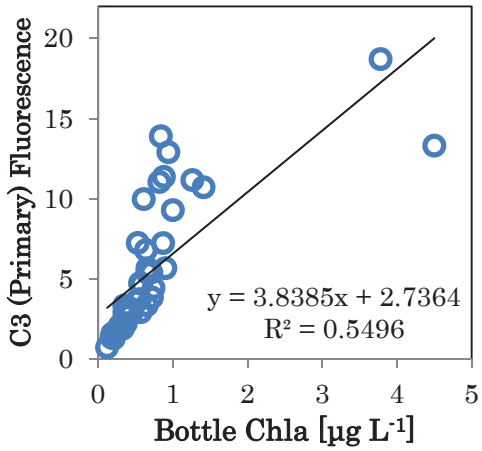



**Figure 4.10-4.** Correlation of fluorescence between sensor data and bottle data.

## 4.11. Dissolved Greenhouse Gases

### 4.11.1. Continuous Measurement of Surface $pCO_2/pCH_4$ by CRDS

(1) Personnel

Shuji Aoki (Tohoku University): Principal Investigator
Masao Ishii (Meteorological Research Institute / JMA)
Daisuke Sasano (Meteorological Research Institute / JMA)
Naohiro Kosugi (Meteorological Research Institute / JMA)
Hisayuki Yhoshikawa-Inoue (Hokkaido University)
Hiroshi Uchida (JAMSTEC)
Sakae Toyoda (Interdisciplinary Graduate School of Science and Engineering
Tokyo Institute of Technology)
Kushi Kudo (Interdisciplinary Graduate School of Science and Engineering
Tokyo Institute of Technology)

(2) Objective

The oceans have strong interactions with the atmosphere and are the major sinks for the increasing $CO_2$. Although it is believed that the Arctic Ocean is playing an important role for the variations of greenhouse gases in the atmosphere, their spatial and temporal variations in the Arctic Ocean is not well known. Furthermore, sea ice in the Arctic Ocean has been decreasing in summer, leading to change the air-sea interaction and biological activity due to increasing the area of open sea, and possibly leading to affect the global carbon cycle.

Recently, a new $CO_2$ analyzer WS-CRDS (Picarro) was developed on the basis of Cavity Ring-Down Spectroscopy. The advantage of this analyzer is a high precision and stability. In addition, the analyzer can simultaneously measure other trace gases such as $CH_4$. In this study, we challenge to apply WS-CRDS to the underway measurements of $pCO_2$ and $pCH_4$ in the atmosphere and in surface seawater to clarify the distributions of $pCO_2$ and $pCH_4$ and their controlling mechanisms in the Arctic Ocean.

(3) Parameters

Partial pressure of $CO_2$ ($pCO_2$) and $CH_4$ ($pCH_4$) in the atmosphere and in near-surface seawater

(4) Instruments and Methods

We made simultaneous measurements of the $CO_2$ and $CH_4$ concentrations in the dry air equilibrated with the great excess of surface seawater during the whole cruise using an automated measuring system (Nippon ANS Co.). Seawater was taken continuously from the seachest located ca.4.5 m below the sea level and introduced into the MRI-shower-type equilibrator. Wavelength-scanned cavity ring-down spectrometer (WS-CRDS, Picarro, G2301) was used as a detector. We used three standard gases with known $CO_2$ and $CH_4$ mixing ratios once a day. Corrections for the temperature-rise from the seachest to the equilibrator are also to be made. Partial pressure of $CO_2$ and $CH_4$ will be calculated from the concentration of $CO_2$ and $CH_4$ by taking the water vapor pressure and the atmospheric pressure into account.

(5) Observation log

The shipboard continuous measurements were conducted from 2013/08/28 (UTC) to 2013/10/07 (UTC).

(6) Preliminary results

Preliminary data of $CO_2$ and $CH_4$ concentrations in surface water are shown in Figure 4.11.1-1.

(7) Data archive

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will opened to the public via “Data Research for Whole Cruise Information in JAMSTEC” in JAMSTEC home page.

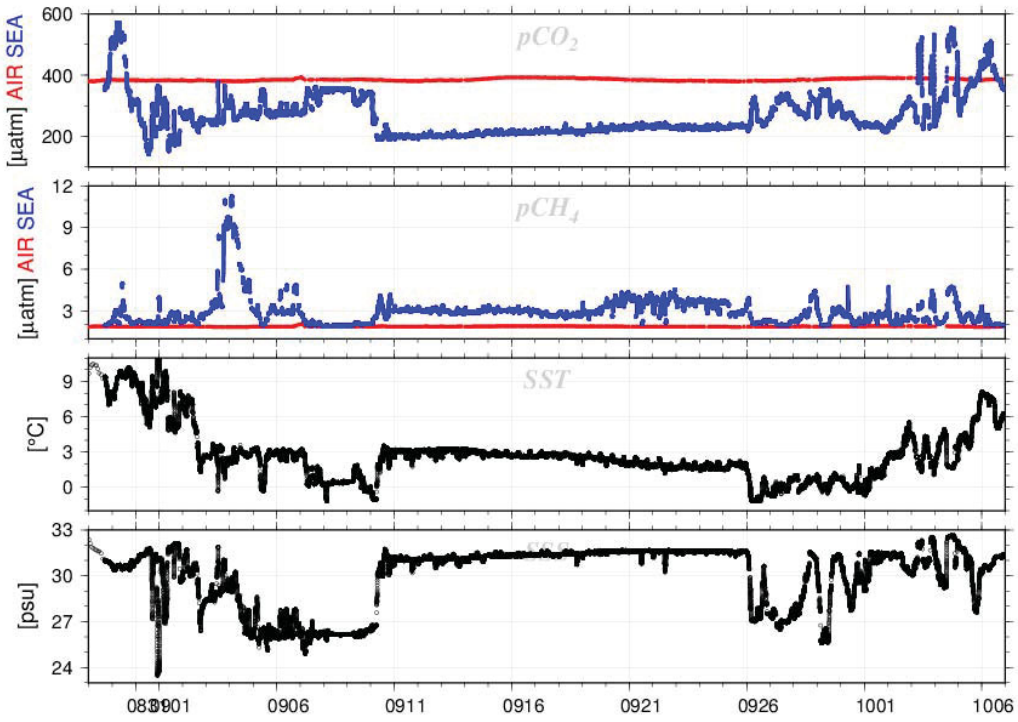



**Figure 4.11.1-1.** Time series of $pCO_2$, $pCH_4$, SST and SSS. As for $pCO_2$ and $pCH_4$, red and blue bots indicate partial pressure of atmosphere and surface seawater respectively.

## 4.11.2. Dissolved Methane ($CH_4$) and Nitrous Oxide ($N_2O$)

(1) Personnel

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(2) Objective

*Methane*

Atmospheric methane ($CH_4$) is a trace gas playing an important role in the global carbon cycle as an one of the greenhouse gases. Its concentration has increased by about 1050 ppbv from 700 ppbv since the pre-industrial era (IPCC, 2007). In order to understand the current global $CH_4$ cycle, it is necessary to quantify its sources and sinks. At present, there remain large uncertainties in the estimated $CH_4$ fluxes from sources. The ocean's source strength for atmospheric $CH_4$ should be examined in more detail, even though it might be a relatively minor source, previously reported to be 0.005 to 3% of total input to the atmosphere (Cicerone and Oremland, 1988; Bange et al., 1994; Lelieveld et al., 1998).

Potentially important source of $CH_4$ from the Arctic Ocean have been reported recently, including degradation of subsea permafrost on the eastern Siberian shelf (ESAS) (Shakhova et al., 2010), aerobic $CH_4$ production by methylotrophic methanogenesis in the central Arctic Ocean (Damm et al., 2010) and sea ice absorbs $CH_4$ in atmosphere potentially related to both photochemical and biochemical oxidation (He et al., 2013). However, the distribution of $CH_4$ in the Arctic Ocean is not widely investigated, and there have been few isotopic study of $CH_4$ dissolved in the Arctic Ocean, which would help understand its production processes. Here we survey distribution of $CH_4$ dissolved in the surface water, the water column and the oversea atmosphere (using to investigate the atmosphere-ocean interaction of $CH_4$) of the Arctic

Ocean and analyze the production and consumption processes of $CH_4$ using stable isotope ratios.

*Nitrous oxide*

Nitrous oxide ($N_2O$) is another trace greenhouse gas present in the troposphere. Unlike $CH_4$, it also has a large stratospheric ozone-depleting potential because its photochemical decomposition products catalytically decompose ozone (Crutzen, 1970). Atmospheric concentration of $N_2O$ increased from 270 ppb during pre-industrial era to 319 ppb in 2005 (IPCC, 2007). The global annual flux of $N_2O$ into the atmosphere is estimated to be about 16 Tg-N $yr^{-1}$, and the oceans are believed to contribute more than 20% of the global flus (IPCC, 2007).

In the seawater or sediments, $N_2O$ is known to be produced by microbial processes such as nitrification and denitrification. In nitrification, which likely to occur under aerobic conditions, $N_2O$ is produced as a byproduct during the oxidation of hydroxylamine ($NH_2OH$) to nitrite ($NO_2^-$) by ammonia oxidizing bacteria (AOB) or archaea (Yoshida and Alexander, 1970). In denitrification, which likely to occur under anaerobic conditions, N2O is produced as an intermediate during the reduction of nitrate ($NO_3^-$) to $N_2$ by denitrifying bacteria. Denitrification can be a sink of $N_2O$ under strongly depleted $O_2$ conditions. Some AOB can produce $N_2O$ by reducing $NO_2^-$ generated by $NH_3$ oxidation, which is often called nitrifier-denitrification (Wrage et al., 2001). Because of these complex pathways, great uncertainly remains in estimation of magnitude of $N_2O$ flux from the oceans, and isotopic analysis is expected to provide qualitative information on $N_2O$ produced and emitted from the oceans.

In the Bering and Chukchi Seas, a single study has been conducted on dissolved $N_2O$ and its isotope ratios (Hirota et al., 2009). The $N_2O$ was found to be supersaturated (up to 157% saturation) in continental shelf water columns between August and September, 2006 (MR06-04 cruise). The authors also observed that the $^{15}N$ and $^{18}O$ in $N_2O$ are respectively depleted and enriched relative to atmospheric $N_2O$, and deduced that $N_2O$ is primarily produced through denitrification in sediments. The purpose of the present study is to extend the previous observation area to the wider area of the Arctic Ocean and to obtain additional new isotopic parameter, $^{15}N$-site preference (SP) in NNO molecule, to elucidate the production and consumption mechanisms of $N_2O$ more in detail.

(3) Parameters

Concentration, stable carbon and hydrogen isotope ratios of dissolved $CH_4$

Concentration, stable nitrogen and oxygen isotope ratios including SP in dissolved $N_2O$

(4) Instruments and Methods

Seawater samples were collected using CTD-CAROUSEL system equipped with 12-L Niskin bottles. Surface water samples were taken at 0 m depth from sea surface in order to compare with on board continuous monitoring system for dissolved $CH_4$ operated by MRI. Vertical sampling of the water column was conducted at several deep stations. Sampling locations and depth profile are shown in the station list (Tables 4.11.2-1 to 4.11.2-4). Each sample was subsampled into 30, 125, 600, and 225 (duplicate) ml glass vials to avoid air contamination for analysis of $CH_4$ concentration, stable carbon and hydrogen isotope ratio of $CH_4$ and $N_2O$ isotope ratios, respectively. These seawater samples were sterilized by adding saturated mercuric chloride ($HgCl_2$) solution ($HgCl_2$ concentration: ca. 0.5% (Tilbrook and Karl, 1995; Watanabe et al., 1995)) to avoid excess $CH_4$ emission from microbe, and were sealed with rubber stoppers and aluminum caps. They will be stored in a dark and cool place until concentration and stable isotope ratio measurement at Tokyo Institute of Technology.

In addition, air samples were collected at 16 m oversea height using a 2-L stainless flask and were stored at room temperature until analysis (Yamada et al., 2005). Sampling locations are shown in the station list (Table 4.11.2-5).

Concentration of dissolved $CH_4$ will be measured with a gas chromatograph equipped with a flame ionization detector (GC-FID). Stable carbon isotope ratio will be measured with gas chromatography-combustion-isotope ratio mass spectrometry (GC-C-IRMS). Stable hydrogen isotope ratio will be measured with gas chromatography-high-temperature conversion-isotope ratio mass spectrometry (GC-TC-IRMS). Each analytical system is equipped with a purge and trap unit, and $CH_4$ is further concentrated in a cryogenic trap in the case of isotopic measurement. Precisions of repeated analyses of $CH_4$ concentration, and carbon and hydrogen isotope ratio are estimated to be better than 5%, 0.3‰ and 3‰, respectively.

Dissolved $N_2O$ concentrations and its isotopic compositions will be measured similarly by mass spectrometry, although the extracted and purified $N_2O$ is directly introduced into the mass spectrometry (GC-IRMS) which was modified for site-specific $^{15}N$ analysis (Yoshida and Toyoda, 2000)

(5) Sampling lists

**Table 4.11.2-1.** Sampling list for concentration of dissolved $CH_4$

| Station No. | Lat. | Long. | Sampling Depth[m] |
|---|---|---|---|
| 1 | 65°50`N | 168°50`W | 0, 20, 30, 45 |
| 12 | 71°34`N | 159°30`W | 0, 20, 40, 59 |
| 22 | 71°40. 83`N | 154°58. 42`W | 0, 50, 150, 157 |
| 23 | 71°45`N | 155°14`W | 0, 50, 100, 150, 232 |
| 30 | 74°50. 03`N | 161°98. 43`W | 0, 50, 100, 150, 200, 300, 500, 1000, 1500, 1615 |
| 37 | 72°45. 00`N | 168°45. 00`W | 0, 40, 49 |
| 38 | 72°30. 00`N | 168°15. 00`W | 0, 40, 47 |
| 41#10 | 72°45. 00`N | 168°15. 00`W | 0, 40, 51 |
| 41#14 | | | 0, 40, 51 |
| 41#21 | | | 0, 40, 51 |
| 41#25 | | | 0, 20, 40, 51 |
| 41#33 | | | 0, 20, 40, 50 |
| 41#41 | | | 0, 20, 40, 52 |
| 41#43 | | | 0, 5, 10, 20, 30, 40, 45, 51 |
| 41#51 | | | 0, 5, 10, 20, 30, 40, 45, 51 |
| 41#57 | | | 0, 20, 40, 51 |
| 48 | 74°00. 00`N | 168°45. 00`W | 0, 20, 50, 100, 150, 174 |
| 56 | 73°48. 00`N | 160°00. 00`W | 0, 10, 20, 50, 100, 150, 200, 500, 800, 1000, 1500, 2000, 2500, 2682 |
| 41#63 | 72°45. 00`N | 168°15. 00`W | 0, 20, 40, 52 |
| 62 | 71°30. 00`N | 168°45. 00`W | 0, 10, 20, 30, 40, 47 |
| 68 | 68°18. 00`N | 167°3. 00`W | 0, 5, 10, 20, 30, 37 |
| 77 | 68°0. 00`N | 168°45. 00`W | 0, 10, 20, 30, 40, 50 |
| 84 | 65°45. 80`N | 168°45. 60`W | 0, 10, 20, 30, 40, 47 |

**Table 4.11.2-2.** Sampling list for $^{13}C$ of dissolved $CH_4$

| Station No. | Lat. | Long. | Sampling Depth[m] |
|---|---|---|---|
| 1 | 65°50`N | 168°50`W | 0, 20, 30, 45 |
| 12 | 71°34`N | 159°30`W | 0, 20, 40, 59 |
| 22 | 71°40. 83`N | 154°58. 42`W | 0, 50, 150, 157 |
| 23 | 71°45`N | 155°14`W | 0, 50, 100, 150, 232 |
| 30 | 74°50. 03`N | 161°98. 43`W | 0, 50, 100, 150, 200, 300, 500, 1000, 1500, 1615 |
| 37 | 72°45. 00`N | 168°45. 00`W | 0, 40, 49 |
| 38 | 72°30. 00`N | 168°15. 00`W | 0, 40, 47 |
| 41#10 | 72°45. 00`N | 168°15. 00`W | 0, 40, 51 |
| 41#14 | | | 0, 40, 51 |
| 41#21 | | | 0, 40, 51 |
| 41#25 | | | 0, 20, 40, 51 |
| 41#33 | | | 0, 20, 40, 50 |
| 41#41 | | | 0, 20, 40, 52 |
| 41#43 | | | 0, 5, 10, 20, 30, 40, 45, 51 |
| 41#51 | | | 0, 5, 10, 20, 30, 40, 45, 51 |
| 41#57 | | | 0, 20, 40, 51 |
| 48 | 74°00. 00`N | 168°45. 00`W | 0, 20, 50, 100, 150, 174 |
| 56 | 73°48. 00`N | 160°00. 00`W | 0, 10, 20, 50, 100, 150, 200, 500, 800, 1000, 1500, 2000, 2500, 2682 |
| 41#63 | 72°45. 00`N | 168°15. 00`W | 0, 20, 40, 52 |
| 62 | 71°30. 00`N | 168°45. 00`W | 0, 10, 20, 30, 40, 47 |
| 68 | 68°18. 00`N | 167°3. 00`W | 0, 5, 10, 20, 30, 37 |
| 77 | 68°0. 00`N | 168°45. 00`W | 0, 10, 20, 30, 40, 45, 50 |
| 84 | 65°45. 80`N | 168°45. 60`W | 0, 10, 20, 30, 40, 47 |

**Table 4.11.2-3.** Sampling list for D of dissolved $CH_4$

| Station No. | Lat. | Long. | Sampling Depth[m] |
|---|---|---|---|
| 1 | 65°50`N | 168°50`W | 0, 30, 45 |
| 12 | 71°34`N | 159°30`W | 0, 40, 59 |
| 22 | 71°40. 83`N | 154°58. 42`W | 0, 50, 150, 157 |
| 23 | 71°45`N | 155°14`W | 0, 50, 100, 232 |
| 30 | 74°50. 03`N | 161°98. 43`W | 0, 50, 100, 150, 200, 300, 500, 1000, 1500, 1615 |
| 37 | 72°45. 00`N | 168°45. 00`W | 0, 40, 49 |
| 38 | 72°30. 00`N | 168°15. 00`W | 0, 40, 47 |
| 41#10 | 72°45. 00`N | 168°15. 00`W | 0, 40, 51 |
| 41#14 | | | 0, 40, 51 |
| 41#21 | | | 0, 40, 51 |
| 41#25 | | | 0, 20, 40, 51 |
| 41#33 | | | 0, 20, 40, 50 |
| 41#41 | | | 0, 20, 40, 52 |
| 41#43 | | | 0, 5, 10, 20, 30, 40, 45, 51 |
| 41#57 | | | 0, 20, 40, 51 |
| 48 | 74°00. 00`N | 168°45. 00`W | 0, 20, 50, 100, 150, 174 |
| 56 | 73°48. 00`N | 160°00. 00`W | 0, 10, 20, 50, 100, 150, 200, 500, 800, 1000, 1500, 2000, 2500, 2682 |
| 41#63 | 72°45. 00`N | 168°15. 00`W | 0, 20, 40, 52 |
| 62 | 71°30. 00`N | 168°45. 00`W | 0, 20, 47 |
| 68 | 68°18. 00`N | 167°3. 00`W | 0, 20, 37 |
| 84 | 65°45. 80`N | 168°45. 60`W | 0, 20, 47 |

**Table 4.11.2-4.** Sampling list for dissolved $N_2O$

| Station No. | Lat. | Long. | Sampling Depth[m] |
|---|---|---|---|
| 1 | 65°50`N | 168°50`W | 0, 30, 45 |
| 12 | 71°34`N | 159°30`W | 0, 40, 59 |
| 22 | 71°40. 83`N | 154°58. 42`W | 0, 50, 150, 157 |
| 23 | 71°45`N | 155°14`W | 0, 50, 100, 150, 232 |
| 30 | 74°50. 03`N | 161°98. 43`W | 0, 50, 100, 150, 200, 300, 500, 1000, 1500, 1615 |
| 37 | 72°45. 00`N | 168°45. 00`W | 0, 40, 49 |
| 38 | 72°30. 00`N | 168°15. 00`W | 0, 40, 47 |
| 41#10 | 72°45. 00`N | 168°15. 00`W | 0, 40, 51 |
| 41#14 | | | 0, 40, 51 |
| 41#21 | | | 0, 40, 51 |
| 41#25 | | | 0, 20, 40, 51 |
| 41#33 | | | 0, 20, 40, 50 |
| 41#41 | | | 0, 20, 40, 52 |
| 41#43 | | | 0, 5, 10, 20, 30, 40, 45, 51 |
| 41#57 | | | 0, 20, 40, 51 |
| 56 | 73°48. 00`N | 160°00. 00`W | 0, 20, 50, 100, 200, 500, 1000, 1500, 2000, 2500, 2682 |
| 41#63 | 72°45. 00`N | 168°15. 00`W | 0, 20, 40, 52 |
| 62 | 71°30. 00`N | 168°45. 00`W | 0, 20, 47 |
| 77 | 68°0. 00`N | 168°45. 00`W | 0, 20, 50 |

**Table 4.11.2-5.** Sampling list for atmospheric $CH_4$

| Station No. | Lat. | Long. |
|---|---|---|
| 12 | 71°34`N | 159°30`W |
| 23 | 71°45`N | 155°14`W |
| 30 | 74°50. 03`N | 161°98. 43`W |
| 37 | 72°45. 00`N | 168°45. 00`W |
| 38 | 72°30. 00`N | 168°15. 00`W |
| 41#10 | 72°45. 00`N | 168°15. 00`W |
| 62 | 71°30. 00`N | 168°45. 00`W |
| 77 | 68°0. 00`N | 168°45. 00`W |
| 84 | 65°45. 80`N | 168°45. 60`W |

(6) Expected results

Preliminary data obtained by on-board continuous monitoring system indicated that surface water of the broad shelves of the Bering Sea and near shore area of Barrow is often supersaturated with $CH_4$ and the atmospheric concentration of $CH_4$ over the Chukchi Sea is often increased. Concentration of $CH_4$ in the seawater and the air samples collected simultaneously with the on-board measurements will be used to cross-check the both observations. Isotope ratios of $CH_4$ and their depth profiles along with concentration would provide the information on origin of the $CH_4$ and isotopic character of $CH_4$ emitted from Arctic Ocean, which is valuable for modeling the isotope budget of atmospheric $CH_4$.

Based on the previous study, concentration of $N_2O$ is expected to be higher than that expected under air-sea equilibrium in continental shelf regions. In the deeper sea area, however, it may show different vertical profile. Along with concentration, isotope ratios including SP will be used to analyze possible sources and sinks of $N_2O$ and its mixing.

(7) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC web site.

After the measurements and quality check, concentration and isotopic data will be submitted to JAMSTEC.

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## 4.12. Underway DIC

(1) Personnel

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Hiroshi Uchida (JAMSTEC)

(2) Objective

$CO_2$ in the atmosphere is increasing at nearly 2 μmol $mol^{-1}$ $yr^{-1}$ owing to human activities such as burning of fossil fuels, deforestation, and cement production. The ocean plays an important role in buffering the increase of atmospheric $CO_2$.

On the other hand, accumulation of surplus $CO_2$ alters budgets of ions and decreases saturation state of calcium carbonate ($CaCO_3$) in seawater. This phenomenon called "Ocean acidification" may be harmful to some creatures which have Skelton or shell made of $CaCO_3$. Furthermore, not only accumulation of $CO_2$ but also the dilutions of seawater by the increase of sea ice meltwater will reduce the saturation state of $CaCO_3$ in the Arctic Ocean. Comprehensive carbonate measurement is needed for better understanding of ocean acidification.

As for oceanic carbonate system, in case that two of 4 primary parameters ($pCO_2$, DIC, TA, and pH) were determined, we can calculate the others and additional parameters such as the saturation state of $CaCO_3$ and buffer factor (Revelle factor). Hence, underway DIC measurements were conducted to calculate other carbonate parameters in combination with continuous measurements of $pCO_2$ (see section 4.11.1)

(3)Parameter

Total Dissolved Inorganic Carbon (DIC)

(4) Instruments and Methods

Surface seawater was taken from an intake placed at the approximately 4.5 m below the sea surface by a pump, and was filled in a 300 ml glass bottle (SCHOTT DURAN). The glass bottles were filled from the bottom, without rinsing, and were overflowed for more than 2 times the amount. Before the analysis, the samples were put in the water bath kept about 20 deg C for one hour.

Measurements of DIC were made with total $CO_2$ measuring system (Nippon ANS, Inc.).

The system was comprised of seawater dispensing unit, a $CO_2$ extraction unit, and a coulometer (Model 3000, Nippon ANS, Inc.) The seawater dispensing unit had an auto-sampler (6 ports), which dispenses the seawater from a glass bottle to a pipette of nominal 15 ml volume. The pipette was kept at 20 ± 0.05 deg C by a water jacket, in which water circulated through a thermostatic water bath (BH201, Yamato).
Dissolved CO2 in seawater was extracted in a stripping chamber of the $CO_2$ extraction unit by adding phosphoric acid (10 % v/v). The stripping chamber was made approx. 25 cm long and has a fine frit at the bottom. First, the certain amount (~2ml) of acid was taken to the constant volume tube from an acid bottle and transferred to the stripping chamber from its bottom by nitrogen gas (99.9999 %). Second, a seawater sample kept in a pipette was introduced to the stripping chamber by the same method as that for an acid. The seawater and phosphoric acid were stirred by the nitrogen bubbles through a fine frit at the bottom of the stripping chamber. The stripped $CO_2$ was carried to the coulometer through two electric dehumidifiers (kept at 2-10 deg C) and a chemical desiccant ($Mg(ClO_4)$ 2) by the nitrogen gas (flow rates of 140 ml $min^{-1}$).

(5)Observation log
The underway measurements were conducted from 2013/08/29 (UTC) to 2013/10/05 (UTC).

(6)Results
During the cruise, 26 bottles of CRM (Scripps Institute of Oceanography; Batch 113) were measured in order to check a stability of the system and to determine the calibration factor. Duplicate measurements were conducted from single bottle. Average and standard deviation of difference between duplicate measurements (2nd – 1st) were -0.46 ± 1.78 μmol $kg^{-1}$, respectively. Standard deviations of the mean of 26 bottles were 2.00 μmol $kg^{-1}$.
Preliminary data of underway DIC during MR13-06 are shown in Figure 4.12-1.

(7) Data archives
These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will opened to the public via “Data Research for Whole Cruise Information in JAMSTEC” in JAMSTEC home page.

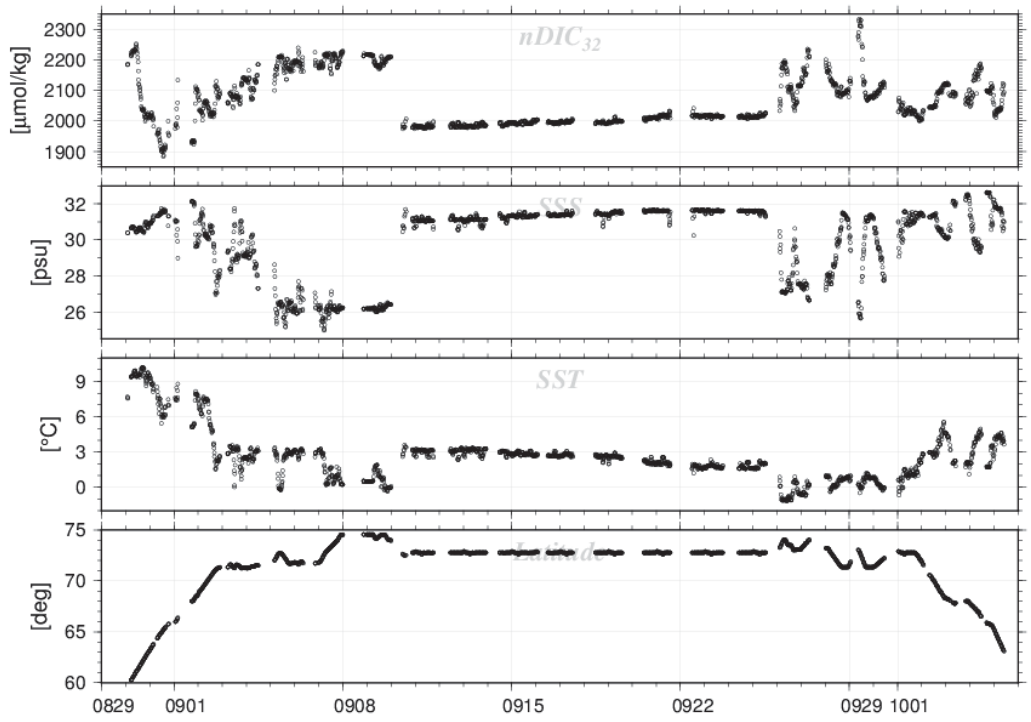


**Figure 4.12-1.** Time series of $nDIC_{32}$ (= DIC / SSS * 32; salinity normalized DIC), SSS, SST.

## 4.13. PFCs･POPs

(1) Personnel

| | |
|---|---|
| Nobuyoshi YAMASHITA | National Institute of Advanced Industrial Science and Technology (AIST): PI |
| Sachi TANIYASU | AIST |

(2) Objective

The Stockholm Convention on Persistent Organic Pollutants (POPs) was adopted in 2001 with twelve POPs that potentially damage human health and the environment. They are divided into three categories: pesticides, industrial chemicals and by-products or unintentionally produced POPs (POPs 2010). Moreover, in 2009 a new list of nine POPs was added to the Convention, and in 2011 endosulfan and its related isomers were included. All POPs are categorized in three annexes. Annex A refers to “elimination”, Annex B to “restriction” and Annex C to “unintentional production”.

The global monitoring plan (GMP) for POPs is an important component of the effectiveness evaluation of the Stockholm Convention, providing a harmonized organizational framework for the collection of comparable monitoring data on the presence of POPs from all regions, in order to identify changes in levels over time, as well as provide information on their regional and global environmental transport.

To evaluate whether the levels of POPs listed under the Stockholm Convention have actually been reduced or eliminated as requested by Articles 3 and 5 of the Convention, information on environmental levels of the chemicals should enable detection of trends over time. Therefore, focus is upon monitoring of background levels of POPs at locations not influenced by local sources.

The objective of the POPs Global Monitoring Plan can therefore be described as to: Provide a harmonized organizational framework for the collection of comparable monitoring data on the presence of the POPs listed in Annexes A, B and C of the Convention in order to identify changes in concentrations over time as well as to provide information on their regional and global environmental transport. Reports on these activities form one of the components of information to be compiled by the global coordination group and the Secretariat to enable periodic effectiveness evaluations of the Convention by the Conference of the Parties.

The GMP focuses on generation of core media data from ambient air and human milk and blood. The programme started with an evaluation of the effectiveness of the Convention through regional monitoring reports that use existing national and international programs. There are regions/sub-regions which are not represented in the first global monitoring report where major data gaps have been identified. Such regions have been identified during the regional organization group inception workshops, and The Stockholm Convention Secretariat is supporting monitoring activities in these regions.

A newly added compound to Annex B with specific exemptions (decision SC-4/17) is the perfluorooctane sulfonic acid (PFOS). PFOS, as well as PFOA (perfluorooctanoic acid), not included in Annex B, are part of the broad class of perfluorocarboxylic acids (PFCAs), which in turn belong to the family of perfluoroalkylated substances (PFAS).

In addition to PFOS also two perfluorooctance sulfonamidoethanol (FOSEs), i.e. (NMEFOSE and NetFOSE), and two perfluorooctane sulphonamides (FOSAs), i.e. (NMeFOSA and NEtFOSA) have been included in Annex B. For the water monitoring, PFOS and PFOSA are recommended.

Environmentally persistent perfluoroalkyl substances (PFASs, shown in Figure 4.13- 1) have appeared as a new class of global pollutants for the last thirteen years.

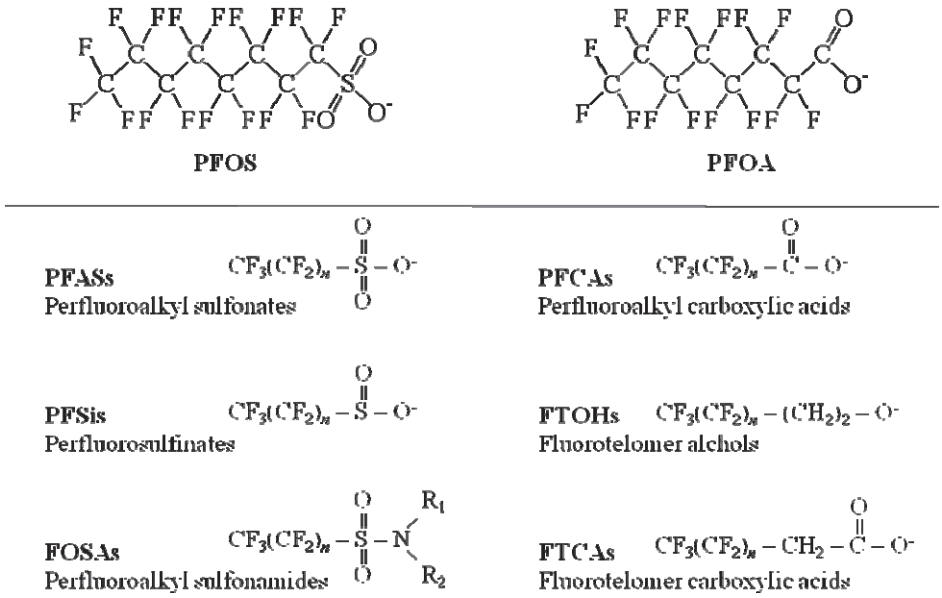


**Figure 4.13- 1.** Perfluoroalkyl substances (PFASs).

These compounds 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 PFASs, especially of PFSAs (perfluoro sulfonic acids) and PFCAs (perfluoro carboxylic acids) 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 PFASs in the oceans around the world, so far. We have conducted several international joint cruises, including South China Sea and Sulu Seas (KH-02-4), the central to Eastern Pacific Ocean (KH03-1 and MR11-08), , North and middle Atlantic Ocean, Southern Pacific and Antarctic Ocean (KH04-5, MR12-05), Labrador Sea and coastal seawater from Asian countries (Japan, China, Hong Kong, Korea) [1, 2, 3]. Vertical profiles of PFASs in the marine water column were associated with the global ocean circulation theory. We found that vertical profiles of PFASs 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 PFASs, 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 PFAS concentrations and profiles in the oceans adhere to a pattern consistent

with the global “Broecker’s Conveyor Belt” theory of open ocean water circulation.

In MR13-06, we tried to confirm the vertical profiles of PFASs found in water columns from above cruises and the Pacific Ocean (KH03-1 and MR11-08) and obtained open ocean samples for further analysis.

(3) Parameters

Perfluoroalkyl substances (PFASs)

(4) Instruments and Methods

Water samples were stored in clean 1 L polypropylene bottles and were kept frozen until analysis. Samples were thawed at room temperature, and a solid phase extraction method using WAX® cartridge (Waters Co.) was used for the determination of PFASs 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 4mL of 25 mM ammonium acetate buffer (pH 4) in Millipore water and dried by centrifugation at 3000 rpm for 2 min. The elution was then divided into two fractions. The first fraction was carried out with 4 mL methanol and the second with 4 mL 0.1% ammoniumhydroxide 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 was operated in the electrospray negative ionization mode. A 5 or 10-μL aliquot of the sample extract was injected into a Betasil C18 column (2.1 mm i.d. × 50 mm length, 5 μm; 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 were kept at 120 and 420°C respectively. MS/MS parameters are optimized so as to transmit the [M-K]- or [M-H]- ions.

MR13-06 is the sixth international research cruise that conducted measurement of POPs in Open ocean waters using ISO method (ISO25101). Because of recent scene of analytical chemistry, uncertainty and reliability of measurement supported by suitable quality assurance and quality control (QAQC) becoming to the essential issue. Our experimental result with ISO25101 supported by the international QAQC (ISO17025 with Guide45) and Japanese Industrial Standard (JIS) will provide the most reliable information of environmental chemistry in Open ocean research for now.

(5) Observation log

List of seawater samples (surface, subsurface and deep water) collected were presented in Table 4.13- 1 and Table 4.13- 2 as follows. Deep seawater samples were taken by Conductivity temperature depth profiler-Carousel multiple sampling system (CTD-CMS) attached X-Niskin samplers of 12 L, together with surface seawater samples taken by stainless bucket at all the water sampling stations. Subsurface waters were also collected from the out let tube of surface water analysis facility in MIRAI during Leg1 (on board ID: MR1306-WS01~WS31). The same sample collection

were kindly carried out by Marine Works Japan Co. Ltd during Leg 2 (on board ID: MR1306-WS32~WS41).

Atmospheric samples were taken with a comprehensive cryogenic moisture sampler (CMS; prototype) which was developed by AIST and SIBATA Co. The air sampler was operated with a flow rate of 10-20 L/min. Samples were collected during underway to avoid contamination from exhaust gas from ship. Operation of CMS was carried out by AIST (Leg 1, on board ID: MR1306-AR01 ~ AR15) and GODI (Leg 2, on board ID: MR1306-AR16 ~ AR18). List of air samples were presented in Table 4.13- 3.

Precipitation samples containing rain water and snow samples were also collected using polypropylene funnel (16.5 cm φ). List of precipitation samples were presented in Table 4.13- 4.

Sea ice sample was collected from one site during Leg 1. List of sea ice sample was presented in Table 4.13- 5.

All collected samples were stored at below -20°C until chemical analysis in AIST laboratory.

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC web site.

PI is requested to participate to "Global Monitoring Plan of the Stockholm Convention by UNEP". Result of survey in this cruise supposed to be useful data to make risk profile of new emerging chemicals according to the Stockholm Convention on Persistent Organic Pollutants (POPs).

(7) References


1) Yamashita N, Kannan K, Taniyasu S, Horii Y, Petrick G, Gamo T, A global survey of perfluorinated acids in oceans, Marine Pollution Bulletin 51 (2005) 658–668
2) Wei S, Chen LQ, Taniyasu S, So MK, Murphy MB, Yamashita N, Yeung LWY, Lam PKS, Distribution of perfluorinated compounds in surface seawaters between Asia and Antarctica, Marine Pollution Bulletin 54 (2007) 1813–1838
3) Yamashita N, Taniyasu S, Petrick G, Wei S, Gamo T, Lam PKL, Kannan K, Perfluorinated acids as novel chemical tracers of global circulation of ocean waters, Chemosphere 70 (2008) 1247–1255
4) Yamashita N, Kannan K, Taniyasu S, Horii Y, Okazawa T, Petrick G, Gamo T, Analysis of Perfluorinated Acids at Parts-Per-Quadrillion Levels in Seawater Using Liquid Chromatography-Tandem Mass Spectrometry, Environ. Sci. Technol. (2004) 38, 5522-5528
5) Taniyasu S, Kannan K, So MK, Gulkowskad A, Sinclair E, Okazawa T, Yamashita N, Analysis of fluorotelomer alcohols, fluorotelomer acids, and short- and long-chain perfluorinated acids in water and biota, Journal of Chromatography A, 1093 (2005) 89–97
6) ISO 25101 (2009) Water quality — Determination of perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) — Method for unfiltered samples using solid phase extraction and liquid chromatography/mass spectrometry

**Table 4.13- 1.** Summary of surface and deep seawater sampling for PFASs analysis

| On board ID | Sta | Cast | Date collected | | | | | Latitude | | | Longitude | | | Sampling Depth |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | YYYY | MM | DD | hh:mm | | deg | min | N/S | deg | min | E/W | m |
| MR1306-WB01 | 1 | 1 | 2013 | 08 | 31 | 19:51 | UTC | 65 | 46.18 | N | 168 | 14.90 | W | 0 |
| MR1306-W01 | 1 | 1 | 2013 | 08 | 31 | 19:51 | UTC | 65 | 46.18 | N | 168 | 14.90 | W | 18.9 |
| MR1306-W02 | 1 | 1 | 2013 | 08 | 31 | 19:51 | UTC | 65 | 46.18 | N | 168 | 14.90 | W | 4.8 |
| MR1306-W03 | 1 | 1 | 2013 | 08 | 31 | 19:51 | UTC | 65 | 46.18 | N | 168 | 14.90 | W | 9.8 |
| MR1306-W04 | 1 | 1 | 2013 | 08 | 31 | 19:51 | UTC | 65 | 46.18 | N | 168 | 14.90 | W | 20.0 |
| MR1306-W05 | 1 | 1 | 2013 | 08 | 31 | 19:51 | UTC | 65 | 46.18 | N | 168 | 14.90 | W | 29.3 |
| MR1306-W06 | 1 | 1 | 2013 | 08 | 31 | 19:51 | UTC | 65 | 46.18 | N | 168 | 14.90 | W | 44.4 |
| MR1306-WB02 | 3 | 1 | 2013 | 08 | 31 | 22:58 | UTC | 65 | 39.44 | N | 168 | 44.85 | W | 0 |
| MR1306-W07 | 3 | 1 | 2013 | 08 | 31 | 22:58 | UTC | 65 | 39.44 | N | 168 | 44.85 | W | 17.7 |
| MR1306-W08 | 3 | 1 | 2013 | 08 | 31 | 22:58 | UTC | 65 | 39.44 | N | 168 | 44.85 | W | 5.3 |
| MR1306-W09 | 3 | 1 | 2013 | 08 | 31 | 22:58 | UTC | 65 | 39.44 | N | 168 | 44.85 | W | 10.3 |
| MR1306-W10 | 3 | 1 | 2013 | 08 | 31 | 22:58 | UTC | 65 | 39.44 | N | 168 | 44.85 | W | 20.0 |
| MR1306-W11 | 3 | 1 | 2013 | 08 | 31 | 22:58 | UTC | 65 | 39.44 | N | 168 | 44.85 | W | 29.9 |
| MR1306-W12 | 3 | 1 | 2013 | 08 | 31 | 22:58 | UTC | 65 | 39.44 | N | 168 | 44.85 | W | 36.4 |
| MR1306-WB03 | 4 | 1 | 2013 | 09 | 01 | 01:45 | UTC | 66 | 0.24 | N | 168 | 15.07 | W | 0 |
| MR1306-W13 | 4 | 1 | 2013 | 09 | 01 | 01:45 | UTC | 66 | 0.24 | N | 168 | 15.07 | W | 10.1 |
| MR1306-W14 | 4 | 1 | 2013 | 09 | 01 | 01:45 | UTC | 66 | 0.24 | N | 168 | 15.07 | W | 5.0 |
| MR1306-W15 | 4 | 1 | 2013 | 09 | 01 | 01:45 | UTC | 66 | 0.24 | N | 168 | 15.07 | W | 10.1 |
| MR1306-W16 | 4 | 1 | 2013 | 09 | 01 | 01:45 | UTC | 66 | 0.24 | N | 168 | 15.07 | W | 20.2 |
| MR1306-W17 | 4 | 1 | 2013 | 09 | 01 | 01:45 | UTC | 66 | 0.24 | N | 168 | 15.07 | W | 30.1 |
| MR1306-W18 | 4 | 1 | 2013 | 09 | 01 | 01:45 | UTC | 66 | 0.24 | N | 168 | 15.07 | W | 39.7 |
| MR1306-W19 | 4 | 1 | 2013 | 09 | 01 | 01:45 | UTC | 66 | 0.24 | N | 168 | 15.07 | W | 44.2 |
| MR1306-WB04 | 8 | 1 | 2013 | 09 | 01 | 18:48 | UTC | 68 | 0.25 | N | 168 | 14.18 | W | 0 |
| MR1306-W20 | 8 | 1 | 2013 | 09 | 01 | 18:48 | UTC | 68 | 0.25 | N | 168 | 14.18 | W | 8.1 |
| MR1306-W21 | 8 | 1 | 2013 | 09 | 01 | 18:48 | UTC | 68 | 0.25 | N | 168 | 14.18 | W | 5.1 |
| MR1306-W22 | 8 | 1 | 2013 | 09 | 01 | 18:48 | UTC | 68 | 0.25 | N | 168 | 14.18 | W | 9.9 |
| MR1306-W23 | 8 | 1 | 2013 | 09 | 01 | 18:48 | UTC | 68 | 0.25 | N | 168 | 14.18 | W | 19.9 |
| MR1306-W24 | 8 | 1 | 2013 | 09 | 01 | 18:48 | UTC | 68 | 0.25 | N | 168 | 14.18 | W | 29.9 |
| MR1306-W25 | 8 | 1 | 2013 | 09 | 01 | 18:48 | UTC | 68 | 0.25 | N | 168 | 14.18 | W | 39.7 |
| MR1306-W26 | 8 | 1 | 2013 | 09 | 01 | 18:48 | UTC | 68 | 0.25 | N | 168 | 14.18 | W | 52.5 |
| MR1306-WB05 | 18 | 1 | 2013 | 09 | 04 | 06:50 | UTC | 71 | 24.67 | N | 157 | 29.54 | W | 0 |
| MR1306-W27 | 18 | 1 | 2013 | 09 | 04 | 06:50 | UTC | 71 | 24.67 | N | 157 | 29.54 | W | 12.9 |
| MR1306-W28 | 18 | 1 | 2013 | 09 | 04 | 06:50 | UTC | 71 | 24.67 | N | 157 | 29.54 | W | 4.6 |
| MR1306-W29 | 18 | 1 | 2013 | 09 | 04 | 06:50 | UTC | 71 | 24.67 | N | 157 | 29.54 | W | 9.5 |
| MR1306-W30 | 18 | 1 | 2013 | 09 | 04 | 06:50 | UTC | 71 | 24.67 | N | 157 | 29.54 | W | 19.8 |
| MR1306-W31 | 18 | 1 | 2013 | 09 | 04 | 06:50 | UTC | 71 | 24.67 | N | 157 | 29.54 | W | 29.4 |
| MR1306-W32 | 18 | 1 | 2013 | 09 | 04 | 06:50 | UTC | 71 | 24.67 | N | 157 | 29.54 | W | 39.7 |
| MR1306-W33 | 18 | 1 | 2013 | 09 | 04 | 06:50 | UTC | 71 | 24.67 | N | 157 | 29.54 | W | 49.7 |
| MR1306-W34 | 18 | 1 | 2013 | 09 | 04 | 06:50 | UTC | 71 | 24.67 | N | 157 | 29.54 | W | 74.4 |
| MR1306-W35 | 18 | 1 | 2013 | 09 | 04 | 06:50 | UTC | 71 | 24.67 | N | 157 | 29.54 | W | 99.2 |
| MR1306-W36 | 18 | 1 | 2013 | 09 | 04 | 06:50 | UTC | 71 | 24.67 | N | 157 | 29.54 | W | 113.2 |
| MR1306-WB06 | 26 | 1 | 2013 | 09 | 04 | 22:51 | UTC | 71 | 44.19 | N | 155 | 53.40 | W | 0 |
| MR1306-W37 | 26 | 1 | 2013 | 09 | 04 | 22:51 | UTC | 71 | 44.19 | N | 155 | 53.40 | W | 19.6 |
| MR1306-W38 | 26 | 1 | 2013 | 09 | 04 | 22:51 | UTC | 71 | 44.19 | N | 155 | 53.40 | W | 5.5 |
| MR1306-W39 | 26 | 1 | 2013 | 09 | 04 | 22:51 | UTC | 71 | 44.19 | N | 155 | 53.40 | W | 10.1 |
| MR1306-W40 | 26 | 1 | 2013 | 09 | 04 | 22:51 | UTC | 71 | 44.19 | N | 155 | 53.40 | W | 19.7 |
| MR1306-W41 | 26 | 1 | 2013 | 09 | 04 | 22:51 | UTC | 71 | 44.19 | N | 155 | 53.40 | W | 29.8 |
| MR1306-W42 | 26 | 1 | 2013 | 09 | 04 | 22:51 | UTC | 71 | 44.19 | N | 155 | 53.40 | W | 49.1 |
| MR1306-W43 | 26 | 1 | 2013 | 09 | 04 | 22:51 | UTC | 71 | 44.19 | N | 155 | 53.40 | W | 99.0 |
| MR1306-W44 | 26 | 1 | 2013 | 09 | 04 | 22:51 | UTC | 71 | 44.19 | N | 155 | 53.40 | W | 148.5 |
| MR1306-W45 | 26 | 1 | 2013 | 09 | 04 | 22:51 | UTC | 71 | 44.19 | N | 155 | 53.40 | W | 198.4 |
| MR1306-W46 | 26 | 1 | 2013 | 09 | 04 | 22:51 | UTC | 71 | 44.19 | N | 155 | 53.40 | W | 246.5 |
| MR1306-WB07 | 29 | 1 | 2013 | 09 | 05 | 08:55 | UTC | 72 | 40.82 | N | 154 | 12.05 | W | 0 |
| MR1306-W47 | 29 | 1 | 2013 | 09 | 05 | 08:55 | UTC | 72 | 40.82 | N | 154 | 12.05 | W | 10.3 |
| MR1306-W48 | 29 | 1 | 2013 | 09 | 05 | 08:55 | UTC | 72 | 40.82 | N | 154 | 12.05 | W | 25.1 |
| MR1306-W49 | 29 | 1 | 2013 | 09 | 05 | 08:55 | UTC | 72 | 40.82 | N | 154 | 12.05 | W | 49.8 |
| MR1306-W50 | 29 | 1 | 2013 | 09 | 05 | 08:55 | UTC | 72 | 40.82 | N | 154 | 12.05 | W | 99.5 |
| MR1306-W51 | 29 | 1 | 2013 | 09 | 05 | 08:55 | UTC | 72 | 40.82 | N | 154 | 12.05 | W | 148.7 |
| MR1306-W52 | 29 | 1 | 2013 | 09 | 05 | 08:55 | UTC | 72 | 40.82 | N | 154 | 12.05 | W | 198.7 |
| MR1306-W53 | 29 | 1 | 2013 | 09 | 05 | 08:55 | UTC | 72 | 40.82 | N | 154 | 12.05 | W | 491.2 |
| MR1306-W54 | 29 | 1 | 2013 | 09 | 05 | 08:55 | UTC | 72 | 40.82 | N | 154 | 12.05 | W | 791.0 |
| MR1306-W55 | 29 | 1 | 2013 | 09 | 05 | 08:55 | UTC | 72 | 40.82 | N | 154 | 12.05 | W | 987.4 |
| MR1306-W56 | 29 | 1 | 2013 | 09 | 05 | 08:55 | UTC | 72 | 40.82 | N | 154 | 12.05 | W | 1479.9 |
| MR1306-W57 | 29 | 1 | 2013 | 09 | 05 | 08:55 | UTC | 72 | 40.82 | N | 154 | 12.05 | W | 1971.7 |
| MR1306-W58 | 29 | 1 | 2013 | 09 | 05 | 08:55 | UTC | 72 | 40.82 | N | 154 | 12.05 | W | 2752.6 |
| MR1306-W59 | 29 | 1 | 2013 | 09 | 05 | 08:55 | UTC | 72 | 40.82 | N | 154 | 12.05 | W | 2915.3 |

Table 4.13- 1. (continued)

| On board ID | Sta | Cast | Date collected | | | | | Latitude | | | Longitude | | | Sampling Depth |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | YYYY | MM | DD | hh:mm | | deg | min | N/S | deg | min | E/W | m |
| MR1306-WB08 | 31 | 1 | 2013 | 09 | 08 | 05:47 | UTC | 74 | 31.83 | N | 161 | 5.28 | W | 0 |
| MR1306-W60 | 31 | 1 | 2013 | 09 | 08 | 05:47 | UTC | 74 | 31.83 | N | 161 | 5.28 | W | 46.4 |
| MR1306-W61 | 31 | 1 | 2013 | 09 | 08 | 05:47 | UTC | 74 | 31.83 | N | 161 | 5.28 | W | 4.6 |
| MR1306-W62 | 31 | 1 | 2013 | 09 | 08 | 05:47 | UTC | 74 | 31.83 | N | 161 | 5.28 | W | 9.8 |
| MR1306-W63 | 31 | 1 | 2013 | 09 | 08 | 05:47 | UTC | 74 | 31.83 | N | 161 | 5.28 | W | 19.8 |
| MR1306-W64 | 31 | 1 | 2013 | 09 | 08 | 05:47 | UTC | 74 | 31.83 | N | 161 | 5.28 | W | 49.3 |
| MR1306-W65 | 31 | 1 | 2013 | 09 | 08 | 05:47 | UTC | 74 | 31.83 | N | 161 | 5.28 | W | 99.0 |
| MR1306-W66 | 31 | 1 | 2013 | 09 | 08 | 05:47 | UTC | 74 | 31.83 | N | 161 | 5.28 | W | 148.5 |
| MR1306-W67 | 31 | 1 | 2013 | 09 | 08 | 05:47 | UTC | 74 | 31.83 | N | 161 | 5.28 | W | 198.0 |
| MR1306-W68 | 31 | 1 | 2013 | 09 | 08 | 05:47 | UTC | 74 | 31.83 | N | 161 | 5.28 | W | 495.2 |
| MR1306-W69 | 31 | 1 | 2013 | 09 | 08 | 05:47 | UTC | 74 | 31.83 | N | 161 | 5.28 | W | 789.4 |
| MR1306-W70 | 31 | 1 | 2013 | 09 | 08 | 05:47 | UTC | 74 | 31.83 | N | 161 | 5.28 | W | 986.4 |
| MR1306-W71 | 31 | 1 | 2013 | 09 | 08 | 05:47 | UTC | 74 | 31.83 | N | 161 | 5.28 | W | 1480.3 |
| MR1306-W72 | 31 | 1 | 2013 | 09 | 08 | 05:47 | UTC | 74 | 31.83 | N | 161 | 5.28 | W | 1680.0 |
| MR1306-WB09 | 34 | 1 | 2013 | 09 | 09 | 21:39 | UTC | 73 | 59.83 | N | 168 | 15.47 | W | 0 |
| MR1306-W73 | 34 | 1 | 2013 | 09 | 09 | 21:39 | UTC | 73 | 59.83 | N | 168 | 15.47 | W | 35.2 |
| MR1306-W74 | 34 | 1 | 2013 | 09 | 09 | 21:39 | UTC | 73 | 59.83 | N | 168 | 15.47 | W | 4.7 |
| MR1306-W75 | 34 | 1 | 2013 | 09 | 09 | 21:39 | UTC | 73 | 59.83 | N | 168 | 15.47 | W | 9.8 |
| MR1306-W76 | 34 | 1 | 2013 | 09 | 09 | 21:39 | UTC | 73 | 59.83 | N | 168 | 15.47 | W | 19.7 |
| MR1306-W77 | 34 | 1 | 2013 | 09 | 09 | 21:39 | UTC | 73 | 59.83 | N | 168 | 15.47 | W | 29.4 |
| MR1306-W78 | 34 | 1 | 2013 | 09 | 09 | 21:39 | UTC | 73 | 59.83 | N | 168 | 15.47 | W | 39.5 |
| MR1306-W79 | 34 | 1 | 2013 | 09 | 09 | 21:39 | UTC | 73 | 59.83 | N | 168 | 15.47 | W | 49.3 |
| MR1306-W80 | 34 | 1 | 2013 | 09 | 09 | 21:39 | UTC | 73 | 59.83 | N | 168 | 15.47 | W | 99.0 |
| MR1306-W81 | 34 | 1 | 2013 | 09 | 09 | 21:39 | UTC | 73 | 59.83 | N | 168 | 15.47 | W | 148.2 |
| MR1306-W82 | 34 | 1 | 2013 | 09 | 09 | 21:39 | UTC | 73 | 59.83 | N | 168 | 15.47 | W | 173.8 |
| MR1306-WB10 | 37 | 1 | 2013 | 09 | 10 | 12:36 | UTC | 72 | 30.06 | N | 168 | 15.03 | W | 0 |
| MR1306-W84 | 37 | 1 | 2013 | 09 | 10 | 12:36 | UTC | 72 | 30.06 | N | 168 | 15.03 | W | 22.3 |
| MR1306-W85 | 37 | 1 | 2013 | 09 | 10 | 12:36 | UTC | 72 | 30.06 | N | 168 | 15.03 | W | 5.0 |
| MR1306-W86 | 37 | 1 | 2013 | 09 | 10 | 12:36 | UTC | 72 | 30.06 | N | 168 | 15.03 | W | 10.5 |
| MR1306-W87 | 37 | 1 | 2013 | 09 | 10 | 12:36 | UTC | 72 | 30.06 | N | 168 | 15.03 | W | 20.2 |
| MR1306-W88 | 37 | 1 | 2013 | 09 | 10 | 12:36 | UTC | 72 | 30.06 | N | 168 | 15.03 | W | 30.0 |
| MR1306-W89 | 37 | 1 | 2013 | 09 | 10 | 12:36 | UTC | 72 | 30.06 | N | 168 | 15.03 | W | 39.9 |
| MR1306-W90 | 37 | 1 | 2013 | 09 | 10 | 12:36 | UTC | 72 | 30.06 | N | 168 | 15.03 | W | 48.6 |
| MR1306-WB11 | 41 | 5 | 2013 | 09 | 10 | 12:36 | UTC | 72 | 45.03 | N | 168 | 44.96 | W | 0 |
| MR1306-W91 | 41 | 5 | 2013 | 09 | 11 | 20:42 | UTC | 72 | 45.03 | N | 168 | 44.96 | W | 24.9 |
| MR1306-W92 | 41 | 5 | 2013 | 09 | 11 | 20:42 | UTC | 72 | 45.03 | N | 168 | 44.96 | W | 5.3 |
| MR1306-W93 | 41 | 5 | 2013 | 09 | 11 | 20:42 | UTC | 72 | 45.03 | N | 168 | 44.96 | W | 10.2 |
| MR1306-W94 | 41 | 5 | 2013 | 09 | 11 | 20:42 | UTC | 72 | 45.03 | N | 168 | 44.96 | W | 20.0 |
| MR1306-W95 | 41 | 5 | 2013 | 09 | 11 | 20:42 | UTC | 72 | 45.03 | N | 168 | 44.96 | W | 29.9 |
| MR1306-W96 | 41 | 5 | 2013 | 09 | 11 | 20:42 | UTC | 72 | 45.03 | N | 168 | 44.96 | W | 39.8 |
| MR1306-W97 | 41 | 5 | 2013 | 09 | 11 | 20:42 | UTC | 72 | 45.03 | N | 168 | 44.96 | W | 47.2 |
| MR1306-WB12 | 41 | 25 | 2013 | 09 | 16 | 20:42 | UTC | 72 | 45.09 | N | 168 | 44.80 | W | 0 |
| MR1306-W98 | 41 | 25 | 2013 | 09 | 16 | 20:42 | UTC | 72 | 45.09 | N | 168 | 44.80 | W | 4.8 |
| MR1306-W99 | 41 | 25 | 2013 | 09 | 16 | 20:42 | UTC | 72 | 45.09 | N | 168 | 44.80 | W | 19.3 |
| MR1306-W100 | 41 | 25 | 2013 | 09 | 16 | 20:42 | UTC | 72 | 45.09 | N | 168 | 44.80 | W | 30.0 |
| MR1306-W101 | 41 | 25 | 2013 | 09 | 16 | 20:42 | UTC | 72 | 45.09 | N | 168 | 44.80 | W | 39.8 |
| MR1306-W102 | 41 | 25 | 2013 | 09 | 16 | 20:42 | UTC | 72 | 45.09 | N | 168 | 44.80 | W | 9.8 |
| MR1306-W103 | 41 | 25 | 2013 | 09 | 16 | 20:42 | UTC | 72 | 45.09 | N | 168 | 44.80 | W | 50.8 |
| MR1306-WB13 | 41 | 45 | 2013 | 09 | 21 | 20:41 | UTC | 72 | 44.99 | N | 168 | 44.93 | W | 0 |
| MR1306-W104 | 41 | 45 | 2013 | 09 | 21 | 20:41 | UTC | 72 | 44.99 | N | 168 | 44.93 | W | 5.2 |
| MR1306-W105 | 41 | 45 | 2013 | 09 | 21 | 20:41 | UTC | 72 | 44.99 | N | 168 | 44.93 | W | 10.1 |
| MR1306-W106 | 41 | 45 | 2013 | 09 | 21 | 20:41 | UTC | 72 | 44.99 | N | 168 | 44.93 | W | 20.0 |
| MR1306-W107 | 41 | 45 | 2013 | 09 | 21 | 20:41 | UTC | 72 | 44.99 | N | 168 | 44.93 | W | 29.5 |
| MR1306-W108 | 41 | 45 | 2013 | 09 | 21 | 20:41 | UTC | 72 | 44.99 | N | 168 | 44.93 | W | 39.8 |
| MR1306-W109 | 41 | 45 | 2013 | 09 | 21 | 20:41 | UTC | 72 | 44.99 | N | 168 | 44.93 | W | 50.7 |
| MR1306-WB14 | 46 | 1 | 2013 | 09 | 25 | 13:22 | UTC | 72 | 48.43 | N | 167 | 13.44 | W | 0 |
| MR1306-W110 | 46 | 1 | 2013 | 09 | 25 | 13:22 | UTC | 72 | 48.43 | N | 167 | 13.44 | W | 5.2 |
| MR1306-W111 | 46 | 1 | 2013 | 09 | 25 | 13:22 | UTC | 72 | 48.43 | N | 167 | 13.44 | W | 10.3 |
| MR1306-W112 | 46 | 1 | 2013 | 09 | 25 | 13:22 | UTC | 72 | 48.43 | N | 167 | 13.44 | W | 19.8 |
| MR1306-W113 | 46 | 1 | 2013 | 09 | 25 | 13:22 | UTC | 72 | 48.43 | N | 167 | 13.44 | W | 29.5 |
| MR1306-W114 | 46 | 1 | 2013 | 09 | 25 | 13:22 | UTC | 72 | 48.43 | N | 167 | 13.44 | W | 39.7 |
| MR1306-W115 | 46 | 1 | 2013 | 09 | 25 | 13:22 | UTC | 72 | 48.43 | N | 167 | 13.44 | W | 51.7 |

Table 4.13- 1. (continued)

| On board ID | Sta | Cast | Date collected | | | | | Latitude | | | Longitude | | | Sampling Depth |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | YYYY | MM | DD | hh : mm | | deg | min | N/S | deg | min | E/W | m |
| MR1306-WB15 | 47 | 1 | 2013 | 09 | 26 | 01:14 | UTC | 72 | 59.16 | N | 168 | 4.25 | W | 0 |
| MR1306-W116 | 47 | 1 | 2013 | 09 | 26 | 01:14 | UTC | 72 | 59.16 | N | 168 | 4.25 | W | 10.2 |
| MR1306-W117 | 47 | 1 | 2013 | 09 | 26 | 01:14 | UTC | 72 | 59.16 | N | 168 | 4.25 | W | 20.4 |
| MR1306-W118 | 47 | 1 | 2013 | 09 | 26 | 01:14 | UTC | 72 | 59.16 | N | 168 | 4.25 | W | 30.1 |
| MR1306-W119 | 47 | 1 | 2013 | 09 | 26 | 01:14 | UTC | 72 | 59.16 | N | 168 | 4.25 | W | 39.8 |
| MR1306-W120 | 47 | 1 | 2013 | 09 | 26 | 01:14 | UTC | 72 | 59.16 | N | 168 | 4.25 | W | 49.7 |
| MR1306-W121 | 47 | 1 | 2013 | 09 | 26 | 01:14 | UTC | 72 | 59.16 | N | 168 | 4.25 | W | 63.2 |
| MR1306-WB16 | 52 | 1 | 2013 | 09 | 26 | 22:03 | UTC | 73 | 3.75 | N | 164 | 22.86 | W | 0 |
| MR1306-W122 | 52 | 1 | 2013 | 09 | 26 | 22:03 | UTC | 73 | 3.75 | N | 164 | 22.86 | W | 5.1 |
| MR1306-W123 | 52 | 1 | 2013 | 09 | 26 | 22:03 | UTC | 73 | 3.75 | N | 164 | 22.86 | W | 10.3 |
| MR1306-W124 | 52 | 1 | 2013 | 09 | 26 | 22:03 | UTC | 73 | 3.75 | N | 164 | 22.86 | W | 20.1 |
| MR1306-W125 | 52 | 1 | 2013 | 09 | 26 | 22:03 | UTC | 73 | 3.75 | N | 164 | 22.86 | W | 30.0 |
| MR1306-W126 | 52 | 1 | 2013 | 09 | 26 | 22:03 | UTC | 73 | 3.75 | N | 164 | 22.86 | W | 39.7 |
| MR1306-W127 | 52 | 1 | 2013 | 09 | 26 | 22:03 | UTC | 73 | 3.75 | N | 164 | 22.86 | W | 49.7 |
| MR1306-W128 | 52 | 1 | 2013 | 09 | 26 | 22:03 | UTC | 73 | 3.75 | N | 164 | 22.86 | W | 67.3 |
| MR1306-WB17 | 56 | 1 | 2013 | 09 | 27 | 12:25 | UTC | 73 | 48.03 | N | 159 | 0.62 | W | 0 |
| MR1306-W129 | 56 | 1 | 2013 | 09 | 27 | 12:25 | UTC | 73 | 48.03 | N | 159 | 0.62 | W | 5.2 |
| MR1306-W130 | 56 | 1 | 2013 | 09 | 27 | 12:25 | UTC | 73 | 48.03 | N | 159 | 0.62 | W | 10.0 |
| MR1306-W131 | 56 | 1 | 2013 | 09 | 27 | 12:25 | UTC | 73 | 48.03 | N | 159 | 0.62 | W | 19.8 |
| MR1306-W132 | 56 | 1 | 2013 | 09 | 27 | 12:25 | UTC | 73 | 48.03 | N | 159 | 0.62 | W | 49.6 |
| MR1306-W133 | 56 | 1 | 2013 | 09 | 27 | 12:25 | UTC | 73 | 48.03 | N | 159 | 0.62 | W | 98.8 |
| MR1306-W134 | 56 | 1 | 2013 | 09 | 27 | 12:25 | UTC | 73 | 48.03 | N | 159 | 0.62 | W | 148.7 |
| MR1306-W135 | 56 | 1 | 2013 | 09 | 27 | 12:25 | UTC | 73 | 48.03 | N | 159 | 0.62 | W | 197.6 |
| MR1306-W136 | 56 | 1 | 2013 | 09 | 27 | 12:25 | UTC | 73 | 48.03 | N | 159 | 0.62 | W | 494.5 |
| MR1306-W137 | 56 | 1 | 2013 | 09 | 27 | 12:25 | UTC | 73 | 48.03 | N | 159 | 0.62 | W | 791.3 |
| MR1306-W138 | 56 | 1 | 2013 | 09 | 27 | 12:25 | UTC | 73 | 48.03 | N | 159 | 0.62 | W | 988.2 |
| MR1306-W139 | 56 | 1 | 2013 | 09 | 27 | 12:25 | UTC | 73 | 48.03 | N | 159 | 0.62 | W | 1970.2 |
| MR1306-W140 | 56 | 1 | 2013 | 09 | 27 | 12:25 | UTC | 73 | 48.03 | N | 159 | 0.62 | W | 2460.5 |
| MR1306-W141 | 56 | 1 | 2013 | 09 | 27 | 12:25 | UTC | 73 | 48.03 | N | 159 | 0.62 | W | 2637.3 |
| MR1306-WB18 | 59 | 1 | 2013 | 09 | 28 | 05:33 | UTC | 72 | 44.32 | N | 162 | 31.55 | W | 0 |
| MR1306-W142 | 59 | 1 | 2013 | 09 | 28 | 05:33 | UTC | 72 | 44.32 | N | 162 | 31.55 | W | 4.7 |
| MR1306-W143 | 59 | 1 | 2013 | 09 | 28 | 05:33 | UTC | 72 | 44.32 | N | 162 | 31.55 | W | 9.7 |
| MR1306-W144 | 59 | 1 | 2013 | 09 | 28 | 05:33 | UTC | 72 | 44.32 | N | 162 | 31.55 | W | 20.0 |
| MR1306-W145 | 59 | 1 | 2013 | 09 | 28 | 05:33 | UTC | 72 | 44.32 | N | 162 | 31.55 | W | 30.1 |
| MR1306-W146 | 59 | 1 | 2013 | 09 | 28 | 05:33 | UTC | 72 | 44.32 | N | 162 | 31.55 | W | 40.0 |
| MR1306-WB19 | 41 | 62 | 2013 | 09 | 30 | 21:00 | UTC | 72 | 45.11 | N | 168 | 44.58 | W | 0 |
| MR1306-W147 | 41 | 62 | 2013 | 09 | 30 | 21:00 | UTC | 72 | 45.11 | N | 168 | 44.58 | W | 4.9 |
| MR1306-W148 | 41 | 62 | 2013 | 09 | 30 | 21:00 | UTC | 72 | 45.11 | N | 168 | 44.58 | W | 9.5 |
| MR1306-W149 | 41 | 62 | 2013 | 09 | 30 | 21:00 | UTC | 72 | 45.11 | N | 168 | 44.58 | W | 19.5 |
| MR1306-W150 | 41 | 62 | 2013 | 09 | 30 | 21:00 | UTC | 72 | 45.11 | N | 168 | 44.58 | W | 29.5 |
| MR1306-W151 | 41 | 62 | 2013 | 09 | 30 | 21:00 | UTC | 72 | 45.11 | N | 168 | 44.58 | W | 39.4 |
| MR1306-W152 | 41 | 62 | 2013 | 09 | 30 | 21:00 | UTC | 72 | 45.11 | N | 168 | 44.58 | W | 50.8 |
| MR1306-WB20 | 65 | 1 | 2013 | 10 | 02 | 12:05 | UTC | 70 | 0.06 | N | 168 | 15.04 | W | 0 |
| MR1306-W153 | 65 | 1 | 2013 | 10 | 02 | 12:05 | UTC | 70 | 0.06 | N | 168 | 15.04 | W | 4.9 |
| MR1306-W154 | 65 | 1 | 2013 | 10 | 02 | 12:05 | UTC | 70 | 0.06 | N | 168 | 15.04 | W | 9.9 |
| MR1306-W155 | 65 | 1 | 2013 | 10 | 02 | 12:05 | UTC | 70 | 0.06 | N | 168 | 15.04 | W | 20.1 |
| MR1306-W156 | 65 | 1 | 2013 | 10 | 02 | 12:05 | UTC | 70 | 0.06 | N | 168 | 15.04 | W | 29.9 |
| MR1306-W157 | 65 | 1 | 2013 | 10 | 02 | 12:05 | UTC | 70 | 0.06 | N | 168 | 15.04 | W | 35.3 |
| MR1306-WB21 | 68 | 1 | 2013 | 10 | 02 | 22:56 | UTC | 68 | 18.08 | N | 167 | 57.25 | W | 0 |
| MR1306-W158 | 68 | 1 | 2013 | 10 | 02 | 22:56 | UTC | 68 | 18.08 | N | 167 | 57.25 | W | 5.0 |
| MR1306-W159 | 68 | 1 | 2013 | 10 | 02 | 22:56 | UTC | 68 | 18.08 | N | 167 | 57.25 | W | 9.9 |
| MR1306-W160 | 68 | 1 | 2013 | 10 | 02 | 22:56 | UTC | 68 | 18.08 | N | 167 | 57.25 | W | 19.9 |
| MR1306-W161 | 68 | 1 | 2013 | 10 | 02 | 22:56 | UTC | 68 | 18.08 | N | 167 | 57.25 | W | 30.1 |

**Table 4.13- 2.** Summary of sub-surface seawater sampling for PFASs analysis

| On board ID | Sta | Cast | Date collected | | | | | Latitude | | | Longitude | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | YYYY | MM | DD | hh:mm | | deg | min | N/S | deg | min | E/W |
| MR1306-WS01 | - | - | 2013 | 08 | 28 | 22:30 | UTC | 54 | 33.00 | N | 166 | 37.44 | W |
| MR1306-WS02 | - | - | 2013 | 08 | 29 | 17:40 | UTC | 58 | 11.38 | N | 167 | 29.33 | W |
| MR1306-WS03 | - | - | 2013 | 08 | 30 | 20:50 | UTC | 62 | 43.55 | N | 167 | 20.76 | W |
| MR1306-WS04 | 1 | - | 2013 | 08 | 31 | 19:03 | UTC | 65 | 45.87 | N | 168 | 45.59 | W |
| MR1306-WS05 | 3 | - | 2013 | 08 | 31 | 23:02 | UTC | 65 | 39.54 | N | 168 | 45.27 | W |
| MR1306-WS06 | 4 | - | 2013 | 09 | 01 | 01:56 | UTC | 66 | 0.38 | N | 168 | 44.91 | W |
| MR1306-WS07 | 8 | - | 2013 | 09 | 01 | 18:07 | UTC | 68 | 45.13 | N | 168 | 45.38 | W |
| MR1306-WS08 | - | - | 2013 | 09 | 02 | 10:18 | UTC | 70 | 7.29 | N | 164 | 32.27 | W |
| MR1306-WS09 | 18 | - | 2013 | 09 | 03 | 06:21 | UTC | 71 | 23.71 | N | 157 | 29.94 | W |
| MR1306-WS10 | 26 | - | 2013 | 09 | 04 | 22:40 | UTC | 71 | 44.14 | N | 155 | 6.55 | W |
| MR1306-WS11 | - | - | 2013 | 09 | 05 | 20:20 | UTC | 71 | 40.29 | N | 155 | 0.28 | W |
| MR1306-WS12 | - | - | 2013 | 09 | 07 | 06:06 | UTC | 72 | 40.06 | N | 154 | 47.95 | W |
| MR1306-WS13 | - | - | 2013 | 09 | 08 | 03:36 | UTC | 74 | 46.15 | N | 161 | 59.71 | W |
| MR1306-WS14 | 31 | 1 | 2013 | 09 | 08 | 05:42 | UTC | 74 | 31.82 | N | 161 | 54.78 | W |
| MR1306-WS15 | 31 | 2 | 2013 | 09 | 09 | 00:37 | UTC | 74 | 32.12 | N | 161 | 57.95 | W |
| MR1306-WS16 | 34 | 1 | 2013 | 09 | 09 | 23:02 | UTC | 73 | 60.00 | N | 168 | 44.47 | W |
| MR1306-WS17 | | | 2013 | 09 | 10 | 12:25 | UTC | 72 | 30.01 | N | 168 | 45.00 | W |
| MR1306-WS18 | 41 | 5 | 2013 | 09 | 11 | 20:55 | UTC | 72 | 45.07 | N | 168 | 14.89 | W |
| MR1306-WS19 | 41 | 25 | 2013 | 09 | 16 | 20:55 | UTC | 72 | 45.20 | N | 168 | 15.38 | W |
| MR1306-WS20 | 41 | 45 | 2013 | 09 | 21 | 20:55 | UTC | 72 | 45.04 | N | 168 | 14.97 | W |
| MR1306-WS21 | 46 | 1 | 2013 | 09 | 25 | 13:20 | UTC | 72 | 48.43 | N | 167 | 46.61 | W |
| MR1306-WS22 | 47 | 1 | 2013 | 09 | 26 | 01:26 | UTC | 72 | 59.17 | N | 168 | 55.84 | W |
| MR1306-WS23 | 52 | 1 | 2013 | 09 | 26 | 21:50 | UTC | 73 | 3.80 | N | 164 | 37.40 | W |
| MR1306-WS24 | 56 | 1 | 2013 | 09 | 27 | 12:41 | UTC | 73 | 48.06 | N | 159 | 59.28 | W |
| MR1306-WS25 | 59 | 1 | 2013 | 09 | 28 | 05:33 | UTC | 72 | 44.32 | N | 162 | 31.55 | W |
| MR1306-WS26 | 41 | 62 | 2013 | 09 | 30 | 21:07 | UTC | 72 | 45.13 | N | 168 | 0.00 | W |
| MR1306-WS27 | 65 | 1 | 2013 | 10 | 02 | 11:59 | UTC | 70 | 0.03 | N | 168 | 44.99 | W |
| MR1306-WS28 | 68 | 1 | 2013 | 10 | 02 | 23:05 | UTC | 68 | 18.12 | N | 167 | 2.73 | W |
| MR1306-WS29 | 77 | - | 2013 | 10 | 03 | 22:11 | UTC | 67 | 59.95 | N | 168 | 45.64 | W |
| MR1306-WS30 | - | - | 2013 | 10 | 05 | 23:12 | UTC | 60 | 51.73 | N | 167 | 44.43 | W |
| MR1306-WS31 | - | - | 2013 | 10 | 06 | 20:35 | UTC | 57 | 18.29 | N | 167 | 15.99 | W |
| MR1306-WS32 | - | - | 2013 | 10 | 9 | 22:43 | UTC | 54 | 13.09 | N | 167 | 24.52 | W |
| MR1306-WS33 | - | - | 2013 | 10 | 10 | 19:29 | UTC | 53 | 58.12 | N | 173 | 18.05 | W |
| MR1306-WS34 | - | - | 2013 | 10 | 11 | 20:12 | UTC | 53 | 35.27 | N | 178 | 7.63 | E |
| MR1306-WS35 | - | - | 2013 | 10 | 12 | 20:42 | UTC | 52 | 15.49 | N | 170 | 53.79 | E |
| MR1306-WS36 | - | - | 2013 | 10 | 14 | 3:33 | UTC | 48 | 46.70 | N | 165 | 51.58 | E |
| MR1306-WS37 | - | - | 2013 | 10 | 15 | 1:34 | UTC | 45 | 57.30 | N | 162 | 35.25 | E |
| MR1306-WS38 | - | - | 2013 | 10 | 16 | 2:07 | UTC | 42 | 32.79 | N | 157 | 42.34 | E |
| MR1306-WS39 | - | - | 2013 | 10 | 17 | 3:04 | UTC | 40 | 38.89 | N | 153 | 49.33 | E |
| MR1306-WS40 | - | - | 2013 | 10 | 18 | 3:39 | UTC | 40 | 6.30 | N | 148 | 31.21 | E |
| MR1306-WS41 | - | - | 2013 | 10 | 19 | 6:02 | UTC | 40 | 23.26 | N | 142 | 26.46 | E |

**Table 4.13- 3.** Summary of air sampling by CMS for PFASs analysis

| On board ID | | Date collected | | | | | Latitude | | | Longitude | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | YYYY | MM | DD | hh : mm | | deg | min | N/S | deg | min | E/W |
| MR1306-AR01 | start | 2013 | 08 | 28 | 08:00 | UTC | 54 | 14.45 | N | 166 | 32.41 | W |
| | stop | 2013 | 08 | 30 | 01:21 | UTC | 59 | 36.55 | N | 167 | 50.94 | W |
| MR1306-AR02 | start | 2013 | 08 | 30 | 03:22 | UTC | 59 | 55.17 | N | 167 | 55.71 | W |
| | stop | 2013 | 08 | 31 | 17:04 | UTC | 65 | 37.71 | N | 168 | 28.13 | W |
| MR1306-AR03 | start | 2013 | 09 | 02 | 02:26 | UTC | 69 | 2.02 | N | 168 | 37.90 | W |
| | stop | 2013 | 09 | 02 | 21:56 | UTC | 71 | 19.63 | N | 157 | 39.59 | W |
| MR1306-AR04 | start | 2013 | 09 | 07 | 01:30 | UTC | 71 | 49.88 | N | 155 | 18.97 | W |
| | stop | 2013 | 09 | 08 | 03:59 | UTC | 73 | 59.67 | N | 161 | 58.25 | W |
| MR1306-AR05 | start | 2013 | 09 | 09 | 06:19 | UTC | 74 | 30.94 | N | 161 | 57.00 | W |
| | stop | 2013 | 09 | 10 | 03:31 | UTC | 73 | 28.89 | N | 168 | 21.34 | W |
| MR1306-AR06 | start | 2013 | 09 | 10 | 06:31 | UTC | 73 | 20.51 | N | 168 | 20.65 | W |
| | stop | 2013 | 09 | 11 | 02:35 | UTC | 72 | 44.97 | N | 168 | 15.00 | W |
| MR1306-AR07 | start | 2013 | 09 | 12 | 17:33 | UTC | 72 | 44.99 | N | 168 | 16.08 | W |
| | stop | 2013 | 09 | 13 | 04:50 | UTC | 72 | 44.56 | N | 168 | 17.36 | W |
| MR1306-AR08 | start | 2013 | 09 | 13 | 04:50 | UTC | 72 | 44.56 | N | 168 | 17.36 | W |
| | stop | 2013 | 09 | 14 | 02:01 | UTC | 72 | 46.38 | N | 168 | 15.09 | W |
| MR1306-AR09 | start | 2013 | 09 | 14 | 03:13 | UTC | 72 | 45.08 | N | 168 | 15.09 | W |
| | stop | 2013 | 09 | 15 | 07:30 | UTC | 72 | 38.69 | N | 168 | 15.23 | W |
| MR1306-AR10 | start | 2013 | 09 | 15 | 16:08 | UTC | 72 | 44.75 | N | 168 | 15.54 | W |
| | stop | 2013 | 09 | 16 | 16:58 | UTC | 72 | 43.61 | N | 168 | 16.69 | W |
| MR1306-AR11 | start | 2013 | 09 | 22 | 23:04 | UTC | 72 | 45.26 | N | 168 | 14.21 | W |
| | stop | 2013 | 09 | 23 | 22:36 | UTC | 72 | 45.45 | N | 168 | 13.76 | W |
| MR1306-AR12 | start | 2013 | 09 | 26 | 02:51 | UTC | 73 | 14.50 | N | 168 | 53.03 | W |
| | stop | 2013 | 09 | 28 | 04:40 | UTC | 72 | 52.37 | N | 162 | 25.78 | W |
| MR1306-AR13 | start | 2013 | 09 | 30 | 00:14 | UTC | 71 | 20.69 | N | 157 | 40.37 | W |
| | stop | 2013 | 09 | 30 | 17:39 | UTC | 72 | 44.75 | N | 168 | 18.60 | W |
| MR1306-AR14 | start | 2013 | 10 | 01 | 17:35 | UTC | 72 | 44.46 | N | 163 | 15.73 | W |
| | stop | 2013 | 10 | 04 | 05:22 | UTC | 67 | 15.05 | N | 168 | 45.02 | W |
| MR1306-AR15 | start | 2013 | 10 | 04 | 22:21 | UTC | 65 | 33.83 | N | 168 | 18.32 | W |
| | stop | 2013 | 10 | 07 | 04:05 | UTC | 55 | 58.90 | N | 166 | 56.67 | W |
| MR1306-AR16 | start | 2013 | 10 | 09 | 22:50 | UTC | 54 | 13.05 | N | 167 | 26.79 | W |
| | stop | 2013 | 10 | 13 | 01:30 | UTC | 51 | 22.99 | N | 169 | 45.80 | E |
| MR1306-AR17 | start | 2013 | 10 | 14 | 01:40 | UTC | 48 | 46.64 | N | 166 | 19.19 | E |
| | stop | 2013 | 10 | 16 | 03:43 | UTC | 42 | 15.84 | N | 157 | 24.06 | E |
| MR1306-AR18 | start | 2013 | 10 | 16 | 04:10 | UTC | 42 | 10.77 | N | 157 | 18.94 | E |
| | stop | 2013 | 10 | 18 | 23:15 | UTC | 40 | 19.44 | N | 143 | 46.30 | E |

**Table 4.13- 4.** Summary of precipitation sampling for PFASs analysis

| On board ID | | Date collected | | | | | Latitude | | | Longitude | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | YYYY | MM | DD | hh : mm | | deg | min | N/S | deg | min | E/W |
| MR1306-R01 | start | 2013 | 08 | 27 | 00:36 | UTC | 53 | 54.21 | N | 166 | 31.55 | W |
| | stop | 2013 | 08 | 28 | 17:30 | UTC | ” | " | N | ” | " | W |
| MR1306-R02 | start | 2013 | 08 | 31 | 01:51 | UTC | 63 | 29.74 | N | 167 | 43.58 | W |
| | stop | 2013 | 08 | 31 | 16:42 | UTC | 65 | 35.02 | N | 168 | 29.06 | W |
| MR1306-R03 | start | 2013 | 09 | 02 | 19:13 | UTC | 71 | 12.56 | N | 159 | 25.41 | W |
| | stop | 2013 | 09 | 03 | 23:57 | UTC | 71 | 14.82 | N | 157 | 9.90 | W |
| MR1306-R04 | start | 2013 | 09 | 03 | 23:57 | UTC | 71 | 14.82 | N | 157 | 9.90 | W |
| | stop | 2013 | 09 | 06 | 20:54 | UTC | 71 | 43.03 | N | 155 | 8.32 | W |
| MR1306-R05 | start | 2013 | 09 | 06 | 20:54 | UTC | 71 | 43.03 | N | 155 | 8.32 | W |
| | stop | 2013 | 09 | 09 | 20:07 | UTC | 74 | 9.80 | N | 168 | 25.37 | W |
| MR1306-R06 | start | 2013 | 09 | 09 | 20:07 | UTC | 74 | 9.80 | N | 168 | 25.37 | W |
| | stop | 2013 | 09 | 12 | 17:08 | UTC | 72 | 44.28 | N | 168 | 12.79 | W |
| MR1306-R07 | start | 2013 | 09 | 12 | 17:08 | UTC | 74 | 9.80 | N | 168 | 25.37 | W |
| | stop | 2013 | 09 | 16 | 15:53 | UTC | 72 | 44.52 | N | 168 | 14.29 | W |
| MR1306-R08 | start | 2013 | 09 | 16 | 15:53 | UTC | 72 | 44.52 | N | 168 | 14.29 | W |
| | stop | 2013 | 09 | 19 | 22:16 | UTC | 72 | 45.25 | N | 168 | 15.74 | W |
| MR1306-R09 | start | 2013 | 09 | 19 | 22:16 | UTC | 72 | 45.25 | N | 168 | 15.74 | W |
| | stop | 2013 | 09 | 24 | 16:10 | UTC | 72 | 45.31 | N | 168 | 14.14 | W |
| MR1306-R10 | start | 2013 | 09 | 24 | 16:10 | UTC | 72 | 45.31 | N | 168 | 14.14 | W |
| | stop | 2013 | 09 | 28 | 21:32 | UTC | 71 | 19.62 | N | 157 | 39.66 | W |
| MR1306-R11 | start | 2013 | 09 | 28 | 21:32 | UTC | 71 | 19.62 | N | 157 | 39.66 | W |
| | stop | 2013 | 10 | 01 | 02:17 | UTC | 72 | 45.79 | N | 168 | 15.06 | W |
| MR1306-R12 | start | 2013 | 10 | 01 | 02:17 | UTC | 72 | 45.79 | N | 168 | 15.06 | W |
| | stop | 2013 | 10 | 02 | 20:04 | UTC | 68 | 44.58 | N | 168 | 9.02 | W |
| MR1306-R13 | start | 2013 | 10 | 02 | 20:04 | UTC | 68 | 44.58 | N | 168 | 9.02 | W |
| | stop | 2013 | 10 | 06 | 02:13 | UTC | 60 | 22.01 | N | 167 | 55.99 | W |
| MR1306-R14 | start | 2013 | 10 | 06 | 02:13 | UTC | 60 | 22.01 | N | 167 | 55.99 | W |
| | stop | 2013 | 10 | 06 | 23:22 | UTC | 56 | 47.24 | N | 167 | 7.94 | W |
| MR1306-R15 | start | 2013 | 10 | 06 | 23:22 | UTC | 56 | 47.24 | N | 167 | 7.94 | W |
| | stop | 2013 | 10 | 07 | 17:58 | UTC | 53 | 56.66 | N | 166 | 29.09 | W |

**Table 4.13- 5.** Summary of sea ice sampling for PFASs analysis

| On board ID | Date collected | | | | | Latitude | | | Longitude | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | YYYY | MM | DD | hh : mm | | deg | min | N/S | deg | min | E/W |
| MR1306-Ice01 | 2013 | 09 | 08 | 03:34 | UTC | 74 | 46.65 | N | 161 | 59.58 | W |

## 4.14. Zooplankton

(1) Personnel

Kohei Matsuno (National Institute of Polar Research)
Atsushi Yamaguchi (Hokkaido University, not onboard)
Toru Hirawake (Hokkaido University, not onboard): Principal Investigator
Naomi Harada (JAMSTEC, not onboard)
Katsunori Kimoto (JAMSTEC)
Takahito Ikenoue (Kyushu University)

(2) Objective

After 1990s, decreasing of sea ice in the Arctic Ocean is reported in the western Arctic Ocean because of increasing amount of the warm Pacific water passed into the Arctic Ocean. The Pacific water passed through the Bering Strait may induce intrusion of the Pacific originated zooplankton to the Arctic Ocean. Previously, the transported Pacific zooplankton is considered to be died off. It has been reported to be extinct transportation (invalid dispersion) because the amount of the transported zooplankton was few before 1990s. The transported zooplankton by Pacific water is mainly composed by large-sized copepods (*Neocalanus cristatus, N. flemingeri*, *N. plumchrus*, *Eucalanus bungii*, *Metridia pacifica*), which are dominant components in the North Pacific Ocean (Matsuno et al., 2011, 2012).

The zooplankton fauna in the Arctic Ocean is known to be completely varied with that in the North Pacific. Early copepodite stages of the Pacific copepods (e.g. *Neocalanus* spp.) grow and store oil in their body during phytoplankton bloom. Pre-adult stage (C5) of the Pacific copepods descent into deeper layer (>1000 m), mature and spawn at that depth. While the spawning of the Arctic copepods (e.g. *Calanus glacialis* and *Metridia longa*) is known to occur at epipelagic zone with grazing during phytoplankton bloom. Thus, the utilization of phytoplankton bloom varied with species fauna: i.e. the Pacific species utilize as energy of growth of young, while the Arctic species as energy of reproduction of adults. Therefore the Pacific copepods may use efficiently the energy of the phytoplankton bloom than the Arctic copepods, and biological efficiency of the Pacific copepods is known to be higher than that of the Arctic copepods (Parsons and Lalli, 1988).

In the western Arctic Ocean where the sea ice is decreasing, the Pacific copepods may be intruded and inhabited, but the details of their ecological impact haves not been evaluated.

The goals of this study are following:

1) Estimate the amount of the transported Pacific copepods into the Arctic Ocean.
2) Evaluate physical conditions (gut pigment and lipid accumulation) of the Pacific and Arctic copepods in the Arctic Ocean.
3) Clarify the grazing impact of the transported Pacific copepods in the Arctic Ocean ecosystem.

(3) Sampling

Zooplankton samples were collected by vertical haul of two type nets at 36 stations in the western Arctic Ocean. Twin NORPAC net (mesh sizes: 335 and 62 μm, mouth diameter: 45 cm) was towed between surface and 150 m depth or bottom -5 m (stations where the bottom shallower than 150 m) at all stations (Fig. 4.14-1 and Table 4.14-1). Zooplankton samples collected by the NORPAC net with 335 μm mesh were immediately fixed with 5% buffered formalin for zooplankton structure analysis. Other samples collected with 62 μm mesh were split with Motoda box splitter. One aliquot was immediately fixed with 5% buffered formalin for zooplankton structure analysis later. The remaining aliquot was fixed with 99.5% ethanol for analysis on Foraminifera and Radiolaria (investigator: Katsunori Kimoto [JAMSTEC] and Takahito Ikenoue [Kyushu University]). The volume of water filtered through the net was estimated from the reading of a flow-meter mounted in the mouth ring. Also, we collected water samples from five depths (0, 5, 10, 20 and 30 m) at 18 stations to investigate microplankton community in the western Arctic Ocean. The samples were immediately fixed with 1% glutaraldehyde.

80 cm ring net (mesh: 335 μm, mouth diameter: 80 cm) was towed between surface and 150 m depth or bottom -5 m at 8 stations (Fig. 4.14-1 and Table 4.14-2), fresh samples were used for grazing experiments (8 times at 5 stations) and evaluation of the copepod physiological activity (i.e. wet mass, dry mass, ash-free dry mass and gut pigment) (51 times at 1 fixed station). Also, the 80 cm ring net was towed between surface and bottom -5 m at 5 stations, the fresh samples were immediately fixed with 5% buffered formalin for collecting Euphausiacea (investigator: Minoru Kitamura [JAMSTEC]).

Closing PCP net (mesh size: 62 μm, mouth diameter: 60 cm) was towed at 1 fixed station from 2 layers (0–20 m and 20–49 m) when the clear stratification was identified by temperature and salinity. VMPS (mesh size: 62 μm, open mouth area: 0.276 $m^2$) was towed from 4 layers (0–100–250–500–1000 m) at 2 stations. The volume of water filtered through the net was estimated from the reading of a flow-meter mounted in the mouth ring. Zooplankton samples collected by closing PCP net and VMPS were split

with Motoda box splitter. One aliquot was immediately fixed with 5% buffered formalin for zooplankton structure analysis (Fig. 4.14-1 and Table 4.14-3). The remaining aliquot was fixed with 99.5% ethanol for analysis on Foraminifera and Radiolaria (investigator: Katsunori Kimoto [JAMSTEC] and Takahito Ikenoue [Kyushu University]).

(4) On-board treatment

[Individual wet weight, dry weight, ash-free dry mass and gut pigment]

Fresh zooplankton samples collected with 80 cm ring net were immediately added with 10% soda water ($CO_2$ water) used for gut pigment analysis. We sorted with late copepodid stages of the Pacific copepods (*Neocalanus cristatus, N. plumchrus, N. flemingeri, Eucalanus bungii, Metridia pacifica*) and the Arctic copepods (*Calanus glacialis, C. hyperboreus, M. longa*). Some specimens were rinsed with distilled water, transferred into pre-weighted aluminum pan and stored in -30°C. At land laboratory, these samples will be weighed for wet weight, dry weight, and ash-free dry mass with a precision of 0.01 g using an electronic balance. Other specimens transferred into a cuvette tube immersed with 6 ml dimethylformamide, stored and extracted for >24 hours. After extract the pigment, these samples were measured fluorescence with a Turner model 10-005-R Filter Fluorometer.

[Grazing rate experiment] (by Matsuno, Fujiwara, Yamaguchi and Hirawake [Hokkaido University])

Fresh zooplankton samples collected with 80 cm ring net were sorted with Pacific copepods (*Neocalanus cristatus* C5, *N. plumchrus* C5, *N. flemingeri* C5) and Arctic copepods (*Calanus glacialis* C5, *C. hyperboreus* C6F and *Metridia longa* C6F). Sorting was made only for individuals that were actively swimming and undamaged. These specimens were re-sorted into an experiments bottle (2.2 L) filled with ambient sea water from chlorophyll maximum layer, and were incubated for 24h in a experiment cistern on-deck with running surface sea water and ambient light condition. After incubation, the experiment water filtered 10, 2 and 0.45 μm size-fractioned.

(5) Results

As preliminary results, we present following items.

Figure 4.14-1: Location of the plankton net sampling stations.

Figure 4.14-2: Time-series changes on gut pigment of *C. glacialis* C5 at fixed station.

(6) References

Parsons, T. R. and C. M. Lalli (1988) Comparative oceanic ecology of the plankton communities of the subarctic Atlantic and Pacific Oceans. *Oceanogr. Mar. Biol. Annu. Rev.*, **26**, 317-359.

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Table 4.14-1. Data on plankton samples collected by vertical hauls with twin NORPAC net.
GG54: 335 μm mesh.

| Station | Position | | S.M.T. | | Length of | Angle of | Depth estimated | Kind of | Flowmeter | | Estimated volume of | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| no. | Lat. (N) | Lon. | Date | Hour | wire (m) | wire (°) | by wire angle (m) | cloth | No. | Reading | water filtered ($m^3$) | Remark |
| 001 | 65-46 | 168-45 W | 31 Aug. | 8:28 | 45 | 3 | 45 | GG54 | 1039 | 310 | 5.39 | |
| | | | | | | | | 62 μm | 2771 | 168 | 2.99 | 1) |
| 003 | 65-41 | 168-17 W | 31 Aug. | 12:38 | 38 | 5 | 38 | GG54 | 1039 | 325 | 5.65 | |
| | | | | | | | | 62 μm | 2771 | 265 | 4.72 | 1) |
| 005 | 66-30 | 168-45 W | 31 Aug. | 18:10 | 48 | 4 | 48 | GG54 | 1039 | 408 | 7.09 | |
| | | | | | | | | 62 μm | 2771 | 86 | 1.53 | 1) |
| 007 | 67-30 | 168-45 W | 1 Sep. | 0:41 | 42 | 9 | 41 | GG54 | 1039 | 390 | 6.78 | |
| | | | | | | | | 62 μm | 2771 | 197 | 3.51 | 1) |
| 008 | 68-00 | 168-45 W | 1 Sep. | 7:10 | 52 | 5 | 52 | GG54 | 1039 | 397 | 6.90 | |
| | | | | | | | | 62 μm | 2771 | 250 | 4.45 | 1) |
| 009 | 68-30 | 168-45 W | 1 Sep. | 11:46 | 46 | 1 | 46 | GG54 | 1039 | 361 | 6.27 | |
| | | | | | | | | 62 μm | 2771 | 278 | 4.95 | 1) |
| 011 | 71-21 | 157-37 W | 2 Sep. | 18:52 | 100 | 15 | 97 | GG54 | 1039 | 822 | 14.29 | |
| | | | | | | | | 62 μm | 2771 | 510 | 9.08 | 1) |
| 014 | 71-15 | 157-10 W | 3 Sep. | 13:52 | 39 | 9 | 39 | GG54 | 1039 | 332 | 5.77 | |
| | | | | | | | | 62 μm | 2771 | 212 | 3.77 | 1) |
| 018 | 71-25 | 157-31 W | 3 Sep. | 20:24 | 115 | 9 | 114 | GG54 | 1039 | 1035 | 17.99 | |
| | | | | | | | | 62 μm | 2771 | 757 | 13.48 | 1) |
| 022 | 71-33 | 156-21 W | 4 Sep. | 3:35 | 150 | 3 | 150 | GG54 | 1039 | 1230 | 21.38 | |
| | | | | | | | | 62 μm | 2771 | 839 | 14.94 | 1) |
| 024 | 71-36 | 154-51 W | 4 Sep. | 8:05 | 37 | 2 | 37 | GG54 | 1039 | 388 | 6.74 | |
| | | | | | | | | 62 μm | 2771 | 315 | 5.61 | 1) |
| 026 | 71-44 | 155-06 W | 4 Sep. | 12:36 | 150 | 4 | 150 | GG54 | 1039 | 1198 | 20.82 | |
| | | | | | | | | 62 μm | 2771 | 750 | 13.35 | 1) |
| 028 | 71-56 | 155-40 W | 4 Sep. | 16:34 | 132 | 4 | 132 | GG54 | 1039 | 1097 | 19.07 | |
| | | | | | | | | 62 μm | 2771 | 768 | 13.67 | 1) |
| 031 | 74-32 | 161-54 W | 7 Sep. | 20:07 | 150 | 3 | 150 | GG54 | 1039 | 1185 | 20.60 | |
| | | | | | | | | 62 μm | 2771 | 761 | 13.55 | 1) |
| 033 | 74-10 | 162-01 W | 8 Sep. | 23:00 | 150 | 2 | 150 | GG54 | 1039 | 1164 | 20.23 | |
| | | | | | | | | 62 μm | 2771 | 756 | 13.46 | 1) |
| 034 | 74-00 | 168-44 W | 9 Sep. | 11:23 | 150 | 3 | 150 | GG54 | 1039 | 1149 | 19.97 | |
| | | | | | | | | 62 μm | 2771 | 736 | 13.10 | 1) |

S.M.T. was GMT-11h.
1) shared 1/2 sample with JAMSTEC Kimoto

Table 4.14-1. (Continued)

| Station no. | Position | | S.M.T. | | Length of wire (m) | Angle of wire (°) | Depth estimated by wire angle (m) | Kind of cloth | Flowmeter | | Estimated volume of water filtered ($m^3$) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lat. (N) | Lon. | Date | Hour | | | | | No. | Reading | | |
| 035 | 73-00 | 168-45 W | 9 Sep. | 21:16 | 54 | 5 | 54 | GG54 | 1039 | 442 | 7.68 | |
| | | | | | | | | 62 μm | 2771 | 334 | 5.95 | 1) |
| 041 | 72-45 | 168-15 W | 10 Sep. | 9:45 | 49 | 4 | 49 | GG54 | 1039 | 409 | 7.11 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 297 | 5.29 | 1) |
| 041 | 72-45 | 168-15 W | 10 Sep. | 22:12 | 49 | 5 | 49 | GG54 | 1039 | 406 | 7.06 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 268 | 4.77 | 1) |
| 041 | 72-45 | 168-15 W | 11 Sep. | 10:52 | 49 | 1 | 49 | GG54 | 1039 | 392 | 6.81 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 264 | 4.70 | 1) |
| 041 | 72-45 | 168-15 W | 11 Sep. | 22:10 | 49 | 1 | 49 | GG54 | 1039 | 405 | 7.04 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 260 | 4.63 | 1) |
| 041 | 72-45 | 168-15 W | 12 Sep. | 10:25 | 49 | 2 | 49 | GG54 | 1039 | 372 | 6.47 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 275 | 4.90 | 1) |
| 041 | 72-45 | 168-15 W | 12 Sep. | 22:14 | 49 | 1 | 49 | GG54 | 1039 | 410 | 7.13 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 268 | 4.77 | 1) |
| 041 | 72-45 | 168-15 W | 13 Sep. | 10:56 | 49 | 2 | 49 | GG54 | 1039 | 411 | 7.14 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 300 | 5.34 | 1) |
| 041 | 72-45 | 168-15 W | 13 Sep. | 22:13 | 49 | 2 | 49 | GG54 | 1039 | 435 | 7.56 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 286 | 5.09 | 1) |
| 041 | 72-45 | 168-15 W | 14 Sep. | 10:35 | 49 | 1 | 49 | GG54 | 1039 | 503 | 8.74 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 357 | 6.36 | 1) |
| 041 | 72-45 | 168-15 W | 14 Sep. | 22:16 | 49 | 1 | 49 | GG54 | 1039 | 460 | 8.00 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 330 | 5.88 | 1) |
| 041 | 72-45 | 168-15 W | 15 Sep. | 10:50 | 49 | 1 | 49 | GG54 | 1039 | 412 | 7.16 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 313 | 5.57 | 1) |
| 041 | 72-45 | 168-15 W | 15 Sep. | 22:14 | 49 | 6 | 49 | GG54 | 1039 | 420 | 7.30 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 270 | 4.81 | 1) |
| 041 | 72-45 | 168-15 W | 16 Sep. | 10:35 | 49 | 1 | 49 | GG54 | 1039 | 448 | 7.79 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 280 | 4.98 | 1) |
| 041 | 72-45 | 168-15 W | 16 Sep. | 22:35 | 49 | 4 | 49 | GG54 | 1039 | 416 | 7.23 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 265 | 4.72 | |
| 041 | 72-45 | 168-15 W | 17 Sep. | 4:13 | 49 | 2 | 49 | GG54 | 1039 | 440 | 7.65 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 312 | 5.55 | |
| 041 | 72-45 | 168-15 W | 17 Sep. | 10:48 | 49 | 1 | 49 | GG54 | 1039 | 415 | 7.21 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 295 | 5.25 | |
| 041 | 72-45 | 168-15 W | 17 Sep. | 16:08 | 49 | 1 | 49 | GG54 | 1039 | 462 | 8.03 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 318 | 5.66 | |
| 041 | 72-45 | 168-15 W | 17 Sep. | 22:12 | 49 | 2 | 49 | GG54 | 1039 | 425 | 7.39 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 300 | 5.34 | |
| 041 | 72-45 | 168-15 W | 18 Sep. | 4:09 | 49 | 1 | 49 | GG54 | 1039 | 400 | 6.95 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 275 | 4.90 | |
| 041 | 72-45 | 168-15 W | 18 Sep. | 10:29 | 49 | 1 | 49 | GG54 | 1039 | 423 | 7.35 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 271 | 4.82 | |
| 041 | 72-45 | 168-15 W | 18 Sep. | 16:10 | 49 | 1 | 49 | GG54 | 1039 | 489 | 8.50 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 350 | 6.23 | |
| 041 | 72-45 | 168-15 W | 18 Sep. | 22:14 | 49 | 1 | 49 | GG54 | 1039 | 443 | 7.70 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 285 | 5.07 | |
| 041 | 72-45 | 168-15 W | 19 Sep. | 4:12 | 49 | 3 | 49 | GG54 | 1039 | 564 | 9.80 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 398 | 7.09 | |
| 041 | 72-45 | 168-15 W | 19 Sep. | 10:51 | 49 | 2 | 49 | GG54 | 1039 | 478 | 8.31 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 313 | 5.57 | |
| 041 | 72-45 | 168-15 W | 19 Sep. | 16:08 | 49 | 2 | 49 | GG54 | 1039 | 461 | 8.01 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 340 | 6.05 | |

S.M.T. was GMT-11h.

1) shared 1/2 sample with JAMSTEC Kimoto

Table 4.14-1. (Continued)

| Station no. | Position | | S.M.T. | | Length of wire (m) | Angle of wire (°) | Depth estimated by wire angle (m) | Kind of cloth | Flowmeter | | Estimated volume of water filtered ($m^3$) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lat. (N) | Lon. | Date | Hour | | | | | No. | Reading | | |
| 041 | 72-45 | 168-15 W | 19 Sep. | 22:21 | 49 | 2 | 49 | GG54 | 1039 | 489 | 8.50 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 364 | 6.48 | |
| 041 | 72-45 | 168-15 W | 20 Sep. | 4:13 | 49 | 3 | 49 | GG54 | 1039 | 447 | 7.77 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 333 | 5.93 | |
| 041 | 72-45 | 168-15 W | 20 Sep. | 10:46 | 49 | 8 | 49 | GG54 | 1039 | 460 | 8.00 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 409 | 7.28 | |
| 041 | 72-45 | 168-15 W | 20 Sep. | 16:14 | 49 | 2 | 49 | GG54 | 1039 | 526 | 9.14 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 366 | 6.52 | |
| 041 | 72-45 | 168-15 W | 20 Sep. | 22:18 | 49 | 7 | 49 | GG54 | 1039 | 446 | 7.75 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 401 | 7.14 | |
| 041 | 72-45 | 168-15 W | 21 Sep. | 4:13 | 49 | 3 | 49 | GG54 | 1039 | 463 | 8.05 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 370 | 6.59 | |
| 041 | 72-45 | 168-15 W | 21 Sep. | 11:01 | 49 | 1 | 49 | GG54 | 1039 | 476 | 8.27 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 321 | 5.71 | |
| 041 | 72-45 | 168-15 W | 21 Sep. | 16:10 | 49 | 2 | 49 | GG54 | 1039 | 423 | 7.35 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 303 | 5.39 | |
| 041 | 72-45 | 168-15 W | 21 Sep. | 22:11 | 49 | 4 | 49 | GG54 | 1039 | 506 | 8.80 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 336 | 5.98 | |
| 041 | 72-45 | 168-15 W | 22 Sep. | 4:08 | 49 | 2 | 49 | GG54 | 1039 | 416 | 7.23 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 285 | 5.07 | |
| 041 | 72-45 | 168-15 W | 22 Sep. | 11:09 | 49 | 1 | 49 | GG54 | 1039 | 395 | 6.87 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 262 | 4.66 | |
| 041 | 72-45 | 168-15 W | 22 Sep. | 16:10 | 49 | 2 | 49 | GG54 | 1039 | 400 | 6.95 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 258 | 4.59 | |
| 041 | 72-45 | 168-15 W | 22 Sep. | 22:12 | 49 | 1 | 49 | GG54 | 1039 | 395 | 6.87 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 230 | 4.09 | |
| 041 | 72-45 | 168-15 W | 23 Sep. | 4:10 | 49 | 1 | 49 | GG54 | 1039 | 413 | 7.18 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 268 | 4.77 | |
| 041 | 72-45 | 168-15 W | 23 Sep. | 10:39 | 49 | 1 | 49 | GG54 | 1039 | 397 | 6.90 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 268 | 4.77 | |
| 041 | 72-45 | 168-15 W | 23 Sep. | 16:10 | 49 | 1 | 49 | GG54 | 1039 | 424 | 7.37 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 266 | 4.74 | |
| 041 | 72-45 | 168-15 W | 23 Sep. | 22:13 | 49 | 1 | 49 | GG54 | 1039 | 405 | 7.04 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 251 | 4.47 | |
| 041 | 72-45 | 168-15 W | 24 Sep. | 4:15 | 49 | 4 | 49 | GG54 | 1039 | 425 | 7.39 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 295 | 5.25 | |
| 041 | 72-45 | 168-15 W | 24 Sep. | 11:10 | 49 | 1 | 49 | GG54 | 1039 | 459 | 7.98 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 294 | 5.23 | |
| 041 | 72-45 | 168-15 W | 24 Sep. | 16:09 | 49 | 1 | 49 | GG54 | 1039 | 468 | 8.13 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 312 | 5.55 | |
| 041 | 72-45 | 168-15 W | 24 Sep. | 22:17 | 49 | 1 | 49 | GG54 | 1039 | 405 | 7.04 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 260 | 4.63 | |
| 041 | 72-45 | 168-15 W | 25 Sep. | 10:50 | 49 | 2 | 49 | GG54 | 1039 | 422 | 7.34 | |
| (Fixed station) | | | | | | | | 62 μm | 2771 | 250 | 4.45 | 1) |
| 049 | 73-30 | 168-45 W | 26 Sep. | 0:03 | 110 | 5 | 110 | GG54 | 1039 | 838 | 14.57 | |
| | | | | | | | | 62 μm | 2771 | 560 | 9.97 | 1) |
| 052 | 73-04 | 164-37 W | 26 Sep. | 11:45 | 66 | 1 | 66 | GG54 | 1039 | 545 | 9.47 | |
| | | | | | | | | 62 μm | 2771 | 349 | 6.21 | 1) |
| 054 | 73-42 | 162-39 W | 26 Sep. | 18:11 | 151 | 8 | 150 | GG54 | 1039 | 1188 | 20.65 | |
| | | | | | | | | 62 μm | 2771 | 779 | 13.87 | 1) |
| 056 | 73-48 | 159-59 W | 27 Sep. | 3:00 | 150 | 2 | 150 | GG54 | 1039 | 1218 | 21.17 | |
| | | | | | | | | 62 μm | 2771 | 867 | 15.44 | 1) |

S.M.T. was GMT-11h.

1) shared 1/2 sample with JAMSTEC Kimoto

Table 4.14-1. (Continued)

| Station no. | Position Lat. (N) | Lon. | S.M.T. Date | Hour | Length of wire (m) | Angle of wire (°) | Depth estimated by wire angle (m) | Kind of cloth | Flowmeter No. | Reading | Estimated volume of water filtered ($m^3$) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 058 | 73-09 | 162-17 W | 27 Sep. | 15:54 | 151 | 8 | 150 | GG54 | 1039 | 1185 | 20.60 | |
| | | | | | | | | 62 µm | 2771 | 830 | 14.78 | 1) |
| 061 | 72-00 | 168-44 W | 1 Oct. | 12:16 | 43 | 3 | 43 | GG54 | 1039 | 368 | 6.40 | |
| | | | | | | | | 62 µm | 2771 | 258 | 4.59 | 1) |
| 063 | 71-00 | 168-45 W | 1 Oct. | 18:32 | 37 | 8 | 37 | GG54 | 1039 | 321 | 5.58 | |
| | | | | | | | | 62 µm | 2771 | 180 | 3.20 | 1) |
| 065 | 70-00 | 168-45 W | 2 Oct. | 0:45 | 34 | 1 | 34 | GG54 | 1039 | 302 | 5.25 | |
| | | | | | | | | 62 µm | 2771 | 175 | 3.12 | 1) |
| 067 | 69-00 | 168-45 W | 2 Oct. | 7:30 | 46 | 9 | 45 | GG54 | 1039 | 406 | 7.06 | |
| | | | | | | | | 62 µm | 2771 | 250 | 4.45 | 1) |
| 068 | 68-18 | 167-03 W | 2 Oct. | 12:59 | 31 | 5 | 31 | GG54 | 1039 | 263 | 4.57 | |
| | | | | | | | | 62 µm | 2771 | 195 | 3.47 | 1) |
| 070 | 68-12 | 167-20 W | 2 Oct. | 15:04 | 40 | 6 | 40 | GG54 | 1039 | 313 | 5.44 | |
| | | | | | | | | 62 µm | 2771 | 239 | 4.25 | 1) |
| 072 | 68-00 | 168-00 W | 2 Oct. | 18:48 | 47 | 6 | 47 | GG54 | 1039 | 376 | 6.54 | |
| | | | | | | | | 62 µm | 2771 | 188 | 3.35 | 1) |
| 074 | 67-45 | 168-30 W | 2 Oct. | 22:07 | 42 | 4 | 42 | GG54 | 1039 | 351 | 6.10 | |
| | | | | | | | | 62 µm | 2771 | 250 | 4.45 | 1) |
| 077 | 68-00 | 168-45 W | 3 Oct. | 10:16 | 51 | 1 | 51 | GG54 | 1039 | 436 | 7.58 | |
| | | | | | | | | 62 µm | 2771 | 270 | 4.81 | 1) |
| 081 | 67-00 | 168-45 W | 3 Oct. | 21:04 | 38 | 3 | 38 | GG54 | 1039 | 376 | 6.54 | |
| | | | | | | | | 62 µm | 2771 | 282 | 5.02 | 1) |
| 083 | 66-00 | 168-45 W | 4 Oct. | 4:06 | 46 | 1 | 46 | GG54 | 1039 | 377 | 6.55 | |
| | | | | | | | | 62 µm | 2771 | 319 | 5.68 | 1) |
| 084 | 65-46 | 168-45 W | 4 Oct. | 7:58 | 45 | 1 | 45 | GG54 | 1039 | 374 | 6.50 | |
| | | | | | | | | 62 µm | 2771 | 264 | 4.70 | 1) |
| 086 | 65-39 | 168-15 W | 4 Oct. | 10:48 | 35 | 3 | 35 | GG54 | 1039 | 311 | 5.41 | |
| | | | | | | | | 62 µm | 2771 | 245 | 4.36 | 1) |

S.M.T. was GMT-11h.

1) shared 1/2 sample with JAMSTEC Kimoto

Table 4.14-2. Data on plankton samples collected by vertical hauls with 80 cm ring net.
GG54: 335 µm mesh.

| Station no. | Position Lat. (N) | Lon. | S.M.T. Date | Hour | Length of wire (m) | Angle of wire (°) | Depth estimated by wire angle (m) | Kind of cloth | Flowmeter No. | Reading | Estimated volume of water filtered ($m^3$) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 008 | 68-00 | 168-45 W | 1 Sep. | 7:17 | 52 | 2 | 52 | GG54 | 3691 | 381 | 20.79 | 2) |
| 008 | 68-00 | 168-45 W | 1 Sep. | 7:27 | 52 | 1 | 52 | GG54 | 3691 | | | 1) |
| 009 | 68-30 | 168-45 W | 1 Sep. | 11:54 | 46 | 7 | 46 | GG54 | 3691 | 358 | 19.54 | 2) |
| 018 | 71-25 | 157-31 W | 3 Sep. | 20:34 | 113 | 3 | 113 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 10 Sep. | 9:52 | 49 | 4 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 10 Sep. | 22:20 | 49 | 3 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 11 Sep. | 11:00 | 49 | 6 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 11 Sep. | 22:18 | 49 | 4 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 12 Sep. | 10:33 | 49 | 4 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 12 Sep. | 22:21 | 49 | 1 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 13 Sep. | 11:04 | 49 | 5 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 13 Sep. | 11:12 | 25 | 1 | 25 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 13 Sep. | 22:22 | 49 | 1 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 13 Sep. | 22:31 | 25 | 1 | 25 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 14 Sep. | 10:43 | 49 | 1 | 49 | GG54 | 3691 | | | 1) |

S.M.T. was GMT-11h.

1) for gut pigment or grazing experiment

2) JAMSTEC Kitamura sample

Table 4.14-2. (Continued)

| Station no. | Position | | S.M.T. | | Length of wire (m) | Angle of wire (°) | Depth estimated by wire angle (m) | Kind of cloth | Flowmeter | | Estimated volume of water filtered ($m^3$) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lat. (N) | Lon. | Date | Hour | | | | | No. | Reading | | |
| 041 | 72-45 | 168-15 W | 14 Sep. | 22:25 | 49 | 2 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 15 Sep. | 10:57 | 49 | 5 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 15 Sep. | 22:23 | 49 | 2 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 16 Sep. | 10:43 | 49 | 3 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 16 Sep. | 22:42 | 49 | 2 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 17 Sep. | 4:20 | 49 | 1 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 17 Sep. | 10:55 | 49 | 1 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 17 Sep. | 16:15 | 49 | 1 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 17 Sep. | 22:19 | 49 | 4 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 18 Sep. | 4:15 | 49 | 12 | 48 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 18 Sep. | 10:35 | 49 | 6 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 18 Sep. | 16:17 | 49 | 1 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 18 Sep. | 22:21 | 49 | 4 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 19 Sep. | 4:17 | 49 | 3 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 19 Sep. | 10:58 | 49 | 3 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 19 Sep. | 16:15 | 49 | 3 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 19 Sep. | 22:29 | 49 | 2 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 20 Sep. | 4:19 | 49 | 4 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 20 Sep. | 10:55 | 49 | 1 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 20 Sep. | 16:19 | 49 | 2 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 20 Sep. | 22:26 | 49 | 3 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 21 Sep. | 4:20 | 49 | 1 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 21 Sep. | 11:10 | 49 | 1 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 21 Sep. | 16:16 | 49 | 1 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 21 Sep. | 22:20 | 49 | 2 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 22 Sep. | 4:14 | 49 | 2 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 22 Sep. | 11:15 | 49 | 2 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 22 Sep. | 16:17 | 49 | 1 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 22 Sep. | 22:18 | 49 | 3 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 23 Sep. | 4:16 | 49 | 1 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 23 Sep. | 10:47 | 49 | 4 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 23 Sep. | 16:17 | 49 | 2 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 23 Sep. | 22:22 | 49 | 2 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 24 Sep. | 4:21 | 49 | 4 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 24 Sep. | 11:17 | 49 | 1 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 24 Sep. | 16:17 | 49 | 3 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 24 Sep. | 22:24 | 49 | 1 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 25 Sep. | 10:59 | 49 | 1 | 49 | GG54 | 3691 | | | 1) |
| 054 | 73-42 | 162-39 W | 26 Sep. | 18:21 | 150 | 5 | 149 | GG54 | 3691 | | | 1) |
| 058 | 73-09 | 162-17 W | 27 Sep. | 16:05 | 150 | 18 | 143 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 30 Sep. | 11:20 | 49 | 8 | 49 | GG54 | 3691 | | | 1) |
| 041 | 72-45 | 168-15 W | 30 Sep. | 22:10 | 49 | 3 | 49 | GG54 | 3691 | | | 1) |
| 072 | 68-00 | 168-00 W | 2 Oct. | 18:54 | 47 | 4 | 47 | GG54 | 3691 | 359 | 19.59 | 2) |
| 077 | 68-00 | 168-45 W | 3 Oct. | 10:24 | 51 | 2 | 51 | GG54 | 3691 | 416 | 22.70 | 2) |
| 077 | 68-00 | 168-45 W | 3 Oct. | 10:32 | 51 | 5 | 51 | GG54 | 3691 | | | 1) |
| 079 | 67-30 | 168-45 W | 3 Oct. | 16:00 | 42 | 1 | 42 | GG54 | 3691 | 347 | 18.94 | 2) |

S.M.T. was GMT-11h.

1) for gut pigment or grazing experiment

2) JAMSTEC Kitamura sample

Table 4.14-3. Data on plankton collected by vertical hauls with a closing PCP net or VMPS.

| Station no. | Position | | S.M.T. | | Length of wire (m) | Angle of wire (°) | Depth estimated by wire angle (m) | Closed net depth (m) | Mesh size | Flowmeter | | Estimated volume of water filtered ($m^3$) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lat. (N) | Lon. | Date | Hour | | | | | | No. | Reading | | |
| 032 | 74-32 | 161-58 W | 8 Sep. | 14:24 | 100 | | 100 | 0 | 62 μm | | 137 | 22.47 | 1) |
| | | | | 14:22 | 250 | | 250 | 100 | 62 μm | | 183 | 30.02 | 1) |
| | | | | 14:18 | 500 | | 500 | 250 | 62 μm | | 267 | 43.80 | 1) |
| | | | | 14:10 | 1000 | | 1000 | 500 | 62 μm | | 533 | 87.44 | 1) |
| 041 | 72-45 | 168-15 W | 14 Sep. | 10:55 | 20 | 1 | 20 | 0 | 62 μm | 1852 | 222 | 3.42 | 1) |
| (Fixed station) | | | | 11:34 | 49 | 2 | 49 | 20 | 62 μm | 1852 | 306 | 4.72 | 1) |
| 041 | 72-45 | 168-15 W | 14 Sep. | 22:35 | 20 | 2 | 20 | 0 | 62 μm | 1852 | 173 | 2.67 | 1) |
| (Fixed station) | | | | 22:40 | 49 | 3 | 49 | 20 | 62 μm | 1852 | 200 | 3.08 | 1) |
| 041 | 72-45 | 168-15 W | 16 Sep. | 10:52 | 20 | 1 | 20 | 0 | 62 μm | 1852 | 160 | 2.47 | 1) |
| (Fixed station) | | | | 10:57 | 49 | 1 | 49 | 20 | 62 μm | 1852 | 236 | 3.64 | 1) |
| 041 | 72-45 | 168-15 W | 16 Sep. | 22:53 | 20 | 1 | 20 | 0 | 62 μm | 1852 | 160 | 2.47 | 1) |
| (Fixed station) | | | | 22:59 | 49 | 2 | 49 | 21 | 62 μm | 1852 | 274 | 4.23 | 1) |
| 041 | 72-45 | 168-15 W | 16 Sep. | 4:29 | 20 | 1 | 20 | 0 | 62 μm | 1852 | 178 | 2.75 | |
| (Fixed station) | | | | 4:35 | 49 | 1 | 49 | 20 | 62 μm | 1852 | 288 | 4.44 | |
| 041 | 72-45 | 168-15 W | 17 Sep. | 11:21 | 20 | 1 | 20 | 0 | 62 μm | 1852 | 180 | 2.78 | 1) |
| (Fixed station) | | | | 11:33 | 49 | 1 | 49 | 20 | 62 μm | 1852 | 207 | 3.19 | 1) |
| 041 | 72-45 | 168-15 W | 17 Sep. | 16:23 | 20 | 1 | 20 | 0 | 62 μm | 1852 | 140 | 2.16 | |
| (Fixed station) | | | | 16:29 | 49 | 1 | 49 | 20 | 62 μm | 1852 | 228 | 3.52 | |
| 041 | 72-45 | 168-15 W | 17 Sep. | 22:29 | 20 | 1 | 20 | 0 | 62 μm | 1852 | 180 | 2.78 | 1) |
| (Fixed station) | | | | 22:35 | 49 | 1 | 49 | 20 | 62 μm | 1852 | 178 | 2.75 | 1) |
| 041 | 72-45 | 168-15 W | 18 Sep. | 4:23 | 20 | 2 | 20 | 0 | 62 μm | 1852 | 140 | 2.16 | |
| (Fixed station) | | | | 4:30 | 49 | 2 | 49 | 20 | 62 μm | 1852 | 250 | 3.86 | |
| 041 | 72-45 | 168-15 W | 18 Sep. | 10:43 | 20 | 2 | 20 | 0 | 62 μm | 1852 | 147 | 2.27 | 1) |
| (Fixed station) | | | | 10:49 | 49 | 1 | 49 | 20 | 62 μm | 1852 | 215 | 3.32 | 1) |
| 041 | 72-45 | 168-15 W | 18 Sep. | 16:25 | 20 | 1 | 20 | 0 | 62 μm | 1852 | 209 | 3.22 | |
| (Fixed station) | | | | 16:31 | 49 | 2 | 49 | 20 | 62 μm | 1852 | 213 | 3.29 | |
| 041 | 72-45 | 168-15 W | 18 Sep. | 22:32 | 20 | 1 | 20 | 0 | 62 μm | 1852 | 221 | 3.41 | 1) |
| (Fixed station) | | | | 22:37 | 49 | 2 | 49 | 20 | 62 μm | 1852 | 250 | 3.86 | 1) |
| 041 | 72-45 | 168-15 W | 19 Sep. | 4:25 | 20 | 1 | 20 | 0 | 62 μm | 1852 | 240 | 3.70 | |
| (Fixed station) | | | | 4:31 | 49 | 2 | 49 | 20 | 62 μm | 1852 | 336 | 5.18 | |
| 041 | 72-45 | 168-15 W | 19 Sep. | 11:09 | 20 | 3 | 20 | 0 | 62 μm | 1852 | 169 | 2.61 | 1) |
| (Fixed station) | | | | 11:14 | 49 | 2 | 49 | 20 | 62 μm | 1852 | 319 | 4.92 | 1) |
| 041 | 72-45 | 168-15 W | 19 Sep. | 16:24 | 20 | 3 | 20 | 0 | 62 μm | 1852 | 213 | 3.29 | |
| (Fixed station) | | | | 16:30 | 49 | 4 | 49 | 20 | 62 μm | 1852 | 270 | 4.16 | |
| 041 | 72-45 | 168-15 W | 19 Sep. | 22:40 | 20 | 8 | 20 | 0 | 62 μm | 1852 | 340 | 5.24 | 1) |
| (Fixed station) | | | | 22:47 | 49 | 3 | 49 | 20 | 62 μm | 1852 | 358 | 5.52 | 1) |
| 041 | 72-45 | 168-15 W | 20 Sep. | 4:28 | 20 | 4 | 20 | 0 | 62 μm | 1852 | 222 | 3.42 | |
| (Fixed station) | | | | 4:35 | 49 | 6 | 49 | 19 | 62 μm | 1852 | 374 | 5.77 | |
| 041 | 72-45 | 168-15 W | 20 Sep. | 11:05 | 20 | 5 | 20 | 0 | 62 μm | 1852 | 338 | 5.21 | 1) |
| (Fixed station) | | | | 11:25 | 49 | 4 | 49 | 20 | 62 μm | 1852 | 497 | 7.67 | 1) |
| 041 | 72-45 | 168-15 W | 20 Sep. | 16:26 | 20 | 3 | 20 | 0 | 62 μm | 1852 | 239 | 3.69 | |
| (Fixed station) | | | | 16:34 | 49 | 3 | 49 | 19 | 62 μm | 1852 | 343 | 5.29 | |
| 041 | 72-45 | 168-15 W | 20 Sep. | 22:37 | 20 | 4 | 20 | 0 | 62 μm | 1852 | 269 | 4.15 | 1) |
| (Fixed station) | | | | 22:44 | 49 | 1 | 49 | 20 | 62 μm | 1852 | 494 | 7.62 | 1) |
| 041 | 72-45 | 168-15 W | 21 Sep. | 4:30 | 20 | 4 | 20 | 0 | 62 μm | 1852 | 198 | 3.05 | |
| (Fixed station) | | | | 4:36 | 49 | 2 | 49 | 18 | 62 μm | 1852 | 300 | 4.63 | |
| 041 | 72-45 | 168-15 W | 21 Sep. | 11:20 | 20 | 1 | 20 | 0 | 62 μm | 1852 | 260 | 4.01 | 1) |
| (Fixed station) | | | | 11:26 | 49 | 1 | 49 | 21 | 62 μm | 1852 | 258 | 3.98 | 1) |
| 041 | 72-45 | 168-15 W | 21 Sep. | 16:23 | 20 | 2 | 20 | 0 | 62 μm | 1852 | 159 | 2.45 | |
| (Fixed station) | | | | 16:32 | 49 | 1 | 49 | 20 | 62 μm | 1852 | 359 | 5.54 | |
| 041 | 72-45 | 168-15 W | 21 Sep. | 22:31 | 20 | 1 | 20 | 0 | 62 μm | 1852 | 168 | 2.59 | 1) |
| (Fixed station) | | | | 22:36 | 49 | 1 | 49 | 20 | 62 μm | 1852 | 250 | 3.86 | 1) |
| 041 | 72-45 | 168-15 W | 22 Sep. | 4:23 | 20 | 1 | 20 | 0 | 62 μm | 1852 | 157 | 2.42 | |
| (Fixed station) | | | | 4:30 | 49 | 1 | 49 | 19 | 62 μm | 1852 | 240 | 3.70 | |
| 041 | 72-45 | 168-15 W | 22 Sep. | 11:25 | 20 | 2 | 20 | 0 | 62 μm | 1852 | 91 | 1.40 | 1) |
| (Fixed station) | | | | 11:31 | 49 | 3 | 49 | 20 | 62 μm | 1852 | 194 | 2.99 | 1) |
| 041 | 72-45 | 168-15 W | 22 Sep. | 16:25 | 20 | 1 | 20 | 0 | 62 μm | 1852 | 143 | 2.21 | |
| (Fixed station) | | | | 16:31 | 49 | 1 | 49 | 20 | 62 μm | 1852 | 186 | 2.87 | |

S.M.T. was GMT-11h.

1) shared 1/2 sample with JAMSTEC Kimoto

Table 4.14-3. (Continued)

| Station no. | Position | | S.M.T. | | Length of wire (m) | Angle of wire (°) | Depth estimated by wire angle (m) | Closed net depth (m) | Mesh size | Flowmeter | | Estimated volume of water filtered ($m^3$) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lat. (N) | Lon. | Date | Hour | | | | | | No. | Reading | | |
| 041 | 72-45 | 168-15 W | 22 Sep. | 22:27 | 20 | 1 | 20 | 0 | 62 µm | 1852 | 150 | 2.31 | 1) |
| (Fixed station) | | | | 22:33 | 49 | 1 | 49 | 21 | 62 µm | 1852 | 220 | 3.39 | 1) |
| 041 | 72-45 | 168-15 W | 23 Sep. | 04:26 | 20 | 1 | 20 | 0 | 62 µm | 1852 | 153 | 2.36 | |
| (Fixed station) | | | | 04:32 | 49 | 2 | 49 | 20 | 62 µm | 1852 | 250 | 3.86 | |
| 041 | 72-45 | 168-15 W | 23 Sep. | 10:56 | 20 | 2 | 20 | 0 | 62 µm | 1852 | 148 | 2.28 | 1) |
| (Fixed station) | | | | 11:01 | 49 | 1 | 49 | 20 | 62 µm | 1852 | 212 | 3.27 | 1) |
| 041 | 72-45 | 168-15 W | 23 Sep. | 16:24 | 20 | 1 | 20 | 0 | 62 µm | 1852 | 150 | 2.31 | |
| (Fixed station) | | | | 16:30 | 49 | 1 | 49 | 20 | 62 µm | 1852 | 222 | 3.42 | |
| 041 | 72-45 | 168-15 W | 23 Sep. | 22:31 | 20 | 1 | 20 | 0 | 62 µm | 1852 | 163 | 2.51 | 1) |
| (Fixed station) | | | | 22:37 | 49 | 1 | 49 | 20 | 62 µm | 1852 | 218 | 3.36 | 1) |
| 041 | 72-45 | 168-15 W | 24 Sep. | 4:30 | 20 | 2 | 20 | 0 | 62 µm | 1852 | 197 | 3.04 | |
| (Fixed station) | | | | 4:37 | 49 | 2 | 49 | 20 | 62 µm | 1852 | 283 | 4.37 | |
| 041 | 72-45 | 168-15 W | 24 Sep. | 11:28 | 20 | 1 | 20 | 0 | 62 µm | 1852 | 172 | 2.65 | 1) |
| (Fixed station) | | | | 11:34 | 49 | 1 | 49 | 20 | 62 µm | 1852 | 250 | 3.86 | 1) |
| 041 | 72-45 | 168-15 W | 24 Sep. | 16:25 | 20 | 2 | 20 | 0 | 62 µm | 1852 | 163 | 2.51 | |
| (Fixed station) | | | | 16:31 | 49 | 1 | 49 | 20 | 62 µm | 1852 | 257 | 3.96 | |
| 041 | 72-45 | 168-15 W | 24 Sep. | 22:35 | 20 | 1 | 20 | 0 | 62 µm | 1852 | 125 | 1.93 | 1) |
| (Fixed station) | | | | 22:41 | 49 | 1 | 49 | 20 | 62 µm | 1852 | 185 | 2.85 | 1) |
| 056 | 73-48 | 159-59 W | 27 Sep. | 6:36 | 100 | | 100 | 0 | 62 µm | | 106 | 17.39 | 1) |
| | | | | 6:34 | 250 | | 250 | 100 | 62 µm | | 160 | 26.25 | 1) |
| | | | | 6:30 | 500 | | 500 | 250 | 62 µm | | 274 | 44.95 | 1) |
| | | | | 6:22 | 1000 | | 1000 | 500 | 62 µm | | 550 | 90.23 | 1) |

S.M.T. was GMT-11h.

1) shared 1/2 sample with JAMSTEC Kimoto

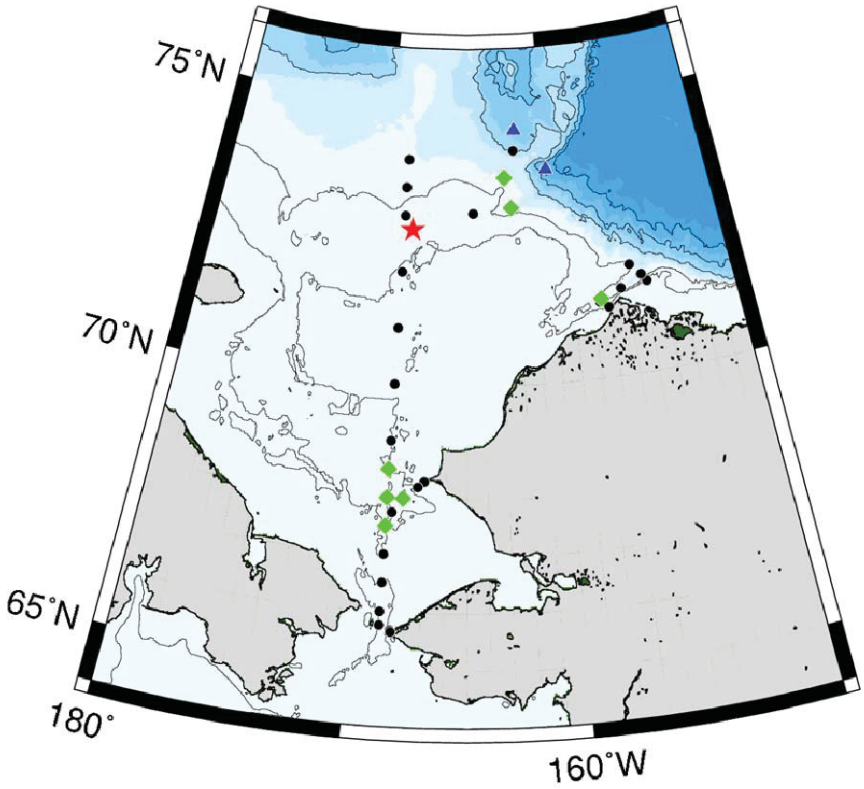


**Fig. 4.14-1. Location of the sampling stations in the western Arctic Ocean (circles: NORPAC net, diamonds: NORPAC net + 80 cm ring net, triangles: NORPAC net + VMPS). Star indicates a fixed station during 10–25 September 2013.**

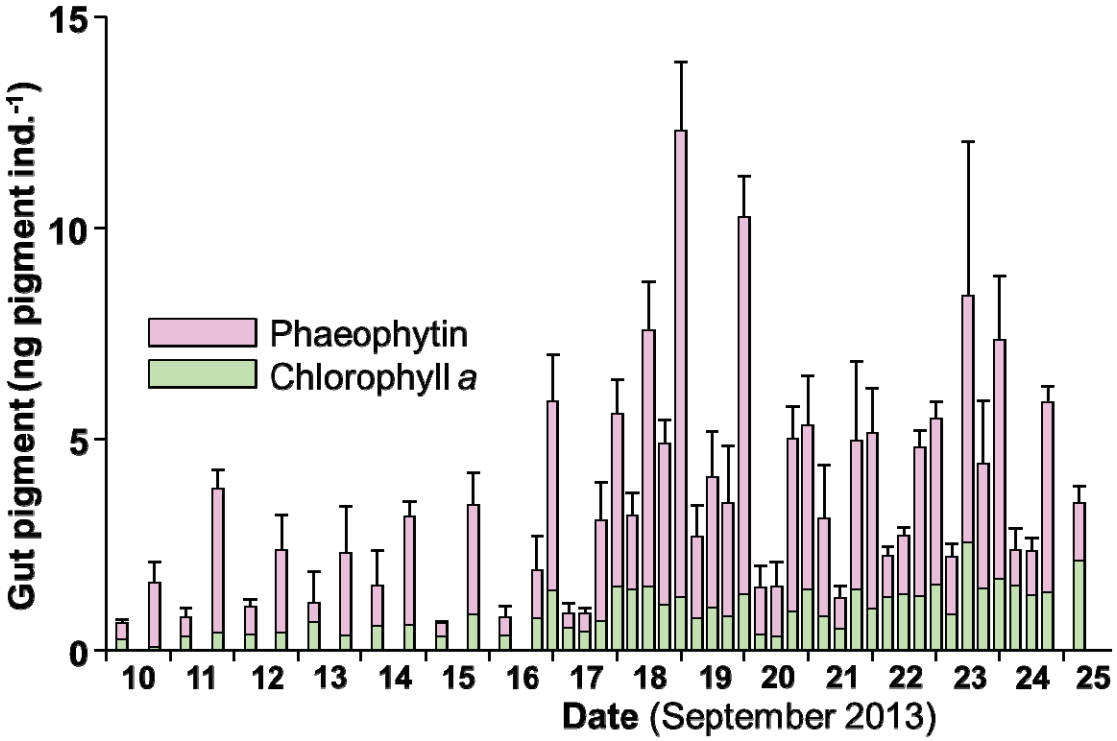


Figure 4.14-2. Temporal changes in gut pigment of *C. glacialis* C5 at a fixed station during 10–25 September 2013.

## 4.15. Sediment trap moorings

(1) Personnel

Naomi Harada (JAMSTEC, not onboard): Principal Investigator
Yuichiro Tanaka (AIST, not onboard)
Shigeto Nishino (JAMSTEC)
Takahashi Kikuchi (JAMSTEC, not onboard)
Katsunori Kimoto (JAMSTEC)
Yusuke Okazaki (Kyushu Univ./JAMSTEC, not onboard)
Takahito Ikenoue (Kyushu Univ.)
Makio C. Honda (JAMSTEC, not onboard)
Kana Nagashima (JAMSTEC, not onboard)
Sanae Chiba (JAMSTEC, not onboard)
Atsushi Yamaguchi (Hokkaido Univ., not onboard)
Manami Satoh (Tsukuba Univ., not onboard)
Miyako Satoh (JAMSTEC, not onboard)
Jonaotaro Onodera (JAMSTEC)
Hirokatsu Uno (MWJ): Technical staff for mooring deployment
Soh-ichiro Sueyoshi (GODI): Technical staff for bathymetry survey

(2) Objectives

The objectives of this task are to understand the relationship between marine lower ecosystem and rapid environmental change such as the recent sea-ice decrease in the western Arctic Ocean. We have continued time-series monitoring of sinking particle fluxes in the Northwind Abyssal Plain and the shelf slope of Chukchi Abyssal Plain since October 2010 (Figure 4.15-1). The recovery and deployment operations of two sediment trap moorings were planned in this cruise.

(3) Instruments and methods

The mooring IDs for recovery are NAP12t and CAP12t. These moorings were deployed by the R/V Mirai Cruise MR12-E03 in the last summer. The instruments with recovery moorings are sediment trap, DO sensor, C-T sensor, acoustic transponder, and tandem acoustic releasers. In addition to those equipments, deployment moorings newly contain ice profiling sonar, ADCP, electromagnetic current meter, SeaGuard monitoring system with $pCO_2$ sensor, EXO multi water quality profiler, pH sensor, multi-wave length excitation fluorescence photometer (Multi-Exciter), and submarine camera

system. The method of mooring operation on deck is basically the same as the works in MR12-E03. Before the deployment work, the response test of double releasers and water sampling was conducted at 1613 m depth with CTD observation at Station 30 near NAP13t. As mentioned below, the deployment position of NAP13t was changed from NAP12t position because of sea-ice condition. Therefore, bathymetric survey and revision of mooring design (change of rope length) were conducted around NAP13t (Figures 4.15-2 and 4.15-3).

(4) Station list or Observation log

Sediment trap recovery

No recovery operations of sediment trap moorings were conducted due to inadequate sea-ice condition around NAP12t and CAP12t.

Sediment trap deployment

The log of deployment operation in Table 4.15-1

The layout of sediment trap moorings in Figures 4.15-4.

(5) Results

Cancelled recovery of sediment trap moorings NAP12t and CAP12t

Because of ice edge situation around the mooring stations, the R/V Mirai could not reach the area within the range of available acoustic communication between transducer from ship and moored transponder or acoustic releasers. Therefore, the mooring recovery operations at Stations NAP12t and CAP12t were totally cancelled. The presence of mooring was not also confirmed. The revisit and recoveries of NAP12t and CAP12t are to be planned in next summer season.

Deployment of sediment trap mooring NAP13t

The deployment of NAP13t was conducted at alternative location, 30 nautical miles south from NAP12t (Figure 4.15-2). The bottom depth at NAP13t is about 300 m shallower than that at original NAPt station. Therefore, some shorter Kevlar ropes, which were the spare or the recovered mooring ropes from Barrow Canyon, were applied for NAP13t. The deployment operation was successful without any injuries. According to transponder at the upper part of NAP13t, the estimated water depth at the top of mooring is about 37 m.

Cancelled deployment of sediment trap mooring CAP13t

The R/V Mirai could not take a chance to enter the western Chukchi Sea due to inadequate ice condition. The deployment of CAP13t was cancelled.

**Table 4.15-1.** Deployment log of sediment trap mooring NAP13t (by Dr. Kawaguchi)

| | |
|---|---|
| Mooring ID | NAP13t |
| Project | MR13-06 |
| Ship | R/V Mirai |
| Start Time of Deploy (UTC) | 8 Sep. 2013, 20:02 |
| Start Position of Deploy | 74°33.4316'N 161°58.4060'W |
| Depth of Start Position | 1715 m |
| Submersion Time of Instruments (UTC) | |
| Ice Profiling Sonar (s/n 51123) | 20:04 |
| w/ C-T Sensor (s/n 1367) | |
| w/ Multi-Exciter (s/n 19) | |
| Transponder XT6001-13 (s/n 60645) | 20:04 |
| Benthos Glass Floats | 20:04 |
| ADCP WHS-300 (s/n 13838) | 20:08 |
| Benthos Glass Floats | 20:11 |
| SeaGuard Sensor (s/n 67) | 20:18 |
| w/ EXO Sensor (s/n 12E101329) | |
| w/ C-T Sensor (s/n 2155) | |
| w/ pH Sensor (s/n 346259004) | |
| Sediment Trap (s/n ST98058) | 20:30 |
| w/ C-T Sensor (s/n 2156) | |
| w/ Camera System (s/n 12E101339) | |
| Electromag. Current Meter S4D (s/n 5282332) | 20:30 |
| Benthos Glass Floats | 20:57 |
| Sediment Trap (s/n ST98083) | 21:18 |
| w/ C-T Sensor (s/n 2163) | |
| Benthos Glass Floats | 21:36 |
| Releaser Nichiyu-LGC (s/n LGC0021) | 21:37 |
| Releaser Benthos 865A (s/n 1078) | 21:37 |
| Time of Sinker Release (UTC) | 8 Sep. 2013, 21:59 |
| Position of Sinker Release | 74°31.1885'N 161°55.3575'W |
| Depth of Sinker Release Position | 1680-1689 m |

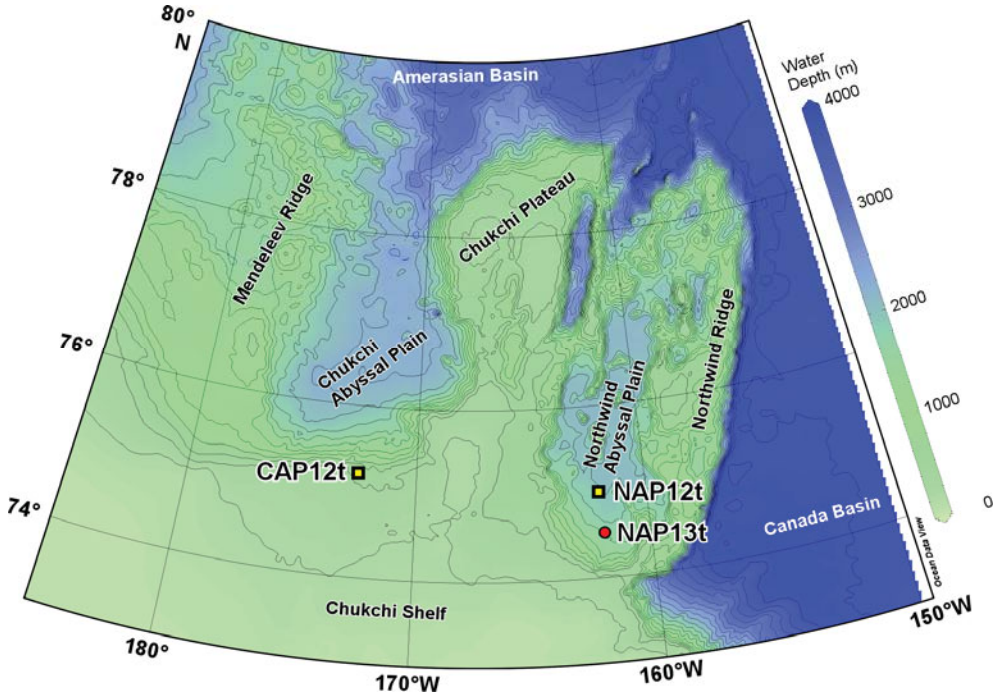


**Figure 4.15-1.** The locality map of sediment-trap mooring Stations NAP12t, NAP13t, and CAP12t. The contours are drawn by IBCAO bathymetry data.

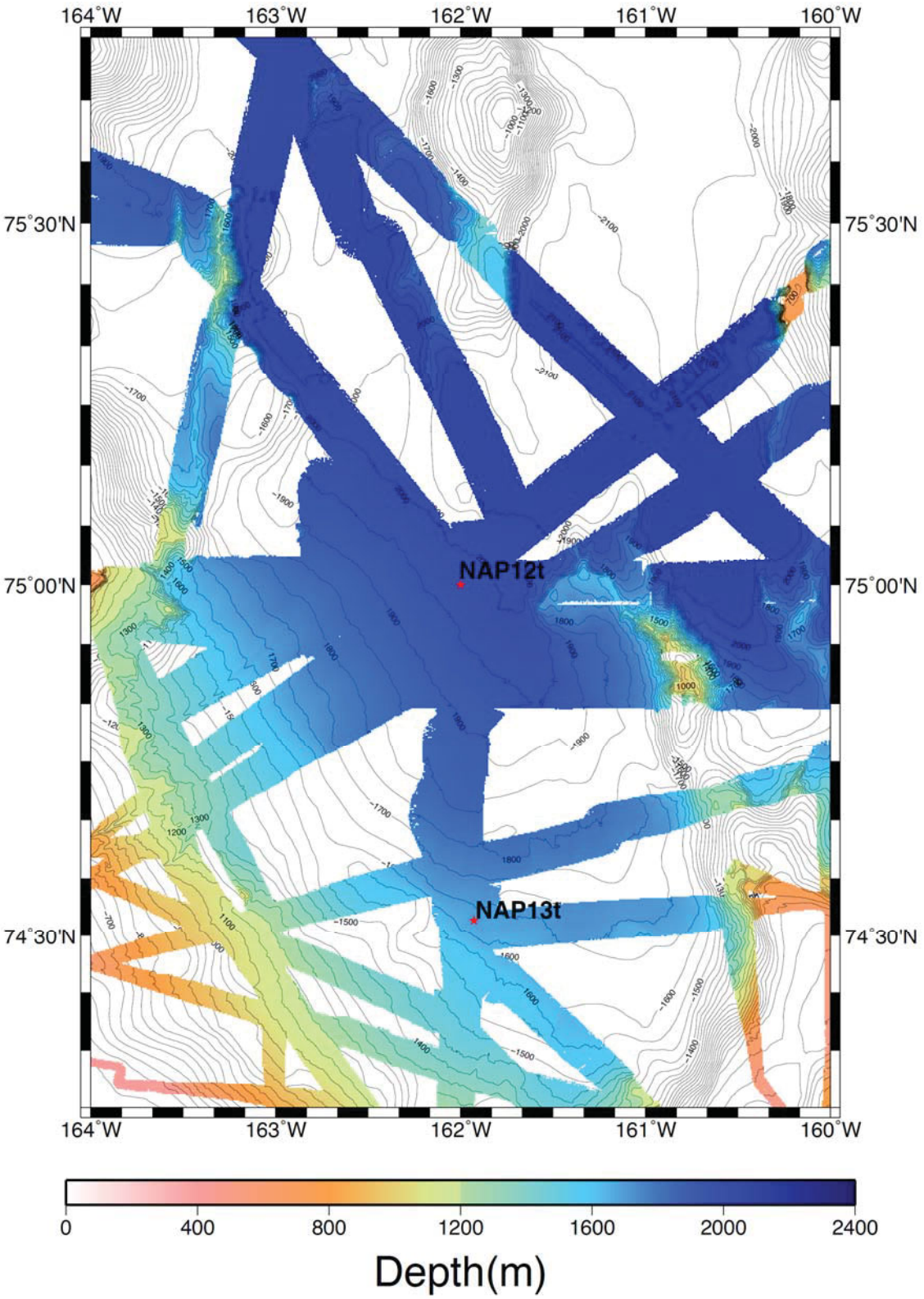


**Figure 4.15-2.** The bottom survey map around Stations NAP12t and NAP13t. The survey data obtained by previous R/V Mirai cruises are also used. The background contours are drawn based on IBCAO bathymetry data.

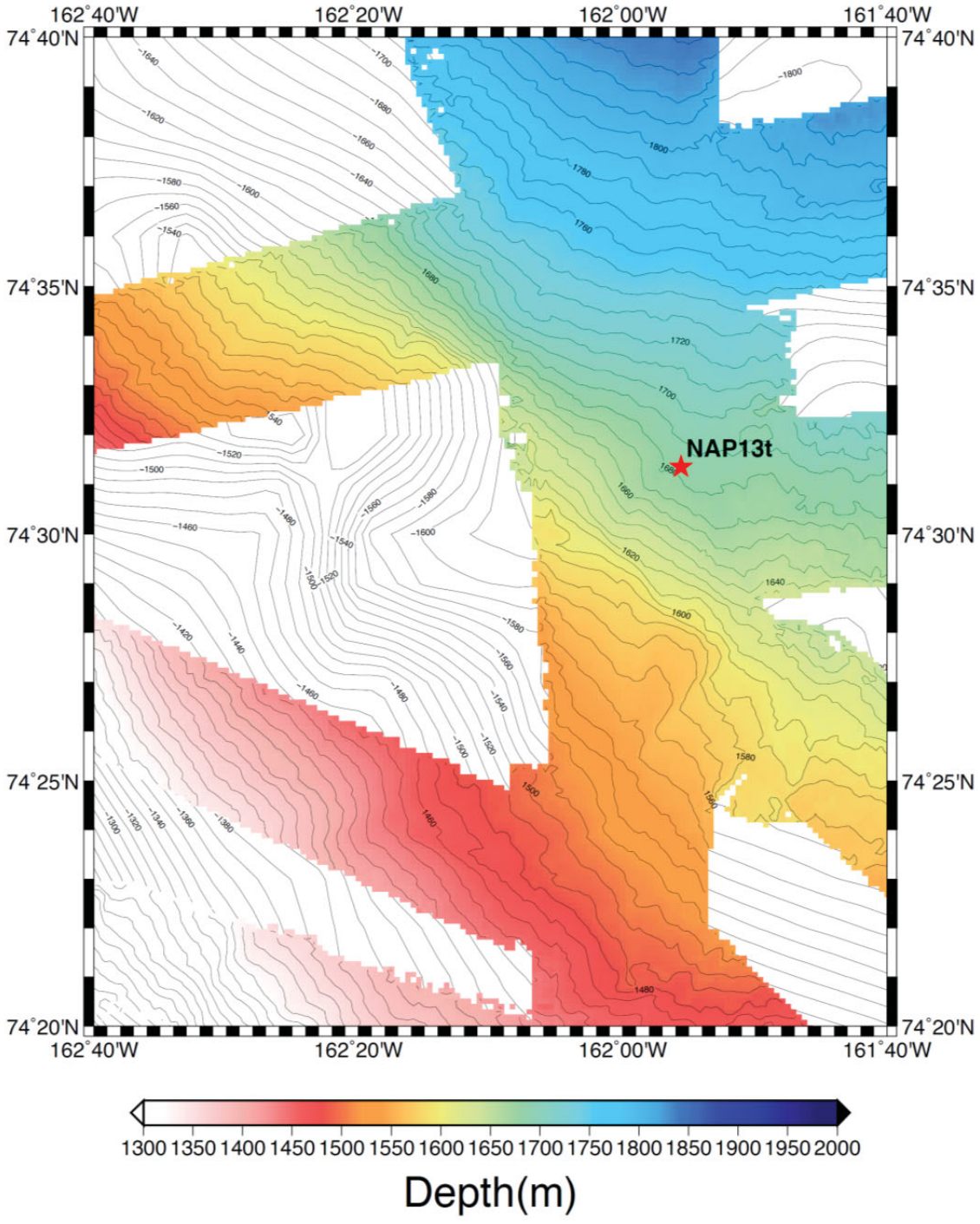


**Figure 4.15-3.** The bottom survey map around Stations NAP13t. The survey data obtained by previous R/V Mirai cruises are also used. The background contours are drawn based on IBCAO bathimetric data.

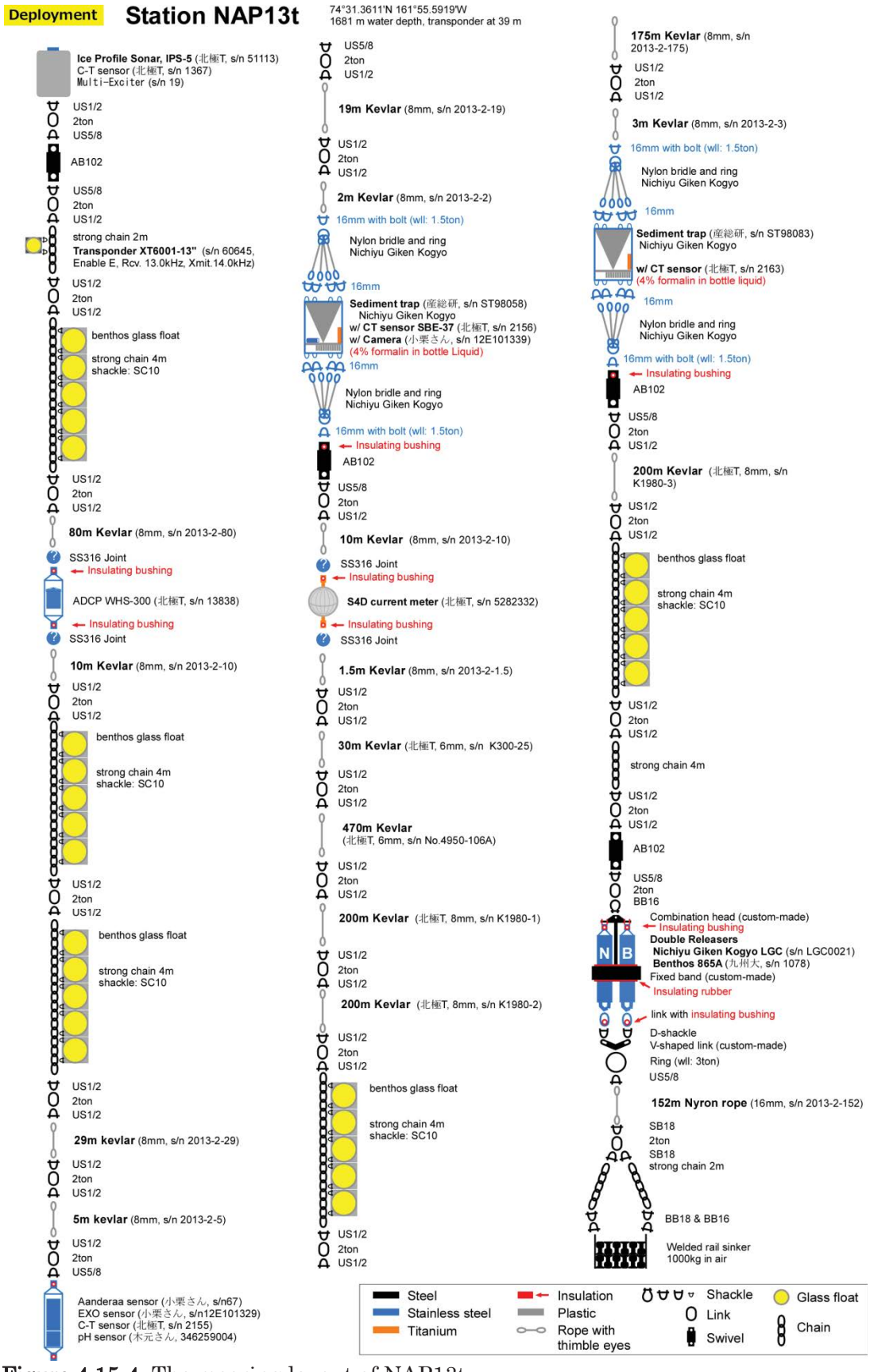


**Figure 4.15-4.** The mooring layout of NAP13t.

## 4.16. Radionuclides

(1) Personnel

Yuichiro KUMAMOTO (JAMSTEC): Principal Investigator
Hisaki NAGAI (Nihon University)

(2) Objective

Determination of activity concentrations of radionuclides, including radiocesium and radioiodine.

(3) Parameters

$^{134}Cs$, $^{137}Cs$, and $^{129}I$

(4) Instruments and Methods

a. Sampling

Seawater samples for the radionuclides were collected using 12-liter Niskin-X bottles and a bucket. In addition, surface seawater was also collected from continuous pumped-up water from about 4-m depth. The seawater sample was collected into a 20-L plastic container after two time washing. In our laboratory on shore, a seawater sample was divided into two for radiocesium (about 20-L) and radioiodine (about 1-L). The seawater for radiocesium was then acidified by 40-$cm^3$ of concentrated nitric acid. The seawater for radioiodine was siphoned into 1-L plastic bottle.

b. Preparation and analysis

In our laboratory on shore, radiocesium in the seawater samples will be concentrated using ammonium phosphomolybdate (AMP) that forms insoluble compound with cesium. The radiocesium ($^{134}Cs$ and $^{137}Cs$) in AMP will be measured using Ge γ-ray spectrometer. Measurements of radioiodine will be also conducted at our laboratory on shore. Iodine in the seawater samples is extracted by the solvent extraction technique. Extracted iodine is then precipitated as silver iodide by the addition of the silver nitrate. Iodine isotopic ratios ($^{129}I/^{127}I$) of the silver iodide are measured by the Accelerator Mass Spectrometry (AMS). To evaluate the $^{129}I$ concentration in the seawater samples, iodine concentration ($^{127}I$) will be measured by the inductively coupled plasma mass spectrometry (ICP-MS) and/or the voltammetry.

(5) Sample list

We collected 22 seawaters for the radionuclide measurement in Arctic Sea, Bering Sea, and northern North Pacific Ocean during this cruise (Table 4.16-1).

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via “Data Research for Whole Cruise Information in JAMSTEC” in JAMSTEC web site.

**Table 4.16-1.** Seawater samples collected for the radionuclide measurement.

| No. | Station | Sampling depth (m) | Method | Latitude (N) | Longitude (E) | Date (UTC) |
|---|---|---|---|---|---|---|
| 1 | surface | 4 | pump | 71.70 | 205.08 | 6 Sep. 2013 |
| 2 | 32 | 0 | bucket | 74.54 | 199.97 | 9 Sep. 2013 |
| 3 | 32 | 25 | niskin | 74.54 | 199.97 | 9 Sep. 2013 |
| 4 | 32 | 65 | niskin | 74.54 | 199.97 | 9 Sep. 2013 |
| 5 | 32 | 100 | niskin | 74.54 | 199.97 | 9 Sep. 2013 |
| 6 | 32 | 150 | niskin | 74.54 | 199.97 | 9 Sep. 2013 |
| 7 | 32 | 200 | niskin | 74.54 | 199.97 | 9 Sep. 2013 |
| 8 | 32 | 300 | niskin | 74.54 | 199.97 | 9 Sep. 2013 |
| 9 | 32 | 400 | niskin | 74.54 | 199.97 | 9 Sep. 2013 |
| 10 | 32 | 600 | niskin | 74.54 | 199.97 | 9 Sep. 2013 |
| 11 | 32 | 800 | niskin | 74.54 | 199.97 | 9 Sep. 2013 |
| 12 | 34 | 0 | bucket | 74.00 | 192.74 | 9 Sep. 2013 |
| 13 | 41 | 0 | bucket | 72.75 | 192.24 | 24 Sep. 2013 |
| 14 | 48 | 0 | bucket | 74.00 | 192.75 | 26 Sep. 2013 |
| 15 | 67 | 0 | bucket | 69.00 | 192.75 | 2 Oct. 2013 |
| 16 | 84 | 0 | bucket | 65.76 | 192.76 | 4 Oct. 2013 |
| 17 | surface | 4 | pump | 57.67 | 193.36 | 6 Oct. 2013 |
| 18 | surface | 4 | pump | 54.22 | 193.45 | 9 Oct. 2013 |
| 19 | surface | 4 | pump | 53.58 | 178.04 | 11 Oct. 2013 |
| 20 | surface | 4 | pump | 48.77 | 165.81 | 14 Oct. 2013 |
| 21 | surface | 4 | pump | 42.51 | 157.67 | 16 Oct. 2013 |
| 22 | surface | 4 | pump | 40.11 | 148.43 | 18 Oct. 2013 |

# 5. Geophysics

## 5.1. Sea bottom topography measurement

(1) Personnel

| | |
|---|---|
| Masao Nakanishi | Chiba University: PI (not on-board) |
| Souichiro Sueyoshi | GODI |
| Katsuhisa Maeno | GODI |
| Masanori Murakami | GODI |
| Koichi Inagaki | GODI |
| Kazuho Yoshida | GODI |
| Ryo Ohyama | MIRAI Crew |

(2) Objective

R/V MIRAI is equipped with a Multi narrow Beam Echo Sounding system (MBES), SEABEAM 3012 Upgrade Model (L3 Communications ELAC Nautik) and with a Sub-bottom Profiler (SBP), Bathy2010 (SyQwest). The objective of MBES and SBP is collecting continuous bathymetric data along ship's track to make a contribution to geological and geophysical investigations and global datasets.

(3) Instruments and Methods

The "SEABEAM 3012 Upgrade Model" on R/V MIRAI was used for bathymetry mapping during the MR13-06 cruise.

To get accurate sound velocity of water column for ray-path correction of acoustic multibeam, we used Surface Sound Velocimeter (SSV) data to get the sea surface (6.62m) sound velocity, and the deeper depth sound velocity profiles were calculated by temperature and salinity profiles from CTD, XCTD and Argo float data by the equation in Del Grosso (1974) during the cruise.

The system configuration and performance are shown in Table 5.1-1 and Table 5.1-2.

**Table 5.1-1.** SEABEAM 3012 System configuration and performance

| | |
|---|---|
| Frequency: | 12 kHz |
| Transmit beam width: | 1.6 degree |
| Transmit power: | 20 kW |
| Transmit pulse length: | 2 to 20 msec. |
| Receive beam width: | 1.8 degree |
| Depth range: | 100 to 11,000 m |
| Beam spacing: | 0.5 degree athwart ship |
| Swath width: | 150 degree (max)<br>120 degree to 4,500 m<br>100 degree to 6,000 m<br>90 degree to 11,000 m |
| Depth accuracy: | Within < 0.5% of depth or ±1m,<br>whichever is greater, over the entire swath.<br>(Nadir beam has greater accuracy;<br>typically within < 0.2% of depth or ±1m, whichever is greater) |

**Table 5.1-2.** Bathy2010 System configuration and performance

| | |
|---|---|
| Frequency: | 3.5 kHz |
| Transmit beam width: | 23 degree |
| Transmit pulse length: | 0.5 to 50 msec |
| Strata resolution: | Up to 8 cm with 300 m of bottom penetration; bottom type dependant |
| Depth resolution: | 0.1 feet, 0.1m |
| Depth accuracy: | ±10 cm to 100 m, ±0.3% to 6,000 m |

(4) Preliminary Results

The results will be published after primary processing.

(5) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC web site.

## 5.2. Sea surface gravity measurement

(1) Personnel

| | |
|---|---|
| Masao Nakanishi | Chiba University: PI (not on-board) |
| Souichiro Sueyoshi | GODI |
| Katsuhisa Maeno | GODI |
| Masanori Murakami | GODI |
| Koichi Inagaki | GODI |
| Kazuho Yoshida | GODI |
| Ryo Ohyama | MIRAI Crew |

(2) Objective

The local gravity is an important parameter in geophysics and geodesy. We collected gravity data at the sea surface during the MR13-06 cruise.

(3) Parameters

Relative Gravity [CU: Counter Unit]

[mGal] = (coefl: 0.9946) * [CU]

(4) Instruments and Methods

We measured relative gravity using LaCoste and Romberg air-sea gravity meter S-116 (Micro-g LaCoste, LLC) during the cruise. To convert the relative gravity to absolute one, we measured gravity using portable gravity meter (Scintrex gravity meter CG-5), at Sekinehama Port as reference point.

(5) Preliminary Results

Absolute gravity table is shown in Table 5.2-1

**Table 5.2-1.** Absolute gravity table

| No | Date | UTC | Port | Absolute Gravity [mGal] | Sea Level [cm] | Draft [cm] | Gravity at Sensor *1 [mGal] | L&R*2 Gravity [mGal] |
|---|---|---|---|---|---|---|---|---|
| #1 | 08/12 | 01:05 | Sekinehama | 980371.95 | 263 | 640 | 980373.01 | 12663.39 |
| #2 | 10/21 | 08:20 | Sekinehama | 980371.93 | 231 | 625 | 980372.86 | 12665.70 |

*1: Gravity at Sensor = Absolute Gravity + Sea Level*0.3086/100 + (Draft-530)/100*0.2222

*2: LaCoste and Romberg air-sea gravity meter S-116

(6) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in

JAMSTEC web site.

## 5.3. Surface magnetic field measurements

### 1) Three-components magnetometer

(1) Personnel

| | |
|---|---|
| Masao Nakanishi | Chiba University: PI (not on-board) |
| Souichiro Sueyoshi | GODI |
| Katsuhisa Maeno | GODI |
| Kazuho Yoshida | GODI |
| Masanori Murakami | GODI |
| Koichi Inagaki | GODI |
| Ryo Ohyama | MIRAI Crew |

(2) Objective

Measurement of magnetic force on the sea is required for the geophysical investigations of marine magnetic anomaly caused by magnetization in upper crustal structure. We measured geomagnetic field using a three-component magnetometer during the MR13-06 cruise.

(3) Instruments and Methods

A shipboard three-component magnetometer system (SFG1214, Tierra Tecnica) is equipped on-board R/V MIRAI. Three-axes flux-gate sensors with ring-cored coils are fixed on the fore mast. Outputs from the sensors are digitized by a 20-bit A/D converter (1 nT/LSB), and sampled at 8 times per second. Ship's heading, pitch, and roll are measured by the Inertial Navigation System (INS) for controlling attitude of a Doppler radar. Ship's position (GPS) and speed data are taken from LAN every second.

The relation between a magnetic-field vector observed on-board, $\mathbf{H}$ob, (in the ship's fixed coordinate system) and the geomagnetic field vector, $\mathbf{F}$, (in the Earth's fixed coordinate system) is expressed as:

$$\mathbf{H}\mathrm{ob} = \tilde{\mathbf{A}}\ \tilde{\mathbf{R}}\ \tilde{\mathbf{P}}\ \tilde{\mathbf{Y}}\ \mathbf{F} + \mathbf{H}\mathrm{p} \qquad \text{(a)}$$

where $\tilde{\mathbf{R}}$, $\tilde{\mathbf{P}}$ and $\tilde{\mathbf{Y}}$ are the matrices of rotation due to roll, pitch and heading of a ship, respectively. $\tilde{\mathbf{A}}$ is a 3 x 3 matrix which represents magnetic susceptibility of the ship, and $\mathbf{H}$p is a magnetic field vector produced by a permanent magnetic moment of the ship's body. Rearrangement of Eq. (a) makes

$$\tilde{\mathbf{R}}\ \mathbf{H}\mathrm{ob} + \mathbf{H}\mathrm{bp} = \tilde{\mathbf{R}}\ \tilde{\mathbf{P}}\ \tilde{\mathbf{Y}}\ \mathbf{F} \qquad \text{(b)}$$

where $\tilde{\mathbf{R}} = \tilde{\mathbf{A}}^{-1}$, and $\mathbf{H}\mathrm{bp} = -\tilde{\mathbf{R}}\ \mathbf{H}\mathrm{p}$. The magnetic field, $\mathbf{F}$, can be obtained by measuring $\tilde{\mathbf{R}}$, $\tilde{\mathbf{P}}$, $\tilde{\mathbf{Y}}$ and $\mathbf{H}$ob, if $\tilde{\mathbf{R}}$ and $\mathbf{H}$bp are known. Twelve constants in $\tilde{\mathbf{R}}$ and $\mathbf{H}$bp can be determined by measuring variation of $\mathbf{H}$ob with $\tilde{\mathbf{R}}$, $\tilde{\mathbf{P}}$ and $\tilde{\mathbf{Y}}$ at a place where the geomagnetic field, $\mathbf{F}$, is known.

(4) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC web site.

(5) Remarks

a) For calibration of the ship's magnetic effect, we made a "figure-eight" turn (a pair of clockwise and anti-clockwise rotation). This calibration was carried out as below.

06 Sep. 2013, 17:35 to 18:00 UTC 71-39.9N, 155-00.0W
01 Oct. 2013, 09:43 to 10:16 UTC 72-45.3N, 168-10.9W
18 Oct. 2013, 06:00 to 06:24 UTC 40-07.7N, 147-54.7E

**2) Cesium magnetometer**

(1) Personnel

| | |
|---|---|
| Masao Nakanishi | Chiba University: PI (not on-board) |
| Kazuho Yoshida | GODI |
| Masanori Murakami | GODI |
| Ryo Ohyama | MIRAI Crew |

(2) Objective

Measurement of total magnetic force on the sea is required for the geophysical investigations of marine magnetic anomaly caused by magnetization in upper crustal structure.

(3) Data Period

03:39UTC 15 Oct. 2013 - 13:39UTC 15 Oct. 2013

(4) Instruments and Methods

We measured total geomagnetic field using a cesium marine magnetometer (G-882, Geometrics Inc.) and recorded by G-882 data logger (Ver.1.0.0, Clovertech Co.). The G-882 magnetometer uses an optically pumped Cesium-vapor atomic resonance system. The sensor fish towed 500 m behind the vessel to minimize the effects of the ship's magnetic field. Table 5.3-1 shows system configuration of MIRAI cesium magnetometer system.

**Table 5.3-1.** System configuration of MIRAI cesium magnetometer system

| | | |
|---|---|---|
| Dynamic operating range: | 20,000 to 100,000 nT | |
| Absolute accuracy: | < ±2 nT throughout range | |
| Setting: | Cycle rate; | 0.1 sec |
| | Sensitivity; | 0.001265 nT at a 0.1 second cycle rate |
| | Sampling rate; | 1 sec |

(5) Data archives

These data obtained in this cruise will be submitted to the Data Management Group (DMG) of JAMSTEC, and will be opened to the public via "Data Research for Whole Cruise Information in JAMSTEC" in JAMSTEC web site.