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MR12-E02 Leg3 Cruise Report

Off Sanriku, north-eastern Japan

Marine Ecosystems Investigation, Impact by the mega-earthquake (the 2011 Earthquake of the Pacific coast of Tōhoku) and Tsunami: For Recovery and Rebuilding of Sanriku Fisheries Activities

R. V. Mirai

Leg 3: March 23rd to March 30th, 2012
of
March 6, 2012- March 30, 2012

Project: TEAMS (Tohoku Ecosystem Array of Marine Sciences)

JAMSTEC

Cruise Report ERRATA of the Nutrients part

page	Error	Correction
19	potassium nitrate CAS No. 7757-91-1	potassium nitrate CAS No. 7757-79-1

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MR12-E02 Leg3

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R/V Mirai

1-3. Title of the cruise

Marine Ecosystems Investigation, Impact by the mega-earthquake (the 2011 Earthquake of the Pacific coast of Tōhoku) and Tsunami: For Recovery and Rebuilding of Sanriku Fisheries Activities

1-4. Title of proposal

Marine Ecosystems Investigation, Impact by the mega-earthquake (the 2011 Earthquake of the Pacific coast of Tōhoku) and Tsunami: For Recovery and Rebuilding of Sanriku Fisheries Activities

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Leg3: 23rd March to 30th March, 2012

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Hachinohe (23rd March) to Yokohama (30th March)

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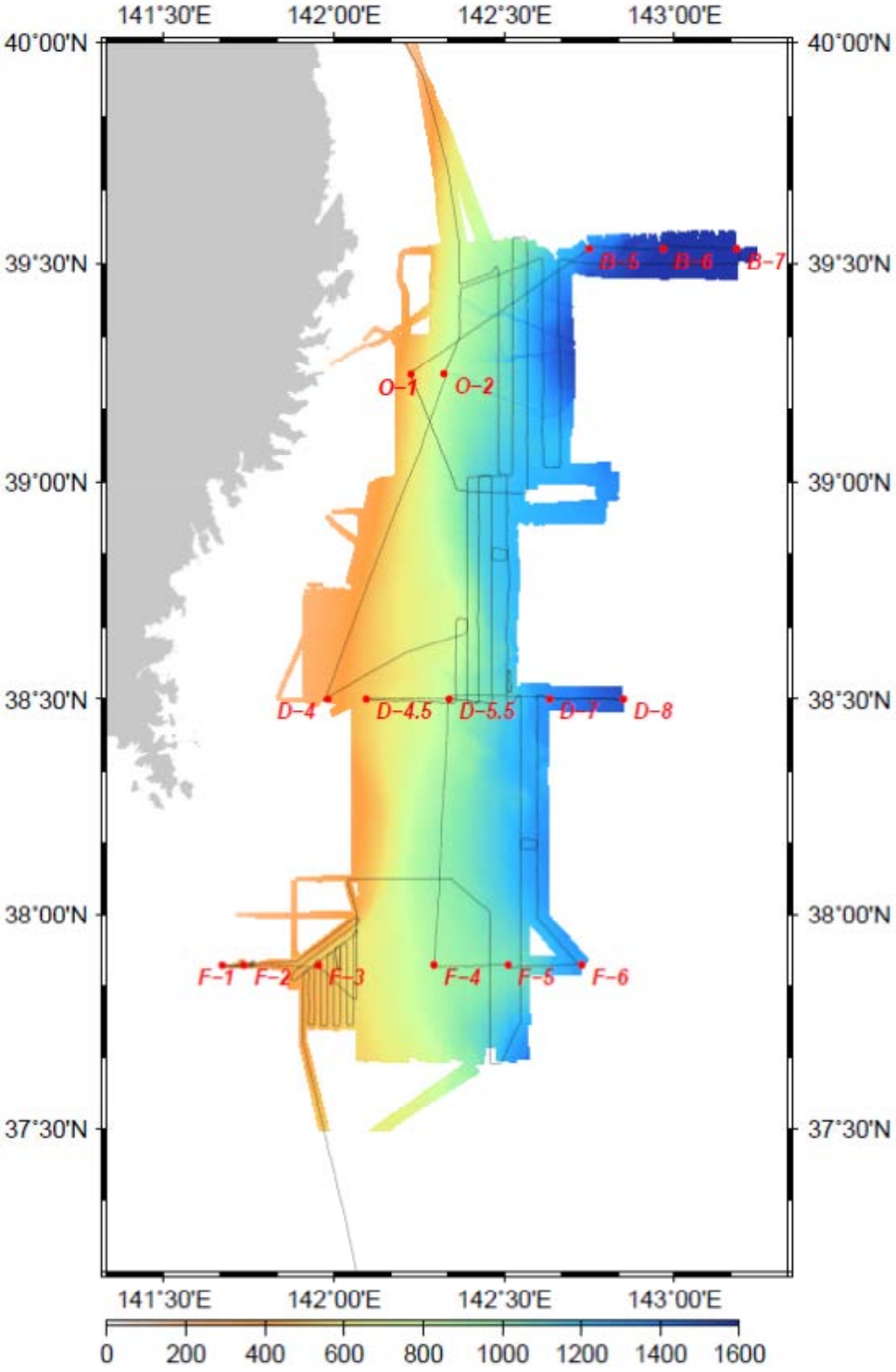

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Ordinary Seaman	Tomohiro	Shimada
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Ordinary Oiler	Hiromi	Ikuta
Ordinary Oiler	Yuichiro	Tani
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Cook	Tatsuya	Hamabe
Cook	Tamotsu	Uemura
Cook	Sakae	Hoshikuma
Steward	Shohei	Maruyama

3. Investigations

3-1. Introduction

The purpose of this cruise is to understand impacts on marine ecosystems by the 2011 Earthquake of the Pacific coast of Tōhoku and Tsunami, and to contribute for recover and rebuild of Sanriku fisheries activities in terms of marine science. Target areas are continental slope. This cruise is conducted under the TEAMS project, namely Tohoku Ecosystem Array of Marine Sciences. Detailed investigation subjects are topographic surveys, mapping of scattered debris, distribution patterns and diversity of benthic organisms, seawater and sediments geochemistry, and sediments characteristics. Based on these data and samples, we will construct habitat map for ecosystem management in Sanriku areas.

3-2. Facilities

3-2-1. Multiple corer

3-2-1-1. Multiple corer (MC)

A Multiple core sampler was used for taking the surface sediment. This core sampler consists of a main body of 620 kg-weight and 8 sub-core samplers (I.D. 74 mm and length of 60 cm). In this cruise, the Inclinometer “APC-USB-02” attached to the flame of MC.

3-2-1-2. Winch operation

When we starts lowering the MC, a speed of wire out is set to be 0.2m/s, and then gradually increased to be 1.0m/s. The MC is stopped at a depth about 50m above the sea floor for 3-5 minutes to reduce any pendulum motion of the sampler. After the sampler is stabilized, the wire is stored out at a speed of 0.3 m/s, and we carefully watch a tension meter. When the MC touches the bottom, wire tension leniently decreases by the loss of the sampler weight. After confirmation that the MC touch seafloor, the wire out is stopped then another 3-5 m rewinding. The wire is started at dead slow speed, until the tension gauge indicates that the corer is lifted off the bottom. After leaving the bottom, which wire is wound in at the maximum speed. The MC came back ship’s deck, the core barrel was detached main body.

3-2-1-3. MSCL measurements

A GEOTEK multi-sensor core logger (MSCL) has three sensors, which is gamma-ray attenuation (GRA), P-wave velocity (PWV), and magnetic susceptibility (MS). There were measured on whole-core section before splitting using the onboard MSCL. These data measurement was carried on every 1 cm.

GRA was measured a gamma ray source and detector. These mounted across the core on a sensor stand that aligns them with the center of the core. A narrow beam of gamma ray is emitted by Caesium-137 (^{137}Cs) with energies principally at 0.662 MeV. Also, the photon of gamma ray is collimated through 5mm diameter in rotating shutter at the front of the housing of ^{137}Cs. The photon passes through the core and is detected on the other side. The detector comprises a scintillator (a 2” diameter and 2” thick NaI crystal).

GRA calibration assumes a two-phase system model for sediments, where the two phases are the minerals

and the interstitial water. Aluminum has an attenuation coefficient similar to common minerals and is used as the mineral phase standard. Pure water is used as the interstitial-water phase standard. The actual standard consists of a telescoping aluminum rob (five elements of varying thickness) mounted in a piece of core liner and filled with distilled water. GRA was measured with 10 seconds counting.

PWV was measured two oil filled Acoustic Rolling Contact (ARC) transducers, which are mounted on the center sensor stand with gamma system. These transducers measure the velocity of P-Wave through the core and the P-Wave pulse frequency.

MS was measured using Bartington loop sensor that has an internal diameter of 100 mm installed in MSCL. An oscillator circuit in the sensor produces a low intensity (approx. 80 A/m RMS) non-saturating, alternating magnetic field (0.565 kHz). MS was measured with 1 second.

3-2-1-4. Core splitting

The sediment sections are longitudinally cut into working and archive halves by a splitting devise and a stainless wire. After that, it marks with the white and blue pins in the 2 cm interval.

3-2-1-5. CCR measurements

Core color reference (CCR) was measured by using the Konica Minolta CM-700d (CM-700d) reference photo spectrometer using 400 to 700nm in wavelengths. This is a compact and hand-held instrument, and can measure spectral reflectance of sediment surface with a scope of 8 mm diameter. To ensure accuracy, the CM-700d was used with a double-beam feedback system, monitoring the illumination on the specimen at the time of measurement and automatically compensating for any changes in the intensity or spectral distribution of the light. The CM-700d has a switch that allows the specular component to be include (SCI) or excluded (SCE). We chose setting the switch to SCE. The SCE setting is the recommended mode of operation for sediments in which the light reflected at a certain angle (angle of specular reflection) is trapped and absorbed at the light trap position on the integration sphere.

Calibrations are zero calibration and white calibration before the measurement of core samples. Zero calibration is carried out into the air. White calibration is carried out using the white calibration piece (CM-700d standard accessories) without crystal clear polyethylene wrap. The color of the split sediment (Archive half core) was measured on every 2 cm through crystal clear polyethylene wrap.

There are different systems to quantify the color reference for soil and sediment measurements, the most common is the $L^*a^*b^*$ system, also referred to as the CIE (Commision International d'Eclairage) LAB system. It can be visualized as a cylindrical coordinate system in which the axis of the cylinder is the lightness variable L^*,ranging from 0 % to 100 %, and the radii are the chromaticity variables a^* and b^*. Variable a* is the green (negative) to red (positive) axis, and variable b* is the blue (negative) to yellow (positive) axis. Spectral data can be used to estimate the abundance of certain components of sediments.

Measurement parameters are displayed Table 3-2-1.1.

Table 3-2-1.1. Measurement parameters.

Instrument	Konica Minolta Photospectrometer CM-700d

Software	Spectra Magic NX CM-S100w Ver.2.02.0002
Illuminant	d/8 (SCE)
Light source	D_{65}
Viewing angle	10 degree
Color system	$L^*a^*b^*$ system

3-2-1-6. Core Photographs

After splitting each section of piston and pilot cores into working and archive halves, sectional photographs of working were taken using a single-lens reflex digital camera (Body: Nikon D90 / Lens: Nikon AF200m Nikkor 24-50mm). When using the digital camera, shutter speed was 1/13 ~ 1/40 sec, F-number was 6.4 ~ 8, sensitivity was ISO 200. File format of raw data is Exif-JPEG. Details for settings were included on property of each file.

3-2-1-7. Soft X-ray photographs

Soft X-ray photographs were taken to observe sedimentary structures of cores.

Sediment samples were put into the original plastic cases (200 x 3 x 7 mm) from cores. Each case has a TEPURA sheel showing cruise code, core number, section number, case number, and section depth (cm), and was rimmed by PARAFILM to seal the sediment.

Soft X-ray photographs were taken to using the device SOFTEX PRO-TEST 150 on board. The condition of X-ray was decided from results of test photographs by each core section. The condition was ranged between 40 ~ 50 KVp, 1.5 ~ 2 mA, and 200 seconds.

All photographs were developed into the negative films by the device FIP-1400 on board.

3-2-2. Hydrographic observations

3-2-2-1. CTD cast and water sampling

Masahide Wakita (JAMSTEC RIGC)
Shinsuke Toyoda (MWJ)
Shungo Oshitani (MWJ)

(1) Objective

Investigation of oceanic structure and water sampling.

(2) Parameters

Temperature (Primary and Secondary)

Conductivity (Primary and Secondary)

Pressure

Dissolved Oxygen

Dissolved Oxygen Voltage

Transmission

Transmission Voltage

Fluorescence

Photosynthetically Active Radiation (PAR)

Altimeter

(3) 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, washed by neutral detergent, were used for sampling seawater. The sensors attached on the CTD were temperature (Primary and Secondary), conductivity (Primary and Secondary), pressure, dissolved oxygen, RINKO III (dissolved oxygen sensor), transmission, transmission voltage, fluorescence, transmission voltage, PAR sensor, 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.7.21d) 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 usually stop at each layer for 30 seconds to stabilize then fire.

14 casts of CTD measurements were conducted (Table 3-2-2-1).

During the up down of B07M01 (382-390dbar), unusual profile was observed in the secondary temperature and conductivity data.

We usually stop at each layer for 30 seconds to stabilize then fire. At the station B07M01, bottles were fired without stopping from 1900 to 400 dbar due to rough sea.

Data processing procedures and used utilities of SBE Data Processing-Win32 (ver.7.18d) and SEASOFT were as follows:

(The process in order)

DATCNV: Convert the binary raw data to engineering unit data. DATCNV also extracts bottle information where scans were marked with the bottle confirm bit during acquisition. The duration was set to 3.0 seconds, and the offset was set to 0.0 seconds.

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

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

BOTTLESUM: Create a summary of the bottle data. The data were averaged over 3.0 seconds.

ALIGNCTD: Convert the time-sequence of sensor output into the pressure sequence to ensure that all calculations were made using measurements from the same parcel of water. Dissolved oxygen data are systematically delayed with respect to depth mainly because of the long time constant of the dissolved oxygen sensor and of an additional delay from the transit time of water in the

pumped pluming line. This delay was compensated by 6 seconds advancing dissolved oxygen sensor (SBE43) output (dissolved oxygen voltage) relative to the temperature data. RINKO III voltage data, transmission data and transmission voltage data 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 voltage (SBE43).

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

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

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

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

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

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

DERIVE: Compute dissolved oxygen (SBE43).

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

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

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

Configuration file: MR12E02A.con

Specifications of the sensors are listed below.

CTD: SBE911plus CTD system

Under water unit:

Temperature sensors:

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

Calibrated Date: 18 May 2011

Secondary: SBE03-04/F (S/N 031524, Sea-Bird Electronics, Inc.)

Calibrated Date: 29 Jul. 2011

Conductivity sensors:

Primary: SBE04-04/0 (S/N 041203, Sea-Bird Electronics, Inc.)

Calibrated Date: 25 May 2011

Secondary: SBE04-04/0 (S/N 041206, Sea-Bird Electronics, Inc.)

Calibrated Date: 14 Jun. 2011

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

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

Calibrated Date: 19 May 2011

Dissolved Oxygen sensor:

SBE43 (S/N 430394, Sea-Bird Electronics, Inc.)

Calibrated Date: 25 Oct. 2011

Dissolved Oxygen sensors:

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

RINK III (S/N 0079, Alec Electronics Co. Ltd.)

Transmissometer:

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

Fluorescence:

Chlorophyll Fluorometer (S/N 3054, Seapoint Sensors, Inc.)

Photosynthetically Active Radiation:

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

Calibrated Date: 22 Jan. 2009

Altimeter:

Benthos PSA-916T (S/N 1157, Teledyne Benthos, Inc.)

Carousel water sampler:

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

Deck unit: SBE11plus (S/N 11P7030-0272, Sea-Bird Electronics, Inc.)

3-2-2-2. Salinity measurement

Masahide WAKITA (JAMSTEC MIO)
Hiroki Ushiromura (MWJ)

(1) Objective

To measure bottle salinity obtained by CTD casts, bucket sampling, and The Continuous Sea Surface Water Monitoring System (TSG).

(2) Methods

a. Salinity Sample Collection

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

The number of samples is shown as follows;

Table 3-2-2-2.1 The number of samples

Sampling type	Number of samples
CTD and Bucket	291
TSG	6
Total	297

b. Instruments and Method

The salinity analysis on R/V MIRAI was carried out during the cruise of MR12-E02Leg3 using the salinometer (Model 8400B "AUTOSAL"; Guildline Instruments Ltd.: S/N 62827) with an additional peristaltic-type intake pump (Ocean Scientific International, Ltd.). A pair of precision digital thermometers (Model 9540; Guildline Instruments Ltd.: S/N 66723 and 62521) were used. The thermometer monitored the ambient temperature and the bath temperature of the salinometer.

The specifications of AUTOSAL salinometer and thermometer 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)

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 21.9 deg C to 23.4 deg C, while the bath temperature was very stable and varied within +/- 0.003 deg C on rare occasion.

The measurement for each sample was done with the double conductivity ratio and defined as the median of 31 readings of the salinometer. Data collection was started 5 seconds after filling the cell with the sample and it took about 10 seconds to collect 31 readings by a personal computer. Data were taken for the sixth and seventh filling of the cell after rinsing five times. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity with the algorithm for practical salinity scale, 1978 (UNESCO, 1981). If the difference was greater than or equal to 0.00003, an eighth filling of the cell was done. In the case of the difference between the double conductivity ratio of these two fillings being smaller than 0.00002, the average value of the double conductivity ratio was used to calculate the bottle salinity. In the case of the double conductivity ratio of eighth filling did not satisfy the criteria above, we measured a ninth filling of the cell and calculated the bottle salinity. The measurement was conducted in about 4 - 10

hours per day and the cell was cleaned with soap after the measurement of the day.

(3) Preliminary Result

a. Standard Seawater

Standardization control of the salinometer was set to 490 and all measurements were done at this setting. The value of STANDBY was 24+5417 +/- 0001 and that of ZERO was 0.0-0000 +/- 0001. The conductivity ratio of IAPSO Standard Seawater batch P153 was 0.99979 (the double conductivity ratio was 1.99958) and was used as the standard for salinity. We measured 13 bottles of P153.

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

Batch	:	P153
conductivity ratio	:	0.99979
salinity	:	34.992
Use by	:	8th-March-2014

(4) Reference

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

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

3-2-2-3. Dissolved oxygen

Masahide WAKITA (JAMSTEC) : Principal Investigator

Miyo IKEDA (MWJ) : Operation Leader

Misato KUWAHARA (MWJ)

(1) Objectives

Determination of dissolved oxygen in seawater by Winkler titration.

(2) Parameter

Dissolved Oxygen

(3) 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-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 version 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 EPJ3885, 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, CTD salinity, 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 3-2-2-3.1 shows results of the standardization and the blank determination during this cruise.

Table 3-2-2-3.1 Results of the standardization and the blank determinations during this cruise.

Data	KIO_3 ID	$Na_2S_2O_3$	DOT-01X(No.7)		DOT-01X(No.8)	
			E.P.	Blank	E.P.	Blank
2012/3/16	CSK	20110602-06-01	3.962	-	3.965	-
2012/3/16	20110524-07-03	20110602-06-01	3.967	-0.004	3.970	0.000
2012/03/20	20110524-07-07	20110602-06-01	3.966	-0.002	3.969	0.001
2012/03/20	20110524-07-07	20110602-06-02	3.965	-0.004	3.968	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 52. The standard deviation of the replicate measurement was 0.16 μmol kg^{-1} that was calculated by a procedure in Guide to best practices for ocean CO_2 measurements Chapter4 SOP23 Ver.3.0 (2007).

3-2-2-4 Nutrients of Sampled Water

Masahide WAKITA(JAMSTEC MIO) Principal Investigator
Masanori ENOKI (MWJ) Operator
Yasuhiro Arii (MWJ) Operator

(1) Objectives

To monitor the environmental properties of water column at off Tohoku area.

(2) Parameters

Nitrate, Nitrite, Phosphate, Silicate and Ammonia.

(3) Instrument and methods

Nutrient analysis was performed on the BL-Tech QUAATRO 2-HR system. The laboratory temperature was maintained between 21-22 deg C.

a. Measured Parameters

Nitrate + nitrite and nitrite were analyzed according to the modification method of Grasshoff (1970). The sample nitrate was reduced to nitrite in a cadmium tube inside of which was coated with metallic copper. The sample streamed with its equivalent nitrite was treated with an acidic, sulfanilamide reagent and the nitrite forms nitrous acid which reacted with the sulfanilamide to produce a diazonium ion. N-1-Naphthylethylene-diamine added to the sample stream then coupled with the diazonium ion to produce a red, azo dye. With reduction of the nitrate to nitrite, both nitrate and nitrite reacted and were measured; without reduction, only nitrite reacted. Thus, for the nitrite analysis, no reduction was performed and the alkaline buffer was not necessary. Nitrate was computed by difference.

Absorbance of 550 nm by azo dye in analysis is measured using a 1 cm length cell for Nitrate and 3 cm length cell for Nitrite.

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

Absorbance of 630 nm by silicomolybdous acid in analysis is measured using a 1 cm length cell.

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

Absorbance of 880 nm by phosphomolybdous acid in analysis is measured using a 1 cm length cell.

The ammonia in seawater was mixed with an alkaline containing EDTA, ammonia as gas state was formed from seawater. The ammonia (gas) was 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 absorbe

in sulfuric acid was determined by coupling with phenol and hypochlorite to form indophenols blue. Wavelength using ammonia analysis was 630 nm, which was absorbance of indophenols blue.

b. Nutrients Standard

Specifications

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

For nitrite standard, "sodium nitrate" provided by Wako, CAS No.: 7632-00-0, was used. The assay of nitrite salts was determined according JIS K8019 were 98.31%. We used that value to adjust the weights taken.

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

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 HC074650 was used.

For the ammonia standard, "ammonia sulfate" provided by Wako, CAS No.: 7783-20-2, was used.

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

Concentrations of nutrients for A, B and C standards

Concentrations of nutrients for A, B and C standards (working standards) were set as shown in Table 3-2-2-4.1. Then the actual concentration of nutrients in each fresh standard was calculated based on the ambient temperature, solution temperature and determined factors of volumetric laboratory wares.

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

Table 3-2-2-4.1. 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	900	0.03	9.2	18.3	36.6	55.0
NO_2 (μM)	4000	20	0.00	0.4	0.8	1.6	2.0
SiO_2 (μM)	36000	2800	0.80	28	56	111	167
PO_4 (μM)	3000	60	0.04	0.6	1.2	2.4	3.6
NH_4 (μM)	4000	200	0.00	0.0	2.0	4.0	6.0

c. Sampling Procedures

Sampling of nutrients followed that oxygen, salinity and trace gases. Samples were drawn into two of 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 were put into water bath adjusted to ambient temperature, 21 ± 1 deg. C, in about 30 minutes before use to stabilize the temperature of samples. The

samples of bottle 14, 20, 26 and 32 were measured in duplicate and the rest were measured in single on each sample run.

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

Sets of 5 different concentrations for nitrate, nitrite, silicate, phosphate and Ammonia of the shipboard standards were analyzed at beginning and end of each group of analysis. The standard solutions of highest concentration were measured every 9 - 17 samples and were used to evaluate precision of nutrients analysis during the cruise. We also used reference material for nutrients in seawater, RMNS (KANSO Co., Ltd., lots BS, BU, BT and BV).

d. Low Nutrients Sea Water (LNSW)

Surface water having low nutrient concentration was taken and filtered using 0.45 μm pore size membrane filter. This water was stored in 20 liter cubitainer with paper box. The concentrations of nutrient of this water were measured carefully in Jan 2011.

(4) Results

Analytical precisions in this cruise were 0.17% for nitrate, 0.16% for nitrite, 0.17% for silicate, 0.18% for phosphate, 0.38% for Ammonia in terms of median of precision, respectively. Summary of precisions are shown as shown in Table 3-2-2-4.2.

Table 3-2-2-4.2. Summary of precision based on the replicate analyses at MR12-E02Leg3.

	Nitrate CV %	Nitrite CV %	Phosphate CV %	Silicate CV %	Ammonia CV%
Median	0.17	0.16	0.17	0.18	0.38
Mean	0.17	0.18	0.14	0.17	0.36
Maximum	0.22	0.28	0.19	0.25	0.49
Minimum	0.12	0.11	0.04	0.09	0.15
N	7	7	7	7	7

3-2-2-5.Chlorophyll *a* measurements by fluorometric determination

Masahide WAKITA (JAMSTEC)
Hideki YAMAMOTO (MWJ)
Shoko TATAMISASHI (MWJ)

(1) Objective

Phytoplankton biomass can estimate as the concentration of chlorophyll *a* (chl-*a*), because all oxygenic photosynthetic plankton contain chl-*a*. Phytoplankton exist various species in the ocean. The objective of this

study is to investigate the vertical distribution of phytoplankton.

(2) Sampling

Samplings of total chl-*a* were conducted from 12 depths between the surface and 200 m at all observational stations.

(3) Instruments and Methods

Water samples (150mL ~ 0.5L) for total chl-*a* were filtered (<0.02 MPa) through 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 (Suzuki and Ishimaru, 1990). Those tubes were stored at –20°C under the dark condition to extract chl-*a* for 24 hours or more.

Fluorescences of each sample were measured by Turner Design fluorometer (10-AU-005), which was calibrated against a pure chl-*a* (Sigma-Aldrich Co.). We applied two kind of fluorometric determination for the samples of total chl-*a*: "Non-acidification method" (Welschmeyer, 1994) and "Acidification method" (Holm-Hansen *et al*., 1965).

Table 3-2-2-5.1. Analytical conditions of "Non-acidification method" and "Acidification method" for chlorophyll *a* with Turner Designs fluorometer (10-AU-005).

	Non-acidification method	Acidification method
Excitation filter (nm)	436	340-500
Emission filter (nm)	680	>665
Lamp	Blue Mercury Vapor	Daylight White

3-2-2-6. Sea surface water monitoring

Masahide WAKITA (JAMSTEC): Principal Investigato
Shoko TATAMISASHI (MWJ)
Misato KUWAHARA (MWJ)
Hideki Yamamoto(MWJ)

(1) Objective

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

(2) Instruments and Methods

The Continuous Sea Surface Water Monitoring System (Marine Works Japan Co. Ltd.) has four sensors and automatically measures salinity, temperature, 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 m water depth and flowed into the system through a vinyl-chloride pipe. The flow rate of the surface seawater was adjusted to be 4.5 dm^3 min^{-1}. Specifications of the each sensor in this system are listed below.

a. Instruments

Software

Seamoni-kun Ver.1.20

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:	4557820-0319
Measurement range:	Temperature -5 to +35 ^oC
	Conductivity 0 to 7 S m^{-1}
Initial accuracy:	Temperature 0.002 ^oC
	Conductivity 0.0003 S m^{-1}
Typical stability (per month):	Temperature 0.0002 ^oC
	Conductivity 0.0003 S m^{-1}
Resolution:	Temperatures 0.0001 ^oC
	Conductivity 0.00001 S m^{-1}

Bottom of ship thermometer

Model:	SBE 38, SEA-BIRD ELECTRONICS, INC.
Serial number:	3857820-0540
Measurement range:	-5 to +35 ^oC
Initial accuracy:	±0.001 ^oC
Typical stability (per 6 month):	0.001 ^oC
Resolution:	0.00025 ^oC

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

Fluorometer

Model:	C3, TURNER DESIGNS
Serial number:	2300123

(3) Measurements

Periods of measurement, maintenance, and problems during MR12-E02 leg3 are listed in Table 3-2-2-6.1.

Table 3-2-2-6.1. Events list of the surface seawater monitoring during MR12-E02 leg3

System Date [UTC]	System Time [UTC]	Events	Remarks
2012/3/23	03:40	All the measurements started and data was available.	Leg 3 start.
2012/3/28	23:19	All the measurements stopped.	Leg3 end.

3-2-2-7. Carbonate system (dissolved inorganic carbon and total alkalinity)

Masahide Wakita (Mutsu Institute for Oceanography, JAMSTEC)
Hajime Kawakami (Mutsu Institute for Oceanography, JAMSTEC)

(1) Purpose of the study

Concentration of CO_2 in the atmosphere is now increasing owing to human activities such as burning of fossil fuels, deforestation, and cement production. The ocean plays an important role in buffering the increase of atmospheric CO_2. Anthropogenic CO_2 emitted into the atmosphere as a result of human activities was globally taken up by oceans at a rate of 2.2 ± 0.4 Pg C y^{-1} during the 1990s [*IPCC*, 2007]. Ocean acidification is a direct consequence of the ocean absorbing large amounts of the anthropogenic CO_2. The CO_2 uptake by the oceans has led to lowering both pH and $CaCO_3$ saturation states with regard to the mineral phases due to increasing hydrogen ions (H^+) and declining carbonate ion (CO_3^{2-}), respectively. Because oceanic biological activity has an important role concerned to CO_2 cycle in the ocean through its photosynthesis and respiration, the chemical changes associated with ocean acidification have the potential to affect ocean biogeochemistry and ecosystems in a myriad of ways. Therefore, it is important to clarify the mechanism of the oceanic CO_2 absorption and ocean acidification and to estimate CO_2 absorption capacity and decrease of pH and $CaCO_3$ saturation states in recent years. When CO_2 dissolves in water, chemical reaction takes place and CO_2 alters its appearance into several species. Concentrations of the individual species of the CO_2 system in solution cannot be measured directly, but calculated from two of four parameters: total dissolved inorganic carbon (DIC), total alkalinity (TA), pH and pCO_2. This study presents the distribution of DIC and TA in March off Sanriku of the north-eastern Japan.

(2) Sampling

Seawater samples of TA and DIC were collected by 12 liter Niskin bottles mounted on the CTD/Carousel Water Sampling System and a bucket at stations O-2, F-2 and F-4 and brought the total to ~60. Seawaters

were sampled in a 250 ml glass bottle for DIC and a 100 ml glass bottle (SCHOTT DURAN) for TA. These bottles were previously soaked in 5 % non-phosphoric acid detergent (pH = 13) solution at least 3 hours and was cleaned by fresh water for 5 times and Milli-Q deionized water for 3 times. A sampling silicone rubber tube with PFA tip was connected to the Niskin bottle when the sampling was carried out. The glass bottles were filled from the bottom, without rinsing, and were overflowed for 20 seconds. After collecting the samples on the deck, the glass bottles were carried to the laboratory. Within one hour after the sampling, 1 % by the bottle volume was removed from the glass bottle and poisoned with 0.04% by volume of over saturated solution of mercury chloride. Then, the samples of DIC were sealed by greased ground glass stoppers. All samples preserved at ~ 5°C cold until analysis in our land laboratory.

(3) Analysis

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

(4) Preliminary result

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

(5) References

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

3-2-2-8. Dissolved Organic Carbon

Masahide Wakita (Mutsu Institute for Oceanography, JAMSTEC)
Hajime Kawakami (Mutsu Institute for Oceanography, JAMSTEC)

(1) Purpose of the study

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

(2) Sampling

Seawater samples were collected at stations O-2, F-2 and F-4 and brought the total to ~90. Seawater from each Niskin bottle was transferred into 60 ml High Density Polyethylene bottle (HDPE) rinsed with

same water three times. Water taken from the surface to 250 m is filtered using precombusted (450°C) GF/F inline filters as they are being collected from the Niskin bottle. At depths > 250 m, the samples are collected without filtration. After collection, samples are frozen upright and preserved at ~ -20 °C cold until analysis in our land laboratory. Before use, all glassware was muffled at 550 °C for 5 hrs.

(3) Analysis

Prior to analysis, samples are returned to room temperature and acidified to pH < 2 with concentrated hydrochloric acid. DOC analysis was basically made with a high-temperature catalytic oxidation (HTCO) system improved a commercial unit, the Shimadzu TOC-V (Shimadzu Co.). In this system, the non-dispersive infrared was used for carbon dioxide produced from DOC during the HTCO process (temperature: 680 °C, catalyst: 0.5% Pt-Al_2O_3).

(4) Preliminary result

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

3-2-2-9. Phytoplankton abundance

Masahide Wakita (Mutsu Institute for Oceanography, JAMSTEC)
Hajime Kawakami (Mutsu Institute for Oceanography, JAMSTEC)

(1) Purpose of the study

The main objective of this study is to estimate phytoplankton abundances and their taxonomy in March off Sanriku of the north-eastern Japan. .Phytoplankton abundances were measured with microscopy for large size phytoplankton.

(2) Sampling

Samplings were conducted using Niskin bottles, except for the surface water, which was taken by a bucket. Samplings were carried out at the three observational stations of O-1, O-2, F-2, F-4 and F-6.

(3) Methods

Water samples were placed in 500 ml plastic bottle in 1000 ml plastic bottle. Samples were fixed with neutral-buffered formalin solution (1% final concentration). The microscopic measurements are scheduled after the cruise.

(4) Preliminary result

The phytoplankton abundances and their taxonomy will be determined as soon as possible after this cruise.

3-2-3. Gravity & Magneto meters

1) Gravitymeter

The LaCoste and Romberg air-sea gravity meter S-116 (Micro-g LaCoste, LLC) is equipped on-board *R/V MIRAI*.

Table 3.2.3-1 shows system configuration of MIRAI gravity meter.

Table 3.2.3-1 system configuration

LaCoste and Romberg air-sea gravity meter meter (S-116)	
Range:	12,000 mGal
Drift rate:	<±3.0 mGal/month
Temperature setpoint:	46 to 55 deg-C
Resolution:	0.01 mGal
Static repeatability:	0.05 mGal
Accuracy at sea:	1.0 mGal or better
Sampling rate:	1 sec
Relative gravity	Counter unit [CU]
	To change gravity [mGal] = (coef1: 0.9946) * [CU]

2) Three-component magnetometer

The shipboard three-component magnetometer system (Tierra Tecnica SFG1214) is equipped on-board *R/V MIRAI*. Three-axes flux-gate sensors with ring-cored coils are fixed on the fore mast. Outputs of 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 utilizing a ring-laser gyro installed for controlling attitude of a Doppler radar. Ship's position (GPS) and speed data are taken from LAN every second.

3-2-4. Seabeam 2112.004

The "SEABEAM 2112.004" (SeaBeam Instruments Inc.) is the Multi-narrow Beam Echo Sounding system (MBES) equipped on-board *R/V MIRAI*. This system is including the Sub-Bottom Profiler (SBP) system.

Table 3-2-4.1 shows system configuration and performance of SEABEAM 2112.004 system.

Table 3-2-4.1. System configuration and performance

SEABEAM 2112.004 (12 kHz system)	
Frequency:	12 kHz
Transmit beam width:	2 degree
Transmit power:	20 kW
Transmit pulse length:	3 to 20 msec.
Depth range:	100 to 11,000 m
Beam spacing:	1 degree athwart ship
Swath width:	150 degree (max)
	120 degree to 4,500 m
	100 degree to 6,000 m
	90 degree to 11,000 m
Depth accuracy:	Within < 0.5% of depth or +/-1m,
	whichever is greater, over the entire swath.
	(Nadir beam has greater accuracy;
	typically within < 0.2% of depth or +/-1m, whichever is greater)

Sub-Bottom Profiler (4kHz system)	

3-3. Cruise log

Date	Time	Description	Position, depth
23-Mar-2012	9:00	Departure from the Hachinohe port	
	14:02	Start MBES, SBP survey	39-54.80N, 142-15.90E
	15:39	XBT	39-35.69N, 142-21.46E
	18:48	XCTD	39-11.83N, 142-29.00E
	21:43	XBT	39-17.59N, 142-31.46E
24-Mar-2012	05:48	Arrive at stn.O-1. Finish MBES, SBP survey	
	06:00 ~06:45	CTD(O-1)	39-14.68N, 142-13.37E Depth:485m
	07:12 ~08:00	MC(O-1:MC01)	39-15.06N, 142-13.58E Depth:500m
	08:32 ~09:14	MC(O-1:MC02)	39-15.04N, 142-13.57E Depth:502m
	09:18	Left stn.O-1	
	12:00	Arrive at stn. B-5	
	12:00 ~13:21	CTD(B-5)	39-32.10N, 142-44.71E Depth:1320m
	13:24	Left stn.B-5	
	14:30	Arrive at stn. B-6	
	14:34 ~16:11	CTD(B-6)	39-32.12N, 142-57.91E Depth:1589m
	16:12	Left stn.B-6	
	17:18	Arrive at stn. B-7	
	17:21 ~18:56	CTD(B-7)	39-32.09N, 143-10.97E Depth:2003m
	19:00	Left stn.B-7 Start MBES, SBP survey	
25-Mar-2012	05:48	Finish MBES, SBP survey Arrive at stn.O-2	
	05:57 ~6:56	CTD(O-2)	39-14.54N, 142-19.27E Depth:829m
	07:09 ~08:12	MC(O-2:MC03)	39-14.65N, 142-19.62E Depth:874m
	08:41 ~09:42	MC(O-2:MC04)	39-14.64N, 142-19.61E Depth:870m

	09:48 13:48	Left stn.O-2 Arrive at stn. D-4	
	13:54 ~14:33	MC(D-4:MC05)	38-29.96N, 141-58.46E Depth:319m
	15:03 ~15:40	MC(D-4:MC06)	38-30.01N, 141-58.47E Depth:319m
	15:42	Left stn.D-4 Start MBES, SBP survey	
	18:12	XCTD	38-44.92N, 142-23.45E
26-Mar-2012	02:01 05:42	XBT Arrive at stn.D-4.5 Finish MBES, SBP survey	38-30.94N, 142-23.49E
	05:58 ~06:41	MC(D-4.5:MC07)	38-30.04N, 142-05.67E Depth:502m
	07:06 ~07:47	MC(D-4.5:MC08)	38-30.02N, 142-05.65E Depth:501m
	08:30 ~9:10	CTD(D-4.5)	38-29.98N, 142-05.69E Depth:491m
	09:48 10:18	Left stn.D-4.5 Arrive at stn. D-5.5	
	10:20 ~11:22	CTD(D-5.5)	38-30.07N, 142-20.28E Depth:825m
	11:45 ~12:42	MC(D-5.5 No Core)	38-30.00N, 142-20.24E Depth:838m
	13:35 ~14:35	MC(D-5.5 No Core)	38-30.01N, 142-20.24E Depth:837m
	14:36 16:42	Left stn.D-5.5 Arrive at stn. D-8	
	16:42 ~18:16	CTD(D-8)	38-30.03N, 142-50.86E Depth:1503m
	18:18	Left stn.D-8 Start MBES, SBP survey	
27-Mar-2012	05:48	Arrive at stn.D-5.5 Finish MBES, SBP survey	
	05:57 ~06:57	MC(D-5.5:MC09)	38-29.99N, 142-20.25E Depth:838m

	07:00	Left stn.D-5.5	
	09:54	Arrive at stn. F-4	
	09:54 ~10:51	CTD(F-4)	37-52.90N, 142-17.57E Depth:866m
	11:01 ~12:00	MC(F-4 MC10)	37-52.98N, 142-17.60E Depth:877m
	12:30 ~13:32	MC(F-4 MC11)	37-52.98N, 142-18.00E Depth:878m
	13:36	Left stn.F-4	
	14:30	Arrive at stn. F-5	
	14:32 ~15:48	CTD(F-5)	37-52.84N, 142-30. 68E Depth:1022m
	15:48	Left stn.F-5	
	16:42	Arrive at stn. F-6	
	16:46 ~18:02	CTD(F-6)	37-52.85N, 142-43. 58E Depth:1267m
	18:06	Left stn.F-6 Start MBES, SBP survey	
	23:28	XBT	37-40.36N, 142-27.49E
28-Mar-2012	01:35	XCTD	38-01.37N, 142-26.12E
	04:07	XBT	37-58.74N, 142-04.02E
	05:48	Arrive at stn.F-3 Finish MBES, SBP survey	
	05:59 ~06:41	MC(F-3:MC12)	37-52.87N, 141-57.18E Depth:498m
	07:10 ~07:52	MC(F-3:MC13)	37-52.86N, 141-57.19E Depth:497m
	08:02 ~08:43	CTD(F-3)	37-52.81N, 141-57.29E Depth:484m
	08:48	Left stn.F-3	
	10:00	Arrive at stn. F-1	
	10:04 ~10:32	CTD(F-1)	37-52.88N, 141-40.32E Depth:203m
	10:36	Left stn.F-1	
	11:24	Arrive at stn. F-2	
	11:28 ~12:03	CTD(F-2)	37-52.84N, 141-44.10E Depth:296m
	12:08	MC(F-2 MC14)	37-52.87N, 141-44.08E

	~12:43		Depth:309m
	12:58 ~13:35	MC(F-2 MC15)	37-52.89N, 141-44.07E Depth:308m
	13:46 ~14:14 14:18	Calibration for the Geomagnetometer and tiltmeter attached to Multiple corer Left stn.F-2 Start MBES, SBP survey	37-53.19N, 141-45.19E
29-Mar-2012	09:00	Stop the continuous sampling of surface seawater Finish MBES, SBP survey	
30-Mar-2012	09:40	Arrival at the Yokohama port	

3-4.General investigation results

3-4-1. CTD Hydrocast Investigations

Hydrocast List

Table. Sampling stations during MR12-E02 Hydrographic observation

Cruise	Station	Latitude		Longitude		Bot. Depth	Memo	Properties
MR12-E02	A-1	40	0.0	141	59.0	98	Cancelled	
MR12-E02	A-2	40	0.0	142	5.0	119	Cancelled	
MR12-E02	A-3	40	0.0	142	11.0	152	Cancelled	
MR12-E02	A-4	40	0.0	142	24.0	627	Cancelled	
MR12-E02	A-5	40	0.0	142	37.0	886	Cancelled	
MR12-E02	A-6	40	0.0	142	50.0	1152	Cancelled	
MR12-E02	A-7	40	0.0	143	3.0	1332	Cancelled	
MR12-E02	B-1	39	32.0	142	6.0	137	Cancelled	
MR12-E02	B-2	39	31.3	142	11.8	249	Leg. 1	CTD DO Sal. Nutrients Chl.a
MR12-E02	B-3	39	31.8	142	18.9	598	Leg. 1	CTD DO Sal. Nutrients Chl.a Phytoplankton
MR12-E02	B-4	39	32.0	142	32.0	971	Leg. 1	CTD DO Sal. Nutrients Chl.a
MR12-E02	B-5	39	32.0	142	45.0	1327	Leg. 2	CTD DO Sal. Nutrients Chl.a
MR12-E02	B-6	39	32.0	142	58.0	1662	Leg. 2	CTD DO Sal. Nutrients Chl.a
MR12-E02	B-7	39	32.0	143	11.0	2039	Leg. 2	CTD DO Sal. Nutrients Chl.a
MR12-E02	O-1	39	14.8	143	13.6	494	Leg. 2	CTD DO Sal. Nutrients Chl.a Phytoplankton
MR12-E02	O-2	39	14.6	143	19.4	502	Leg. 2	CTD DO Sal. Nutrients Chl.a DIC TA DOC Phytoplankton
MR12-E02	C-1	38	56.0	141	44.0	51	Cancelled	
MR12-E02	C-2	38	56.0	141	50.0	130	Cancelled	
MR12-E02	C-3	38	56.0	141	58.6	212	Leg. 1	CTD DO Sal. Nutrients Chl.a
MR12-E02	C-4	38	55.8	142	10.1	497	Leg. 1	CTD DO Sal. Nutrients Chl.a DIC TA DOC Phytoplankton
MR12-E02	C-5	38	55.9	142	23.0	1027	Leg. 1	CTD DO Sal. Nutrients Chl.a
MR12-E02	C-6	38	55.8	142	34.8	1211	Leg. 1	CTD DO Sal. Nutrients Chl.a
MR12-E02	C-7	38	56.3	142	48.4	1303	Leg. 1	CTD DO Sal. Nutrients Chl.a
MR12-E02	C-8	38	56.0	143	1.0	1635	Cancelled	
MR12-E02	D-1	38	30.0	141	34.0	58	Cancelled	
MR12-E02	D-2	38	30.0	141	40.0	138	Cancelled	
MR12-E02	D-3	38	30.0	141	49.9	198	Leg. 1	CTD DO Sal. Nutrients Chl.a
MR12-E02	D-4	38	30.0	141	59.0	331	Leg. 1	CTD DO Sal. Nutrients Chl.a DIC TA
MR12-E02	D-4.5	38	30.0	142	5.7	501	Leg. 2	CTD DO Sal. Nutrients Chl.a
MR12-E02	D-5	38	30.0	142	11.9	632	Leg. 1	CTD DO Sal. Nutrients Chl.a Phytoplankton
MR12-E02	D-5.5	38	30.1	142	20.3	834	Leg. 2	CTD DO Sal. Nutrients Chl.a
MR12-E02	D-6	38	30.0	142	25.1	1010	Leg. 1	CTD DO Sal. Nutrients Chl.a DIC TA DOC Phytoplankton
MR12-E02	D-7	38	30.2	142	38.2	1350	Leg. 1	CTD DO Sal. Nutrients Chl.a
MR12-E02	D-8	38	30.0	142	51.0	1521	Leg. 2	CTD DO Sal. Nutrients Chl.a
MR12-E02	D-9	38	30.0	143	4.0	2085	Cancelled	
MR12-E02	E-1	38	0.0	141	5.0	32	Cancelled	
MR12-E02	E-2	38	0.0	141	11.0	36	Cancelled	
MR12-E02	E-3	38	0.0	141	17.0	49	Cancelled	
MR12-E02	E-4	38	0.0	141	30.0	125	Cancelled	
MR12-E02	E-5	38	0.1	141	42.8	162	Leg. 1	CTD DO Sal. Nutrients Chl.a
MR12-E02	E-6	38	0.1	141	56.0	301	Leg. 1	CTD DO Sal. Nutrients Chl.a
MR12-E02	E-7	37	60.0	142	9.2	691	Leg. 1	CTD DO Sal. Nutrients Chl.a DIC TA DOC Phytoplankton
MR12-E02	E-8	38	0.0	142	22.0	974	Cancelled	
MR12-E02	E-9	38	0.0	142	35.0	1197	Cancelled	
MR12-E02	E-10	38	0.0	142	48.0	1499	Cancelled	
MR12-E02	E-11	38	0.0	143	1.0	1885	Cancelled	
MR12-E02	F-1	37	52.9	141	40.3	214	Leg. 2	CTD DO Sal. Nutrients Chl.a
MR12-E02	F-2	37	52.8	141	44.1	306	Leg. 2	CTD DO Sal. Nutrients Chl.a DIC TA DOC Phytoplankton
MR12-E02	F-3	37	52.8	141	57.3	494	Leg. 2	CTD DO Sal. Nutrients Chl.a
MR12-E02	F-4	37	52.9	142	17.6	876	Leg. 2	CTD DO Sal. Nutrients Chl.a DIC TA DOC Phytoplankton
MR12-E02	F-5	37	52.8	142	30.7	1033	Leg. 2	CTD DO Sal. Nutrients Chl.a
MR12-E02	F-6	37	52.9	142	43.6	1276	Leg. 2	CTD DO Sal. Nutrients Chl.a Phytoplankton

General results

All hydrocasts were conducted using 36-position, 12 liter Niskin bottles carousel system with SBE CTD-DO system, dissolved oxygen sensor (RINKO), Photosynthetically Active Radiation (PAR), fluorescence and transmission sensors. JAMSTEC scientists and MWJ (Marine Work Japan Co. Ltd.) technician group were responsible for analyzing water sample for salinity, dissolved oxygen, nutrients, total dissolved inorganic carbon, total alkalinity, dissolved organic carbon and phytoplankton abundances. During this cruise, 14 casts of CTD observation were carried out.

The water structure off Sanriku was very complicated because both Oyashio from subarctic region and Kuroshio from subtropical region are flowing into Sanriku. The distributions of temperature and salinity in

the surface were very variable and ranged from 1°C to 14°C and 33 to 34.5, respectively. Chlorophyll-a in the surface water was a minimum of ~0.8 μg l^{-1} at F-2 and a maximum of ~10 μg l^{-1} at O-4.5. This very high chlorophyll-a will be due to spring bloom. The small decrease of beam transmittance was observed at not only near surface (< 12%) at station D-4.5, but also near bottom (< 6%) at station O-2. This decrease near bottom appears over all hydrographic stations, which may indicate the effect of landslide due to the 2011 Earthquake of the Pacific coast of Tōhoku. In future, more accurate and longer hydrographic observation off Sanriku will be required to evaluate this speculation.

3-4-2. Topographic Investigations

Hidetaka Nomaki (JAMSTEC) : Principal investigator
Kazuho Yoshida (Global Ocean Development Inc.)
Toshimitsu Goto (GODI)
Ryo Ohyama (MIRAI Crew)

1) Introduction

The objective of MBES is collecting continuous bathymetric and SBP data along ship's track to make a contribution to geological and geophysical investigations and global datasets.

2) Data acquisition

The "SEABEAM 2112.004" on R/V MIRAI was used for bathymetry and seafloor mapping during the MR12-E02 Leg3 cruise from 23 March 2012 to 30 March 2012.

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 (6.2m) sound velocity, and the deeper depth sound velocity profiles were calculated by temperature and salinity profiles from XBT, XCTD and CTD data by the equation in Del Grosso (1974) during the cruise.

3-4-3. Gravity & Magneto meters Investigations

Hidetaka Nomaki (JAMSTEC) : Principal investigator
Kazuho Yoshida (Global Ocean Development Inc.)
Toshimitsu Goto (GODI)
Ryo Ohyama (MIRAI Crew)

1) Introduction

Measurements of magnetic force on the sea are 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 (Tierra Tecnica SFG1214).

The local gravity is an important parameter in geophysics and geodesy. We measured relative gravity using LaCoste and Romberg air-sea gravity meter S-116 (Micro-g LaCoste, LLC).

2) Data acquisition

i) Three-component magnetometer

We measured during the MR12-E02 Leg3 cruise from 23 March 2012 to 30 March 2012.

ii) Gravimeter

We measured relative gravity during the MR12-E02 Leg3 cruise from 23 March 2012 to 30 March 2012.

To convert the relative gravity to absolute one, we measured gravity, using portable gravity meter (Scintrex gravity meter CG-5), at Yokohama before cruise, and will measure after MR12-E02 Leg3 at Yokohama, as the reference point.

3) Preliminary results

The results will be published after primary processing.

3-4-4. Geology (Sedimentology)

Geological description of multiple core samples was conducted to understand origins and depositional processes of the event deposits (including rubbles) at shallow marine due to the 2011 Tohoku earthquake and tsunami.

Core samples were collected at eight sites off Sanriku, northeast Japan using multiple-corer systems operated by Marine Work Japan Co. Ltd. The multiple-corer system has eight hands. 2 casts of that were operated at one coring site (except D-5.5). So that sixteen core samples were collected from one coring site. These core samples were divided to shipboard scientists. Number of core samples for geological description was two at each site, totally sixteen.

The multiple core samples at one site were processed as follow;

One:

1) Measure core thickness, ɤ-ray attenuation, P-wave velocity, magnetic susceptibility using Multi-Sensor Core Logger (MSCL) system, Geotek Ltd.
2) Split the whole core into ARCHIVE half and WORKING half.
3) ARICHIVE half: measure core color reference.
4) WORKING half: describe sedimentary structure by naked eyes and smear slides.
5) Take photographs.
6) Take sampling from WORKING half for soft-X ray photographs, paleomagnetic measurement, grain-size analysis, XRD.
7) Pack cores into D-tubes.

Two:

8) Split the whole core into two WORKING halves (WD and WR).
9) WD: Take sampling for diatom, mineral composition analysis, etc.
10) WR: describe sedimentary structure by naked eyes.
11) Take photographs.
12) Take sampling from WR for radioisotope analysis.
13) Pack cores into D-tubes.

Core samples are composed of sand- to clay-sized particles and have bioturbation except D-4. The layers (2 – 5cm thickness) like event deposits are clearly shown at the uppermost of core samples, O-2, F-2, and F-4. Core samples of O-1, D-4, and D-4.5 are largely composed of sandy deposits. The other samples are composed of silty deposits. Round black gravels (granule to cobble size) are shown in core samples of O-1, D-5. Pumices are shown in core sample s of O-1, D-4.

3-4-5. Organic geochemical analyses

(1) Pollutants in sediment

Due to the Tsunami occurred just after the big earthquake in 11th March in 2011, huge amounts of debris were swept away by a flood. Old voltage converters and capacitors containing PCBs as an insulator, which were storing near the coastal area, were also swept away by the tsunami to the ocean. PCBs are chemically stable substances and some of them are highly toxic like dioxins. They seldom dissolve in the water, but easily in lipids. So it is deeply concerned that a biological concentration of PCBs in lipids in marine animals will be enriched.

We are going to monitor the concentration of PCBs in both surface sediment and benthic animals, which are thought to be food of fish.

In this cruise, we took surface sediment samples (0 - 2.5 cm and 2.5 - 5.0 cm depth in sediments) at 7 sites and some benthic animals. These analyses are outsourced, basically.

(2) Chlorophyll and their degradation products in sediment

Chlorophylls are one of the major biomolecules produced by phytoplankton in sea surface. Chlorophylls decompose easily by oxygen or light into a series of chloropigments and pheopigments. Therefore, a concentration of the pigments in the sediment is regarded as a concentration of fresh organic materials from sea surface, which will be good food for benthic animals.

We took sediment cores at 7 sites and sliced them into subsamples with 1cm to 5cm thickness. After freezing dried, we extract pigments with organic solvents, followed by HPLC analyses to screen and quantify major pigments. Then we construct a vertical profile of concentration of pigments in sediment.

Trap experiment is planning to investigate the flux of particulate materials including pigments from sea surface to deep water. Compiling the sediment data and trap data we will discuss carbon and nutrient cycle in

this area properly.

(3) TOC and TN in sediment

We took an aliquot from every subsample for pigments to measure TOC and TN in sediment. These analyses are outsourced, basically.

3-4-6. Interstitial water analyses

As a part of the primary product produced in sea surface sinks to seafloor, in case benthic water is oxic, most of the organic matter is subjected to oxidize. Remineralized nutrients are released into seawater over the sediment. When sediment are disturbed by earthquake and/or tsunami or redeposited, the vertical profile of a component in interstitial water, such as a nutrient salt concentration, is disorderd. A temporal transition of vertical profiles shows us how relax the disturbed balance between sedimentation and remineralization.

We took 2 sediment cores at each 7 sites and single core at one site (St. D-5.5). We sliced them into subsamples with 1cm to 5cm thickness. Subsamples were centrifuged quickly and supernatant was recovered.

(1) Nutrient salt concentration in the interstitial water

Nutrient salt (NO_3^-, NO_2^-, NH_4^+, PO_4^{3-}, SiO_2) concentrations were measured on board by auto analyzer (QuAAtro-2HR). Before analysis, interstitial water was filtrated with a filter with 0.22 μm pore size. Analytical methods are the same as those for seawater. Nutrient salt concentrations in the interstitial water are generally much higher than those in water column, so we diluted them 5 times or 10 times with nutrient-free seawater before analysis.

(2) pH and total alkalinity (TA) of the interstitial water

We measured pH of unfiltrated interstitial water on board according to DOE (1994). TA was measured on board by one point titration method with 1 ml sample adding 0.27 ml of 0.01/0.02M HCl.

3-4-7. Deep sea macrofauna off Sanriku by multiple coring methodology

Shuichi Shigeno (BioGeos, JAMSTEC)

Survey sites: Off Otsuchi (O series), Onagawa (D series), and Off Sendai bay (F series)

(1) Purpose

Understanding the basic composition of the macrofauna and the ecological impacts after the earthquake of the pacific coast of Tōhoku.

(2) Methods

Sediments were collected down to 5 cm from the surface or often deeper for large samples. Some epibenthic swimmers such as amphipods were included. The mud or sand sediments were washed through three combined types of wired meshes (2 mm, 1 mm, and 0.5 mm), and then observed in the live condition

by eyes or the binocular microscope (X10). All samples were fixed with 99% ethanol or directly frozen at -80 degree for storage. A few samples were fixed with 10% neutralized formalin/seawater at 4 degree for further morphological analysis and stored in 80% ethanol at 4 degree or -30 degree.

(3) Results and discussion

The sediments are generally uniform muddy or fine sands, but the animals exhibit considerable difference among sites dependent with the depth and locality. The notable features are numbers and density of green polychaete tubes and the ophiuroids *Ophiura sarsii*. Many green oval mud clusters were frequently detected after the 1mm and 0.5mm mesh sorting. Their clusters could be possible polychaete feces, since similar types of sand clusters were found in the digestive organs of polychaetes lived in the same regions. Juveniles or larvae of clams, crabs or shrimps were rarely found, but those of eels or fish were not in any regions. The basic types of macrofauna characterized with the sediments, epibenthic organisms and burrowers were categorized as followings:

1) Off Otsuchi: Muddy sand, many ophiuroids (n=6-18 in each core) [O-1_500m]
2) Off Otsuchi (in valley): Muddy sand, many oval polychaete feces [O-2_870m]
3) 38° 30' line: Fine sand, numerous ophiuroids (n=5-40) [D-4_319m]
4) 38° 30' line: Muddy sand, no ophiuroids and rarely tree fragments and leafs [D-4.5_500m]
5) 38° 30' line: Fine sand, gravel-like sediments with stones [D5.5_830m]
6) Off Sendai bay: Fine sand, gravel-like with small stones, few polychaete tubes [F-4_870m]
7) Off Sendai bay: Numerous polychaete tubes (n>100) with big polychaetes [F-3_498m]
8) Off Sendai bay: Many polychaete tubes (n<100) with invertebrate juveniles [F-2_308m]

3-4-8. Foraminifera and meiofauna

Benthic foraminifera (unicellular marine protists living at the sea floor) are considered as reliable indicators for environmental monitoring in benthic ecosystems. Those organisms have a widespread distribution in various marine environments, from coastal areas down to the deepest marine trenches. Our aim of the investigation is to describe the foraminiferal assemblage structure (density, diversity and microhabitat) in the collected sediments from off Sendai bay to off Sanriku. Further, the living specimens will be employed experiment with several different conditions. Those experiments will be carried out at the JAMSTEC culture laboratory.

We collected sediment cores with a multiple corer from 7 sites. For foraminiferal assemblage study, the sediment cores were vertically subsampled at 0.5 cm intervals down to 3 cm, and 1 cm intervals from 3 to 15 cm depth. The samples are fixed by Rose-Bengal formalin. Sliced sediments were stored in plastic bags with a solution of 0.1% Rose-Bengal 5% formalin-seawater. For culture material, bulk surface sediments were preserved at a temperature of ~4°C in the refrigerator.

3-4-9. Microbiology

Takuro Nunoura (JAMSTEC)
Eiji Tasumi (JAMSTEC)

Prokaryotes (both Archaea and Bacteria) and viruses play important roles in marine ecosystems and affect global nutrient and energy cycles. Viral production likely reflects microbial activity, and huge viral production rates in sediment water interface in deep-sea environments have been revealed. During this cruise, we examined viral production rates in sediments. We will examine prokaryotic and viral abundance in both water and sediments. Furthermore, we will determine abundance of nitrifers in both sediments and waters by quantitative PCR analyses.

4. About data

This cruise report is a preliminary documentation as of the end of the cruise.

This report may not be corrected even if changes on contents (i.e. taxonomic classifications) may be found after its publication. This report may also be changed without notice. Data on this cruise report may be raw or unprocessed. If you are going to use or refer to the data written on this report, please ask the Chief Scientist for latest information.

Users of data or results on this cruise report are requested to submit their results to the Data Management Group of JAMSTEC.