

## Cruise Summary

●: must be included

○: may be included as necessary

## 1. Cruise Information

- Cruise ID: YK11-E04 Leg1
- Name of vessel: R/V Yokosuka
- Title of the cruise: Impact by the huge earthquake on marine ecosystem including environment, chemical, geology and geophysics in Off Sanriku area
- Chief scientist [Affiliation]: Leg1: Katsunori Fujikura (BioGeos, JAMSTEC)
- Representative of the Science Party [Affiliation]

### YK11-E04 Leg1 Scientist List

| 名前    | Name                   | position               | affiliation                                                                     |
|-------|------------------------|------------------------|---------------------------------------------------------------------------------|
| 藤倉 克則 | FUJIKURA,<br>Katsunori | Principal<br>Scientist | Biodiversity<br>Research Program,<br>Institute of<br>Biogeosciences,<br>JAMSTEC |
| 古島 靖夫 | FURUSHIMA,<br>Yasuo    | Research<br>Scientist  | Biodiversity<br>Research Program,<br>Institute of<br>Biogeosciences,<br>JAMSTEC |
| 渡部 裕美 | WATANABE,<br>Hiromi    | Research<br>Scientist  | Biodiversity<br>Research Program,<br>Institute of<br>Biogeosciences,<br>JAMSTEC |
| 宮本 教生 | MIYAMOTO,<br>Norio     | Research<br>Scientist  | Biodiversity<br>Research Program,<br>Institute of<br>Biogeosciences,<br>JAMSTEC |
| 金松 敏也 | KANAMATSU,<br>Toshiya  | Senior<br>Technical    | Institute for<br>Research on Earth                                              |

|            |                                     |                                 |                                                                                                                  |
|------------|-------------------------------------|---------------------------------|------------------------------------------------------------------------------------------------------------------|
|            |                                     | Research<br>Scientist           | Evolution,<br>JAMSTEC                                                                                            |
| 牧田 寛子      | MAKITA,<br>Hiroko                   | Research<br>Scientist           | Institute of<br>Biogeosciences,<br>JAMSTEC                                                                       |
| 植平 賢司      | UEHIRA, Kenjj                       | Assistant<br>Professor          | Institute of<br>Seismology and<br>Volcanology,<br>Faculty of Sciences,<br>Kyushu University                      |
| 山田 知朗      | YAMADA,<br>Tomoaki                  | Assistant<br>Professor          | Earthquake<br>Research Institute,<br>University of Tokyo                                                         |
| 中東 和夫      | NAKAHIGASHI,<br>Kazuo               | Researcher                      | Earthquake<br>Research Institute,<br>University of Tokyo                                                         |
| 辻 健        | TSUJI, Takeshi                      | Assistant<br>Professor          | Graduate School of<br>Engineering, Kyoto<br>University                                                           |
| 柴田 晴佳      | SHIBATA,<br>Haruka                  | Ph.D.<br>student                | Graduate School of<br>Fisheries, Kitasato<br>University                                                          |
| 川村 喜一<br>郎 | KAWAMURA,<br>Kiichiro               | Senior<br>Research<br>Scientist | Fukada Geological<br>Institute                                                                                   |
| 新井 和乃      | ARAI, Kazuno                        | Ph.D.<br>student                | Graduate School of<br>Science, Chiba<br>University                                                               |
| 泉 典洋       | IZUMI,<br>Norihiko (Not<br>onboard) | Professor                       | Division of Field<br>Engineering for the<br>Environment,<br>Faculty of<br>Engineering,<br>Hokkaido<br>University |
| 横川美和       | YOKOKAWA,<br>Miwa (Not<br>onboard)  | Professor                       | Lab. of<br>Geoenvironment,<br>Faculty of<br>Information Science<br>and Technology,                               |

|       |                                       |                        |                                                                             |
|-------|---------------------------------------|------------------------|-----------------------------------------------------------------------------|
|       |                                       |                        | Osaka Institute of<br>Technology                                            |
| 成瀬 元  | NARUSE,<br>Hajime (Not<br>onboard)    | Associate<br>Professor | Department of Earth<br>Sciences, Faculty of<br>Science, Chiba<br>University |
| 三宅 裕志 | Miyake, Hiroshi<br>(Not onboard)      | Associate<br>Professor | Kitasato University                                                         |
| 中島 悦子 | Nakashima,<br>Etsuko (Not<br>onboard) | Ph.D<br>student        | Ehime University                                                            |

- Cruise period: June 03, 2011-June 23, 2011  
1 leg: June 03, 2011 - June 13, 2011
- Ports of call: 1 leg: Yokosuka, JAMSTEC June 03, 2011 - Yokosuka, JAMSTEC June 13, 2011
- Research area: General survey area, Off Sanriku (water depth range : 1,600m~7,500m) .  
37°00.0'N, 143°00.0'E, 40°00.0'N, 143°00.0'E  
40°00.0'N, 145°00.0'E, 37°00.0'N, 145°00.0'E

## 2. Overview of the Observation

### • Overview of the observation

The purpose of this cruise is to understand impact to marine ecosystems by the 2011 Off Tohoku Earthquake. Due to the earthquake, various phenomena such as,

- gushing out unique fluids from ocean bottoms,
- occurrence of large scale turbinate,
- supplement of huge amount of stuff including artificial materials from land areas,
- huge mass accumulation of stuff in the trench bottom,
- extinction of marine organisms

have been occurred in Off Sanriku area, northern Japan. We investigate about relationship between marine ecosystems and earthquake using mainly 6000 m-class deep towing TV camera system. We also focus on not only biology but also geology, chemical, and geophysics aspects. Additionally, this cruise is reconnaissance for the HOV Shinkai 6500 dive in near future.

Sea bottom observations using 4000m and 6000m class Deep tow cameras.

6000YKDT #93

Date: 2011/6/4

Survey site: Off Sanriku

Landing Point: 38-11.2301N 143-33.1992E, 3445m

Leaving Point: 38-09.2745N 143-32.6749E, 3617m

Dive Summary:

The YKDT were towed along a small N-S valley associated with a normal fault in the Off Sanriku area.

Observation results were as follows:

-a lot of sinking stuffs looks like Appendicularia's old houses occurred in midwater from 1800m deep to bottom,

-diatomaceous soft sediment layer as well as greenish fluffs cover the seafloor. (This soft sediment should be deposited during or after the 2011 earthquake),

-gravels distributed on the seafloor decrease compared to the pre-earthquake cruise, suggesting surface erosion or recent sedimentation,

-recent erosive surfaces on a bottom of the valley (the erosive surface was not clearly observed at the pre-earthquake observation),

-muddy water was observed at the cliff terrace,

-some fishes, gorgonians, sponges, asteroids and ophiuroids were observed.

Water samples were taken using the Niskin bottles just above sea floor and midwater. Sediment sample on seafloor was taken using the dredge for 5 minutes before leaving for seafloor. Sediment sample is composed of mud- to gravel-size sediment. Mud contains many diatoms. There is three kind of gravel, R1-1, R1-2, R1-3.

4000YKDT #94

Date: 2011/6/6

Survey site: Off Sanriku

Landing Point: 38-39.2243N 143-36.1058E, 3243m

Leaving Point: 38-40.4182N 143-32.3721E, 2901m

Dive Summary:

To describe the geological and biological changes after the earthquakes and tsunami, YKDT was towed to trace the dive track of ROV Kaiko 10K#245 in 2002, an E-W transect of a scar around the depth in 3200m. At least three cracks were discovered around the landing point. The species of the benthic fauna on the muddy sea floor or hard substrata were almost the same as those observed in 2002 (fishes, holothurians, ophiuroids, sea anemones, sea spider, shrimps and snails), but their frequencies of each species had been changed from 2002. A collapsed scar without any sessile animals was observed in a turbid area. Around the western end of the track of Kaiko, the direction of YKDT was changed to NW. Totally eight water samples were collected in the turbid water for chemical and microbiological analyses. A small discoloration area and (probably) some scattered bivalve shells were observed in the slight slope to the leaving point. The water become clear around the depth in 2940m on the slope. YKDT left the bottom after dredge sampling.

6000YKDT #95

Date: 2011/6/4

Survey site: Off Sanriku

Landing Point: 38-09.5488N 143-47.0608E, 5942m

Leaving Point: 38-12.5877N 143-46.8352E, 5617m

Dive Summary:

The purpose of this Deep-tow dive #95 is to know dynamic change of seafloor geometry and animal distribution associated with the 2011 Tohoku earthquake. Four Shinkai 6500 dives had been conducted in this site before the 2011 Tohoku earthquake (Dive #1069, #1072, #1073, and #1074). The previous Shinkai dives revealed *Calyptogen*a colonies at some areas along a steep cliff, where the reverse fault was expected from seismic profiles (Tsuji et al., 2011). In this Deep-tow dive, we revisited the steep cliff as well as *Calyptogen*a colonies.

Dark brown (5Y4/4) diatomaceous soft sediment layer of about 5 cm thick cover on the seafloor. This soft sediment could be deposited after the 2011 earthquake. However, compared to the landward diving site (DT#93), thickness of the soft sediment layer seems to be thicker than that in this diving point. This is because of deeper and steeper seafloor. At the superficial layer, we observed many bands of darker and lighter color. These may be indicating current directions during or just after the deposition of the soft sediment. Below the soft sediment, we observed relatively consolidated mud rock. Above the soft sediment layer, we observed greenish fluffs of about several tens cm. These are composed of mainly diatoms, sponge spicules and calcareous nannofossils, even though this dive site is clearly deeper than the carbonate compensate depth CCD, indicating any calcareous fossils are dissolved. This might suggest that the fluffs were transported rapidly from shallower water depth than the CCD.

Dead *Calyptogen*as are scattered at several points. All *Calyptogen*as observed in this dive have died, maybe due to dynamic seafloor slide during the earthquake. Some *Calyptogen*as were collapsed under falling rocks. Furthermore, other animals are sparsely distributed compared to the pre-earthquake observations. The seafloor slide associated with the earthquake may flow animals on the seafloor.

We found several fissures along the steep cliff. Huge fissures of about 2-3 m in width were observed at the bottom of the steep cliff. Some of the fissures were arranged in N-S direction. Because these fissures were not observed in pre-earthquake observations (YK08-06), they should be appeared between 2008 in the Shinkai dive and 2011 in this dive. We have some small earthquakes for the three years, but the most presumable reason to form these fissures is the Tohoku earthquake. We observed white-colored spots (maybe corresponding to bacteria mattes) at a rim of the fissures, suggesting existence of extensive cold seep. Since such these white-colored spots were not observed during the previous Shinkai dive, these extensive cold seeps should be induced by the 2011 Tohoku earthquake. Thus, we disclosed clearly drastic changes of seafloor geometry and animals before and after the earthquake by the dive #95.

6000YKDT #96

Date: 2011/6/8

Survey site: Off Sanriku

Landing Point: 38-11.3745N 143-46.5049E, 5743m

Leaving Point: 38-13.3228N 143-47.1882E, 5608m

Dive Summary:

The objective of YKDT #96 was follow-up of YKDT #95. #95 found huge fissures and scattered *Calyptogen*a shells in the slope (see YK11\_E04 Leg.1 YKDT#95 Report). It is supposed that the fissures were formed in the slope in association with 2011 Tohoku earthquake, and *Calyptogen*a colonies were disturbed by an event relating to the earthquake also. YKDT #96 was planned to revisit the fissures area

found in YKDT #95, and survey along the structure in order to observe details.

Lithology of surface sediment is similar to those of previous dives. Bedrocks are covered by soft light –dark brownish sediments, and greenish soft fluff (algae-like) materials. Fissures observed during # 96 are 2-3 m in width. The bottoms of fissures are covered by thin brownish sediments, which is same as covering the surface. Judging from the color of side-walls of fissures, the fissures seem to be generated recently. White spots, which is probably bacteria mattes, are observed sporadically. More clear distribution of white spots, which are aligned in line, was found at 38-11.6044N,143-46.6291E. Calyptogena shells are sparsely scattered around the fissure area. Much dense distribution of Calyptogena shells was observed around 38-11.9158N,143-46.7579E.

Artificial debris, such as blankets, glass bottles, fish nets, and plastic bags, are observed. It is not clear that these materials were derived by 2011 Tohoku earthquake.

6000YKDT #97

Date: 2011/6/10

Survey site: Off Sanriku

Landing Point: 38-39.9152N 143-49.4318E, 5758 m

Leaving Point: 38-37.7032N 143-48.7141E, 5571 m

Dive Summary:

Deep-tow #97 followed a roughly south-to-north heading along and up the foot of the lower trench slope, south of the Sanriku escarpment and downslope (to the east) of #94. The area was located on foot of a large submarine landslide, where Sasaki (2003; PhD thesis) described broad folds and a large cliff on the basis of bathymetric maps. Such structures may be related to both the general subduction processes associated with the 2011 Tohoku earthquake, and the effects of the submarine landsliding. Dredge samples from the surface sediment layer in this area could also decipher various geological records for dynamic changes associated with the 2011 Tohoku earthquake.

The dive site is mainly characterized by three regions; a valley, a cliff and a terrace. I described in detail the dive results following the three regions on time series.

First, we landed on a small valley. The seafloor was covered with a soft sediment layer of a few cm thick. Many bands of darker and lighter colors were observed on the superficial layer. These may be indicating current directions during or just after the deposition of the soft sediment layer. Above the sediment layer, we observed greenish fluffs of several tens cm, which are same as the last dive results. But I felt that the amount of these fluffs were smaller than that during the last dives a bit. Gravels of several tens cm in diameter were disseminated in place on the valley, and they are slightly increasing at the deepest floor as a channel axis.

Then we climbed up to a large cliff of about 200 m in height. On foot of the cliff, we observed bolder-to-cobble-sized gravel strata of about several meters in thickness (as talus deposits?). The cliff was stepped by a repetition of a scar, an overhang, and a steep slope. We observed thin sediment cover, greenish fluffs, bedding planes of strata and fractured rocks on the cliff throughout. There is a shell of Calyptogena on the lower steep slope, and a fissure of several cm in width on the upper scar. The fissure was mostly filled with soft sediments and/or greenish fluffs, and it might be formed by the Tohoku earthquake. Furthermore, we observed two types of outcrop surface colors; brownish and grayish rock surfaces. The brownish and

grayish surfaces may indicate older weathered rock surface and fresh rock surface (indicating recent collapse of cliff), respectively.

Finally, we arrived at a terrace having a step of a gentle muddy slope and a rocky scar of several meters in height. Gravels of several tens cm in diameter were disseminated on the muddy slope nearby the rocky scar. We also observed thin sediment cover and greenish fluffs in this area.

Several small rock samples were collected from the rocky cliff on the terrace using a dredger. The samples comprise pebble-sized mudstones and sandstones with small amount of mud samples of yellowish brown (2.5Y5/4) diatomaceous silty clay. Some important structures include: (1) tiny fracture cleavages in mudstones, (2) thin mudstone layers on sandstones, (3) black rounded mudstones, like a fluvial gravel.

6000YKDT #98

Date: 2011/6/11

Survey site: Off Sanriku

Landing Point: 39-06.1469N 143-54.1548E, 5348m

Leaving Point: 39-06.2341N 143-53.7515E, 5333m

The purpose of YKDT #98 was to research the geological and biological changes after the 2011 Tohoku earthquake. YKDT #98 was planned to visit the Calyptogena colonies site. The previous dives, such as YK06-05 (#956, 957, 958), YK07-15 (#1038, 1039m), KR07-14 (#399), YK06-06 (#959), KR00-07 (#183), KR02-09 (#254, 258), YK00-04 (#550, 543, 553), YK09-12 (#1160.1163) observed Calyptogena colonies at some areas along a terrace cliff.

At the landing point, muddy seafloor and no significant mud plume were observed. Dark brown diatomaceous fluffy materials were much less than another site in this cruise. The YKDT head to northwest, and went along the dive points of Calyptogena colonies, which found in previous dives, through the YKDT camera observation. Very small Calyptogenas colony, Dead Calyptogenas and white animals (white bars) were observed around 39-06.3876N 143-53.5055E. Muddy seafloor with numbers of ripple marks was observed around this site. Then, we found 6k ballast in the sloop. We didn't found fissures along the steep cliff in this dive. However, we found changes habitats of Calyptogena colonies site, before and after the earthquake by the dive #98.

YKDT left the bottom after dredge sampling. The species of the benthic fauna on the muddy sea floor were almost same as another site of this cruise, fishes, holothurians, ophiuroids, sea anemones, sea spider, shrimps and snails were observed, but their frequencies of each species were decreased. Artificial debris, such as fish net, lumber, glass bottles, and plastic white board, are observed. Totally eight water samples were collected for chemical and microbiological analyses.

**Recovered OBS**

| Site No. | OBS No. | OBS Position*             |                            |              | RadioBeacon | Recovered Date<br>(Y/M/D)[JS<br>T] | *notes |
|----------|---------|---------------------------|----------------------------|--------------|-------------|------------------------------------|--------|
|          |         | Latitude N (deg.<br>Min.) | Longitude E<br>(deg. Min.) | Depth<br>(m) | CallSign    |                                    |        |

|            |            |    |          |     |          |      |        |            |                |
|------------|------------|----|----------|-----|----------|------|--------|------------|----------------|
| <b>C05</b> | OBS 109    | 39 | 15.7883  | 143 | 24.3796  | 2374 | JS1615 | 2011/06/07 | by acoustics   |
| <b>D04</b> | OBS 165    | 39 | 06.4163  | 143 | 03.3257  | 1877 | JS1784 | 2011/06/07 | by acoustics   |
| <b>D05</b> | OBS 097    | 39 | 02.8466  | 143 | 19.7626  | 2446 | JS1185 | 2011/06/07 | by acoustics   |
| <b>E04</b> | OBS<br>049 | 38 | 53.3215  | 142 | 58.6884  | 1524 | JS1794 | 2011/06/07 | by acoustics   |
| <b>E05</b> | OBS 143    | 38 | 49.7680  | 143 | 15.0154  | 2219 | JS163  | 2011/06/07 | by acoustics   |
| <b>E06</b> | OBS 134    | 38 | 46.1887  | 143 | 31.3095  | 2564 | JS1620 | 2011/06/07 | by acoustics   |
| <b>F06</b> | OBS 126    | 38 | 33.3186  | 143 | 27.3098  | 2546 | JS1624 | 2011/06/06 | throwing point |
| <b>I06</b> | Q2-A       | 37 | 53.71010 | 143 | 13.28598 | 2658 | JS625  | 2011/06/05 | throwing point |
| <b>J03</b> | Q2-I       | 37 | 51.30315 | 142 | 19.57093 | 892  | JS613  | 2011/06/12 | throwing point |
| <b>J06</b> | Q2-L       | 37 | 41.19255 | 143 | 08.97767 | 3259 | JS1299 | 2011/06/05 | throwing point |
| <b>K07</b> | Q2-H       | 37 | 24.55263 | 143 | 20.92264 | 5160 | JS1312 | 2011/06/05 | throwing point |

#### Deployed OBS

| Site No.   | OBS No. | OBS Position*             |                            |              | RadioBeacon | Deployment Date<br>(Y/M/D-H:<br>M:S)[JST] | *notes |                         |                |
|------------|---------|---------------------------|----------------------------|--------------|-------------|-------------------------------------------|--------|-------------------------|----------------|
|            |         | Latitude N (deg.<br>Min.) | Longitude E<br>(deg. Min.) | Depth<br>(m) | CallSign    |                                           |        |                         |                |
| <b>P03</b> | ERI-5D  | 36                        | 33.5176                    | 141          | 53.5571     | 2320                                      | JS1348 | 2011/06/12-<br>12:30:51 | throwing point |
| <b>U02</b> | ERI-5B  | 35                        | 31.6511                    | 141          | 15.8824     | 651                                       | JS1092 | 2011/06/03-<br>16:48:28 | throwing point |
| <b>W02</b> | ERI-5E  | 35                        | 05.4948                    | 141          | 07.7212     | 2510                                      | JS1190 | 2011/06/03-<br>14:57:59 | throwing point |