

Submission date 2011 Aug. 22

Cruise Summary

1. Cruise Information

- Cruise ID: YK11-E06-Leg2
- Name of vessel: R/V Yokosuka
- Title of the cruise: Impact by the mega-earthquake on marine ecosystem including environment, chemical, geology and geophysics in Off Sanriku area
- Chief scientist [Affiliation]: Leg2: Katsunori Fujikura (BioGeos, JAMSTEC)
- Representative of the Science Party [Affiliation]

YK11-E06 Leg2 Scientist List

名前	Name	position	affiliation
藤倉 克則	FUJIKURA, Katsunori	Principal Scientist	Biodiversity Research Program, Institute of Biogeosciences, JAMSTEC
古島 靖夫	FURUSHIMA, Yasuo	Research Scientist	Biodiversity Research Program, Institute of Biogeosciences, JAMSTEC
渡部 裕美	WATANABE, Hiromi	Research Scientist	Biodiversity Research Program, Institute of Biogeosciences, JAMSTEC
宮本 教生	MIYAMOTO, Norio	Research Scientist	Biodiversity Research Program, Institute of Biogeosciences, JAMSTEC
辻 健	TSUJI, Takeshi	Assistant Professor	Graduate School of Engineering, Kyoto University
新井 和乃	ARAI, Kazuno	Ph.D. student	Graduate School of Science, Chiba University
野口 拓郎	NOGUCHI, Takuroh	Postdoctoral researcher	Center for Advanced Marine Core Research, Kochi University
長谷川 和範	HASEGAWA, Kazunori	Senior curator	Department of Zoology, National Museum of Nature and Science
土岐 知弘	TOKI, Tomohiro	Assistant Professor	Faculty of Science, University of the Ryukyus
野牧 秀隆	NOMAKI Hidetaka	Researcher	BioGeos3, JAMSTEC

谷川 亘	TANIKAWA, Wataru	Researcher	Kochi Institute for Core Sample Research
笠谷 貴史	KASAYA, Takafumi	Researcher	IFREE, JAMSTEC
高井 研	TAKAI, Ken	Program Director	SUGAR Program, Biogeosciences, JAMSTEC
砂村 倫成	SUNAMURA Michinari	Assistant Professor	Graduated school of Science, University of Tokyo
町田 秀介	MACHIDA Shusuke	Marin Technician	Nippon Marine Enterprises, Ltd.

- Cruise period: July 50, 2011-Aug 14, 2011
- Ports of call: Yokosuka, JAMSTEC July 30, 2011 - Hachinohe August 14, 2011
- Research area: General survey area, Off Sanriku, Japan Trench

Water depth range : 3,000m~5,500m

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 Investigation

2-1. General

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 the HOV Shinkai 6500 and 4500 m-class deep towing TV camera system. We also focus on not only biology but also geology, chemical, and geophysics aspects.

3. Diving Investigations by the Shinkai 6500

3-1. Shinkai 6500 #1254

Date: 2011/8/1

Researcher: Katsunori Fujikura (JAMSTEC)

Survey site: 39N site, Off Sanriku, Japan Trench, Site3

Landing Point: 39-06.2148'N 143-53.6979'E, 5349m

Leaving Point: 39-06.4314'N 143-32.4062'E, 5332m

Dive Summary:

The purpose of Shinkai6500 #1254 was to investigate the biological geological and chemical changes after the 2011 Tohoku earthquake. The dive was planned to visit the *Calyptogena faseoliformis* colonies site. The previous Shinkai6500 #1161 dive observed *C. faseoliformis* colonies and bacterial mats at this area. This dive runs along on the same track line of Shinkai6500 #1161. During dive survey, we found living and dead *Calyptogena faseoliformis*, and bacterial mat. We conducted:

- Sediments sampling by MBARI cores, deployment of SHAF for HF measurement, waters sampling by WHATS samplers, a bag-type sampler and NISKIN bottles in bacterial mat site,
- Sediments sampling by MBARI cores, waters sampling by WHATS samplers and NISKIN bottles.

3-2. Shinkai 6500 #1255

Date: 2011/8/2

Researcher: Takeshi Tsuji (Kyoto University)

Survey site: 39N site, Off Sanriku, Japan Trench, Site3

Landing Point: 39-06.5649°N 143-53.9828°E, 5349m

Leaving Point: 39-06.4708°N 143-53.1433°E, 5332m

Dive Summary:

- The purpose of *Shinkai6500* #1255 was to investigate dynamic changes of geological, biological and chemical features during the 2011 Tohoku earthquake. The dive was planned to visit (1) bacterial mats observed by YKDT#106, (2) *Calyptogena faseoliformis* observed by 6.5K#1254, and (3) steep cliff maybe associated with fault displacement.
- At the (1) bacterial mats observed by YKDT#106 (northern site), we conducted sediments sampling by MBARI cores, deployment of SHAF for HF measurement, waters sampling by WHATS samplers, a bag-type sampler and NISKIN bottles. We deployed quadrat for the nearby bacterial mat. *Calyptogena faseoliformis* could not be observed around these bacterial mats.
- To retrieve SHAF and observe quadrat, we moved to the (2) *Calyptogena faseoliformis* observed by 6.5K#1254 (southern site). However, we could not find the (2) *Calyptogena faseoliformis* as well as deployed instruments (SHAF, quadrat and marker), although we found many other bacterial mats as well as clam colonies. The bacterial mats in this area are aligned along the fissures (a few centimeter widths), suggesting the existence of seepage along the fissures.
- Beneath the (3) steep cliff, we conducted sediments sampling by MBARI cores. This cliff may be associated with displacement along the backstop reverse fault. Dead *Calyptogena faseoliformis* colonies are observed at the mid slope of cliff. On the top of the cliff, many fissures are developed parallel to the cliff. The soft sediment is not covered on the top of the cliff.

3-3. Shinkai 6500 #1256

Date: 2011/8/3

Researcher: Hidetaka Nomaki (JAMSTEC)

Survey site: 39N site, Off Sanriku, Japan Trench, Site3

Landing Point: 39-06.1667°N 143-53.5799°E, 5350m

Leaving Point: 39-06.2078°N 143-53.4985°E, 5353m

Dive Summary:

The purpose of the Shinkai6500 #1256 dive was 1) Biological samplings using suction sampler and scoop sampler, 2) samplings at the *Calyptogenia faseoliformis* colonies site, 3) samplings at the normal quadrat site, 4) recovery of SAHF which had not recovered during the previous dive, 5) samplings at a bacterial mat site, and 6) samplings at a geologically disturbed area.

Biological samplings mainly for Mega and macrofauna were done at the beginning and the end of the dive. During the biological sampling, we found a newly formed fissure with ~1 m width and >1m depth. We took sediment cores from the edge of the upper fissure and water sample within the fissure. Then we recovered SAHF and observed quadrat at the bacterial mat. Normal sediment quadrat which is ~50m apart from bacterial mat quadrat were also observed by Shinkai, and took 2 push cores from the outside of the quadrat. An active *Calyptogenia* colony, which has no dead clam shell around the colony, was observed at the seafloor ~5m east side of the crack. We took water samples, core samples, and surface sediment samples from the colony. Finally, we took three MT cores from a bacterial mat at the north end of the fissure.

3-4. Shinkai 6500 #1257

Date: 2011/8/5

Researcher: Ken Takai (SUGAR Project, JAMSTEC)

Survey site: Off Miyagi, Japan Trench, Bacterial mat site, Site 2

Landing Point: 37-44.4992N, 143-16.9655E, 3566m

Leaving Point: 37-44.5550N, 143-17.4937E 3451m

Dive Summary:

- The purpose of *Shinkai6500* #1257 was to survey microbial mat distribution along the hidden faults activated by the Tohoku Megaeearthquake and investigate chemical composition and characteristics of fluids through the faults.
- We landed on the seafloor located at 100m east from the N-S extension of potential microbial mats. At the landing point, SAHF measurement and MBARI coring were done.
- We head to southeast to find the microbial mats. The bottom seawater was highly turbid and it was very difficult to see the distant seafloor. There were many kinds of benthic animals and fish at the valley. At the potential N-S microbial mat extension, we changed to head north. After moving 300 m north, we encountered several microbial mats. They looked small but we tried to land near a microbial mat. At the time of landing, an alarm for occurrence of earthquake was sent to us. We went above the seafloor to escape from the possible seafloor displacement. Finally, nothing occurred but we could not return the same point due to heavily turbulent of sediments.
- 100 m northeast from the first microbial mat observed, we found larger microbial mats. At one of the microbial mats, we conducted a series of operation: Niskin sampling, SAHF measurement, MBARI coring, C-WHATS sampling, Bag sampling and Quadrant deployment in the center and margin of the microbial mat although we had the second earthquake emergency call.
- After finishing coring and water sampling, we found an octopus attached to a rock near the microbial mat. Thus, we collected the octopus and rock, and several benthic animals by using suction sampler. Finally, 6K marker #123 was deployed here.

- Next, we head east to survey the outcrop of normal fault that had been observed at the time of YKDT#99. However, during 600 m of survey, we did not find any of the fault outcrops. Instead 200m east from the 6K marker #123, we found a N-S extending gap that was filled with sediments but looked relatively fresh. This gap may be induced at the time of the Tohoku Megaequake.
- In the middle of slope, we changed to head southwest to reach the outcrop of normal fault that had been observed at the time of YKDT#99. At 600 m southeast from 6K marker #123, we collected two MBARI cores and C-WHATS samples. Here we set 6K marker #124. Then we left the bottom.

3-5. Shinkai 6500 #1258

Date: 2011. 8. 6

Researcher: Takafumi Kasaya (IFREE, JAMSTEC)

Survey site: Off Miyagi, Japan Trench, Bacterial mat site, Site 2

Planned landing Point: 37-44.40N 143-17.10E

Dive Summary

The purpose of *Shinkai6500* #1258 was to survey some fissures and faults formed by the 2011 Tohoku earthquake and obtain some samples to investigate for a chemical composition and characteristics of fluids through the faults. At the depth of 3150 meters, an alarm of a part of buoyancy system was sounded. The operation manager Sakurai made a decision to finish this dive. Therefore, we started to ascent before landing.

3-6. Shinkai 6500 #1259

Date: 2011/8/10

Researcher: Norio Miyamoto (JAMSTEC)

Survey site: Off Sanriku, Japan Trench

Landing Point: 38-39.1609'N 143-36.2188'E, 3274m

Leaving Point: 38-39.2993'N 143-35.3001'E, 3230m

Dive Summary:

The purpose of the *Shinkai6500* #1259 dive was to investigate the biological, geological and chemical changes after the 2011 Tohoku earthquake. The dive was planned to visit a bump, two fissures and animal rich area observed in YKDT#107.

The sea floor was muddy flat and quite a lot of faecal casts, trails and burrows of invertebrates, such as holothurians, enteropneusts, bonellians and crustaceans were observed. Just before landing, water sampling by a NISKIN bottle was performed, but the lower cap of the bottle did not closed. At the first fissure, we performed SHAF for HF measurement. During HF measurement, we collected water samples by WHATS sampler, a bag-type sampler and a NISKIN bottles from a bacteria mat in the bottom of the fissure. We collected sediments by MBARI, SGM and MT corers from bottom and upper floor of the fissure and put a quadrat on the upper floor of the fissure. At the bump, we collected water sample by WHATS. After passing the second fissure, we collected sediment samples by MBARI, SGM and MT corers, then put a quadrat. Finally, we collected animals with the suction sampler.

4. Towing Investigations by the 4500 m-class deep towing TV camera system

4-1. 4500YKDT #106

Date: 2011/8/4

Researcher: Michinari SUNAMURA (Univ. Tokyo)

Survey site: Off Miyagi, Japan Trench, Bacterial mat site, Site 2

Landing on water point: 37-42.5000'N 143-17.1000'E

Landing (Start towing) Point: 37-42.4797'N 143-17.1348'E, 3731m

Leaving (Finish towing) Point: 37-45.1249'N 143-17.1725'E, 3472m

Towing Survey Summary:

The purposes of YKDT #106 were 1.) to observe turbidity around the seafloor, 2.) to observe seafloor geological structures and biological colonies, 3.) to collect seawater and sediment samples using ABISMO-Niskin bottle sampler and dredge, respectively, and 4.) to confirm safety of Shinkai 6K diving at Bacterial mat site found during YKDT#99 towing. The towing line was planned along with valley (South to North axis), across the towing line of YKDT#99, and through just above the bacterial mat at the event mark #2 of YKDT#99.

In the water column, we found high turbidity below 3650m-water depth. Seawater around the seafloor was turbid below 2m transparency during the deep towing from the starting point of towing to the point at the 3650-m water depth. The turbidity of seawater got lower with 3-4m transparency above the 3650-m water depth. During the deep-towing, we collected water samples at above the bacterial mats and sediment sample just before leaving the seafloor.

4-2. 4500YKDT #107

Date: 2011/8/8

Researcher: Kazunori HASEGAWA (National Museum of Nature and Science)

Survey site: Off Sanriku (site #4), Japan Trench

Landing on water point: 38-39.200'N 143-36.3000'E

Landing (Start towing) Point: 38-39.2222'N 143-36.3346'E, 3263m

Leaving (Finish towing) Point: 38-39.3901'N 143-34.6535'E, 3044m

Dive Summary:

The purposes of YKDT #107 were 1.) to observe turbidity around the seafloor, 2.) to observe seafloor geological structures and biological colonies, 3.) to collect seawater and sediment samples using ABISMO-Niskin bottle sampler and dredge, respectively, and 4.) to confirm safety of Shinkai 6K diving at the Biological site found during YKDT#94 towing. The towing line was planned to trace the towing line of YKDT#94.

Although high turbidity was observed at this site during YKDT#94 towing, seawater around the seafloor was not very much turbid with the transparency of ca. 5 m throughout the present towing. Rich benthic animals, together with the disturbance of the bottom surface by both infaunal and epifaunal animals, were observed. During the deep-towing, we collected water samples at above small bumps and sediment sample just before leaving the seafloor.

4-3. 4500YKDT #108

Date: 2011/8/8

Researcher: Takafumi KASAYA (IFREE/JAMSTEC)

Survey site: Off Sanriku, Japan Trench

Landing (Start towing) Point: 37-42.4797°N 143-17.1348°E, 3731m

Leaving (Finish towing) Point: 37-45.1249°N 143-17.1725°E, 3472m

Dive Summary:

The purposes of YKDT #106 were to obtain a detailed bathymetric data using Seabat 7125 system. ABISMO-Niskin bottle sampler system was also loaded on YKDT to collect seawater. Before this dive, the adjustment operation of a navigation system was carried out. We could confirm the obtained "Seabat 7125" and the navigation system data in real time at the operation room.

In this dive, the YKDT was towed at the height of about 70-100 meters above a sea bottom. We set the slant range of the seabat system to 300 meters. We could obtain the MBES and navigation data at an observation track 2 km long. After leaving the seafloor, seawater samples were collected at the depth of 3000, 2750, 2500, 2250, 2000, 1500 and 1000 meters.

4-4. 4500YKDT #109

Date: 2011/8/9 (Tue)

Researcher: Wataru TANIKAWA (JAMSTEC/KCC)

Survey site: Off Sanriku, Japan Trench

Landing (Start towing) Point: 38-09.0526°N 143-20.0110°E, 3049m

Leaving (Finish towing) Point: 38-09.2047°N 143-18.3476°E, 2875m

Dive Summary:

The purposes of YKDT #109 were 1.) to observe turbidity around the seafloor, 2.) to observe seafloor geological structures and biological colonies, 3.) to collect seawater and sediment samples using ABISMO-Niskin bottle sampler and dredge, respectively, and 4.) to confirm safety of Shinkai 6K diving at C site in off Sanriku found during YKDT#91 towing. The towing line was planned toward from East to West axis, across the towing line of YKDT#91 (from North to South).

In the water column, we found high turbidity below 3650m-water depth. Seawater around the seafloor was turbid below 2m transparency during the deep towing from the starting point of towing to the point at the 3650-m water depth. The turbidity of seawater got lower with 3-4m transparency above the 3650-m water depth. During the deep-towing, we collected water samples at above the bacterial mats and sediment sample just before leaving the seafloor.

4-5. 4500YKDT #110

Date: 2011/8/9

Observer: Takuroh Noguchi

Survey site: A-site, Off Sanriku, Japan Trench

Landing (Start towing) Point: 38° 08.4748' N, 143° 33.5591' E

Leaving (Finish towing) Point: 38° 08.6139' N, 143° 32.0070' E

Dive Summary:

The purposes of YKDT #110 were 1) to observe turbidity around the seafloor, 2) to observe seafloor geological structures and biological colonies, 3) to collect seawater and sediment samples using ABISMO-Niskin bottle sampler and dredge, respectively, and 4) to confirm safety of SHINKAI 6500 diving at the “A site” surveyed during YKDT#93 towing. The towing line was planned across with valley (South to North axis), across the towing line of YKDT#93.

In the water column, we found high turbidity below 3450m-water depth. Seawater around the seafloor was turbid below 4-5m transparency during the deep towing from the starting point of towing to the point at the 3650-m water depth. During the deep-towing, we collected water samples at above the fissure and sediment sample just before leaving the seafloor.

4-6. 4500YKDT #111

Date: 2011/8/4

Record of observations: Yasuo Furushima (JAMSTEC)

Survey site: Off Sanriku, Japan Trench

Landing on water point: 37-44.0000'N 143-17.0000'E

Landing (Start towing) Point: 37-43.8702'N 143-16.6596'E, 3540m

Leaving (Finish towing) Point: 37-43.9827'N 143-18.4785'E, 3504m

Dive Summary:

A purpose of YKDT#111 (underwater cruise by R/V Yokosuka deep tow system) is security confirmation research underwater cruise of sea bottom by an aftershock generated around bacteria mat site. In YKDT#106, we set a research line of the north and south and found bacteria mat site of the north side. In YKDT#111 observation, we set East-West survey lines to cross bacteria mat site.

We carried out the following research.

To observe turbidity around the seafloor

To observe seafloor geological structures and biological colonies

To collect seawater samples using ABISMO-Niskin bottle sampler and dredge, respectively.

Around of sea bottom, the remarkable turbidity by an aftershock was not seen. As a result, we confirmed that underwater cruise research of SHINKAI 6500 was possible.

5. Benthic biology

Off Tohoku earthquake and subsequent Tsunami on 11 March 2011 had heavily damaged the coastal area of northeastern Japan. In the present study, faunal changes in deep-sea areas off Tohoku caused by the earthquakes and tsunami, and recovering processes will be evaluated, through comparison of the video images and faunal samples obtained before and after the earthquakes.

6. Chemical and microbiology

Large normal faults in the landward plate play a role in the great earthquake in 11th March 2011. Pore fluids make contributions on the weakening of crusts in the developments of the normal faults. We collect seeping fluids from the seafloor and analyze the concentration and isotopic compositions in the fluid samples to investigate the distribution of the active faults and the origin of the seeping fluids.

Chemical and microbiological investigations of collected fluids and sediments also provide clearer evidences what kind of shift in the chemical fluxes and deep-sea microbial communities occurred at the Tohoku Megaequake and have been occurring since the earthquake.

7. Geophysics and geology

The Japan Trench where the Pacific plate is subducting beneath the northeastern Japan Arc is considered to be the typical convergent margin. This subduction region is characterized as tectonic erosion or subduction erosion.

On 11 March 2011, Tohoku, northeast Japan, experienced a great earthquake (Mw 9.0, Mt 9.1) called the 2011 off the Pacific coast of Tohoku earthquake. The rupture region of this earthquake is very large region with a width of about 500 km. Seismic and tsunami inversion analyses have shown that tsunami waves with a maximum run-up height of 38 m were generated after the main shock by topographic changes on the seafloor in the toe region of the Japan Trench slope. Moreover, bathymetric surveys indicate that the toe region slipped about 50 m along the thrust. These phenomena may be related to the generation of tsunamis all along the axis of the Japan Trench.

We carried out various geophysical observations and obtain the seafloor samples in this cruise to observe the fault system around the subduction and seismogenic region. These data will become the keys to understand many phenomena related with the earthquake and tsunami.

Physical properties of shallow core sediments collected from three sites were measured to understand the lithological and regional variations of physical property around fault zones. P-wave velocity and thermal conductivity at fault zones (or bacteria mat sites) were smaller than those at a distance from fault zones.

OBEM operation

OBEM was installed on previous YK11-E06 Leg1 cruise. A calculated OBEM position is 38.2422218° N, and 143.355881° E. This OBEM was recovered at 11 August. Ascending rate is about 45 m/min. After finishing recovery operation, the time difference between the OBEM's clock and the laptop pc synchronized by NTP server. Measured time difference is +5.28 seconds.

Topographic and geological surveys using MNBES and SBP equipped on R/V Yokosuka

The Japan Trench where the Pacific plate is subducting beneath the northeastern Japan Arc is considered to be the typical convergent margin. This subduction region is characterized as tectonic erosion or subduction erosion.

On 11 March 2011, Tohoku, northeast Japan, experienced a great earthquake (Mw 9.0, Mt 9.1) called the 2011 off the Pacific coast of Tohoku earthquake. The rupture region of this earthquake is very large region with a width of about 500 km. Seismic and tsunami inversion analyses have shown that tsunami waves with a maximum run-up height of 38 m were generated after the main shock by topographic changes on the seafloor in the toe region of the Japan Trench slope. Moreover, bathymetric surveys indicate that the toe region slipped about 50 m along the thrust. These phenomena may be related to the generation of tsunamis all along the axis of the Japan Trench.

We carried out various geophysical observations and obtain the seafloor samples in this cruise to observe the fault system around the subduction and seismogenic region. These data will become the keys to understand many phenomena related with the earthquake and tsunami.

Core/Sediments

Soft sediment layers associated with the 2011 Off Tohoku Earthquake were observed in some core samples. In this cruise, observation of seafloor (five sites) and core sediment sampling (three sites) were conducted using the HOV Shinkai6500 and 4500 m-class Deep-tow. As a result, there were soft sediment layer in some sites. However, ripples and greenish fluffs on seafloor observed at the investigation of YK11-E04 leg1 vanished. That is probably affected by bioturbation. Dark olive soft sediment layer that deposited recently were observed at the top of core sediments in two site.

8. Physical environment and drift litter

A purpose of this cruise is to measure physical environmental data (water temperature, salinity, turbidity, DO) around focal region after a big earthquake (five months later). And we try to proving that relationship between deep sea ecosystem and environmental fluctuation. In addition, we carry out monitoring of turbidity around deep-sea floor. We measure environmental data with CTD, turbidity meter and DO meter put on SHINKAI 6500 and YKDT.

Furthermore, in this cruise, we carry out observation of drift litter which would be washed away from the coastal region by tsunami, and deep sea litter. Observation of deep sea litter scans video image provided from SHINKAI 6500 and YKDT, and checks the number of litter, class and characteristic. We establish HD video camera to a bridge of R/V Yokosuka and also measure a class of drift litter, number, and characteristic from a video image of sea surface. We analyze data of these marine litter with oceanographic condition data and contribute to effect to a marine organism (marine ecosystem).