Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

MIS33-01 Room:102B Time:May 26 09:00-09:15

Monitoring of seismic activity around the source region of the Tohoku-oki earthquake by ocean bottom seismometers

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The 2011 off the Pacific coast of Tohoku earthquake occurred at the plate boundary between the Pacific plate and the landward plate on March 11, 2011, and many aftershocks followed the mainshock. To obtain a precise aftershock distribution is important for understanding of mechanism of the earthquake generation. In order to study the aftershock activity of this event, we carried out extensive sea floor aftershock observation using more than 100 ocean bottom seismometers (OBSs) just after the mainshock. Four days after the mainshock, we started to deploy seventy-two OBSs in the source region. Consequently, we observed the aftershocks at 121 sites including the pre-installed OBS sites in total (1st term). The observation area covered the source region of the mainshock with OBS interval of 25 km. Some OBSs were recovered in late April and deployment of OBSs to the same position were carried out (2nd term). In June, almost of the deployed OBS were recovered and we concentrated observations with OBSs in off-Miyagi and off-Boso regions (3rd term). Observations in both areas were terminated in September 2011. There is a possibility that spatial and temporal changes of seismic activity occur due to the recovery process of plate coupling. To detect spatiotemporal changes of the seismic activity, we deployed 40 long-term OBSs (LT-OBSs), which have observation duration of one year, in the whole source region, and started monitoring of seismic activities in the source region (4th term). In April 2012, other 40 LT-OBSs were deployed in the southernmost source region to increase spatial density of the network. In October and November 2012, all the LT-OBSs on seafloor were recovered, and spatial high dense network by using 40 LT-OBSs was deployed with OBS interval of approximately 20 km in the off-Fukushima region (5th term) in November 2012. After one-year seafloor observation, the network off Fukushima was retrieved. In September 2013, we deployed 30 LT-OBSs in off-Miyagi and off-Iwate regions to monitor seismic activity (6th term). These LT-OBSs were successfully recovered in October in 2014, and we continue seafloor seismic observation in the off-Miyagi region with 18 sites from October 2014.

We selected events whose epicenter is located below the OBS network from the JMA earthquake catalog, and P and S-wave arrival times were picked from the OBS data. Hypocenters were estimated by a maximum-likelihood estimation technique with one dimensional velocity structures. Thickness of sedimentary layer, which changes at each OBS site was evaluated and the estimated travel times by the location program were adjusted. From the observations in the 1st and 2nd terms, a precise aftershock distribution for approximately three months were obtained. The aftershocks form a plane dipping landward in the whole area. Comparing our results to velocity structures by marine seismic surveys, there is no aftershock along the plate boundary in the region off Miyagi, where a large slip during the mainshock is estimated. A plate coupling in this region may change due to occurrence of the mainshock. Activity of aftershocks within the landward plate above the source region is high and many aftershocks within the landward plate have normal fault type or strike-slip type mechanism. Within the subducting oceanic plate, most of earthquakes has normal fault type or strike-slip type mechanism. Using hypocenter distribution by long-term observation from the autumn 2011, we compare locations of the hypocenters with those of the aftershock just after the mainshock. In the aftershock distribution, the low-seismicity region is recognized at the plate boundary in the off-Fukushima region. The long-term observations show the seismicity is not low in the identical region. On the other hand, seismic activity along the plate boundary in off-Miyagi region was still low until the end of the long-term observation carried out from 2011 to 2012.

MIS33-02 Room:102B Time:May 26 09:15-09:30

What long-term seafloor observations told us about the 2011 Tohoku-Oki Earthquake

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A number of important aspects of the 2011 Tohoku-Oki earthquake (Mw 9.0) were clarified by the seafloor observation above the rupture area of the earthquake. The most important observations were the extraordinarily large coseismic displacements, putting strong constraint on the processes of the fault rupture and tsunami generation. Continuous monitoring of ground motion using seismometers and pressure gauges clarified that gradual acceleration of the aseismic slip took place not only in the vicinity of the hypocenter of the eventual mainshock but also in the updip side of it. In addition, the seafloor instruments detected several unexpected phenomena associated with the earthquake. One of the instruments was displaced by about 1 km and detected large pressure and temperature excursions beginning three hours after the mainshock occurrence. These observations gave a strong evidence for the occurrence of tsunami-generated turbidity current in the area. Sediments trapped by the outer-shells of these instruments also helped to identify the origin and path of the flow. Including these non-seismological/geodetic ones, pre- co- and post-seismic observations are invaluable to characterize the massive and infrequent event and are still under careful inspection.

We continued seismological and geodetic observation after the earthquake to know postseismic activity. The obtained data indicate that the postseismic crustal deformation field show very complex spatial pattern as compared to those observed by the onshore network. The complexity is caused by large viscoelastic relaxation induced by the huge coseismic slip and makes it difficult to identify the elastic deformation associated with the afterslip along the megathrust, although it is the most important information to understand the behavior of the fault. The situation requires us to enhance the abilities of seafloor monitoring to detect the slip activities on the fault. Detecting slow-slip transient slips is one of the solutions and we started an array of arrays observation including broad-band seismographs to detect and locate slow-slip events and low-frequency tremors, which can happen in the transient process regaining interplate coupling. Another observation we started is direct-path acoustic ranging across the trench axis. Slip rate of the shallow fault can be measured by monitoring the change in distance between the benchmarks on the incoming and overrding plates.

Keywords: 2011 Tohoku-Oki Earthquake, ocean bottom seismology, seafloor geodesy, temperature monitoring

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MIS33-03 Room:102B Time:May 26 09:30-09:45

What happened at the northern Japan Trench (around 39.5 N) during the 2011 Tohoku earthquake ?

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For the 2011 Tohoku earthquake, many models of slip distribution based on seismic waves, GPS and tsunami data have been proposed. The maximum slip is located at around 38 N off Miyagi prefecture, although the amount and the down-dip location (depth) are different among the models. The coastal tsunami height was largest around Miyako city at 39.5 N, which is roughly 100 km north of the maximum slip. Satake et al. (2013, BSSA) made inversion of tsunami waveforms recorded on bottom pressure, GPS and costal wave and tide gauges to estimate spatial and temporal distribution of coseismic slips. Their result indicates that very large slips (maximum 69 m) occurred near the trench axis about 3 minutes after the earthquake origin time (rupture initiation), and it propagated toward north along the trench. They concluded that the delayed slip near the trench axis was the main cause of the largest tsunami in Iwate prefecture.

Because seismic wave analyses indicate that the rupture processes were at most 3 minutes, the delayed slip may not be seismic (faulting) origin. A recent paper by Tappin et al. (2014, Marine Geology) claimed that the cause of the large tsunami along the Iwate coast is a submarine landslide. Their analysis indicates that the submarine landslide occurred at 135 seconds after the origin time at around 39.5 N along Japan Trench, with a length of 40 km, a width of 20 km, a slope thickness of 2 km, a vertical offset (rotation) of 100 m. The total landslide volume was estimated as 500 km^3.

Along the Japan Trench off Iwate, a large slip occurred during the 1896 Sanriku earthquake. The estimated slip amount is 10 to 20 m, and the slip extended further north of the 2011 delayed slip. If coseismic slip occurred in 1896 and 2011, the total slip amount would be 20 to 30 m. Although this is smaller than the largest slip of the 2011 Tohoku earthquake, it is enigmatic that a slip larger than the plate convergence (~8 m/century) occurred within 100 years.

In order to identify the cause of the 2011 tsunami source off Iwate, whether it was a fault slip or a submarine landslide, submarine surveys such as detailed bathymetry or subsurface structure are expected.

Keywords: Tohoku earthquake, Japan Trench, tsunami, submarine landslide

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MIS33-04 Room:102B Time:May 26 09:45-10:00

Regional distribution of seafloor displacement detected by bathymetric surveys after the 2011 Tohoku-oki earthquake

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After the 11 March 2011 Tohoku-oki earthquake (M_W 9.0), we have carried out multibeam bathymetric surveys in the rupture zone. Some survey tracks were aligned along the tracks obtained before the earthquake across the Japan Trench, and we analyzed the difference in bathymetry before and after the earthquake in the area near the trench. For the analysis, apparent offsets of the absolute values of depth soundings and the uncertainty of ship position were examined on the seaward side because the seaward was thought to have suffered little change from the earthquake. Although the results may incorporate errors of several meters in vertical displacement and about 20 m in horizontal displacement [e.g. Fujiwara et al., MGR 2014], the extraordinary coseismic seafloor displacement caused by the 2011 earthquake was detected by the bathymetric surveys. For the survey track crossing the trench axis at 38^{o}05'N, off the coast of Miyagi Tohoku, near the epicenter, there were large relative differences landward extended up to the trench axis, suggesting the earthquake fault rupture reached the trench axis [Fujiwara et al., Science 2011; JpGU 2012]. The seafloor after the earthquake is shallower throughout the landward side. Notably, on the outermost landward slope, the 40-km-wide area between the slope break and the trench axis, the difference shows the seafloor is shallower than 10 m on average. This uplift was likely an important factor contributing to the generation of the huge tsunami. The observed seafloor elevation change on the outermost landward slope corresponds to a sum of vertical displacement and additional uplift for the sloping seafloor due to horizontal coseismic displacement. We estimated the horizontal displacement by calculating the offset distance to maximize the cross-correlation of bathymetry. The estimated displacement is approximately 50 m in the east-southeast toward the trench. Furthermore, locally upward and downward changes in seafloor elevation of $\pm$50 m are evident at the axial seafloor of the survey track. This morphological structure is interpreted as compressional (thrust-up structure) with reverse faults branching from an interface in the subducting sedimentary layer, which is interpreted as the coseismic master fault. The structure where subsidence was observed is interpreted to have formed by slumping, which may have caused gravitational instability [Kodaira et al., Nature Geosci. 2012; Strasser et al., Geology 2013]. The size of this deformed morphological structure is 3 km across the trench and 13 km along the trench within a confined area. For the track crossing the trench axis at 38^{o}35'N, about 50 km north of the 38^{o}05'N track, bathymetric data comparison shows the same trend and there are relative differences landward extended up to the trench axis. However, change in seafloor elevation along this track is of smaller magnitude than that along the 38^{o}05'N track and shows direct evidence indicating smaller coseismic displacement along this track. The horizontal seafloor displacement seems to be difficult to resolve accurately due to the estimation errors. For the track crossing the trench axis at 37^{o}25'N, off the coast of Fukushima, about 70 km south of the 38^{o}05'N track, change in seafloor elevation along this track is even smaller than that along the 38^{o}35'N track. Also, we didn't observe significant deformed structures at the axial seafloor outside of the extra-large displacement area at 38^{o}05'N.

Keywords: 2011 Tohoku-oki earthquake, tsunami, Japan Trench, multibeam bathymetry, seafloor displacement

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MIS33-05 Room:102B Time:May 26 10:00-10:15

Spatial extent of sedimentation triggered by the 2011 Tohoku earthquake from short-lived radioisotope data, Japan Trench

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Extensive work has been conducted along the Japan Trench since the 2011 Tohoku megathrust earthquake and tsunami and much has been learnt as a result of these studies that can be applied regionally and globally to other subduction systems. In 2013, the Japan Agency for Marine-Earth Science and Technology conducted expeditions NT13-02 and NT13-19 to the 2011 Tohoku Mw 9.0 megathrust earthquake and tsunami source, with R/V Natushima in 800-5,900 m water depth. The goal was identifying earthquake-triggered deposits and mapping their spatial and temporal distribution, as a strategy to recognize the sedimentary signature of Tohoku-like events and measure recurrence intervals for seismic hazard assessment. Twenty-four piston cores, 3 to 6 m long, were recovered during the NT13-19 expedition along a 300 km-long portion of the mid-slope terrace. This elongated structure is parallel to the strike of the Japan Trench, and located landward of the frontal prism where deformation is most intense. Faults, sometimes forming steep scarps, define small (5km long) confined basins that were targeted for coring.

Very high activities in xs^{210}Pb and concentrations of ^{137}Cs were measured in the upper half-meter of the cores. Detection of ^{134}Cs and enrichment of ^{137}Cs provided a Fukushima signature that was found in the upper 15 cm of several cores. Together with x-ray fluorescence elemental analyses, these radioisotopes provide evidence for multiple pluses of sedimentation triggered by the Tohoku 2011 earthquake and possibly some of its aftershocks, and of older earthquakes that occurred as far back as the last hundred years.

Widespread shaking by the 2011 earthquake induced synchronous fluidization and resuspension of near bottom sediments for ~250 km along the strike of the Japan Trench. Sediment thickness seems to depend on its proximity to the zone of maximum megathrust slip, but could also depend on local topography and supply of unstable sediment. The sediment deposited as a result of the earthquake shaking is homogeneous and lacks bioturbation. The earthquake also generated turbidity currents as evidenced by sand-rich beds. Proximal to the area of maximum megathrust slip, and presumably disruption on the upper plate, the earthquake caused brecciation, dewatering and minor slumping of sediments. Re-suspended sediments were deposited on the seafloor for at least 30 days after the earthquake and likely for much longer.

Keywords: Sedimentation generated by Tohoku 2011 earthquake, spatial distribution and pulses of sedimentation, short lived radioisotopes track sedimentation, Mid-slope terrace, Japan Trench, detection of Fukushima signature in sediments, sedimentation relative to maximum megathrust slip

MIS33-06 Room:102B Time:May 26 10:15-10:30

Generation process of earthquake-related turbidity currents along the mid slope terrace on the Japan Trench inner slope

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We conducted radiocarbon age determinations for bulk organic carbon of piston core sediment samples, recovered from the mid slope terrace on the Japan Trench inner slope, 36.6-40.8 N, 142.8-144.2 E, water depth 4203-6217 m, during the NT13-19 and YK14-E01 cruises. The obtained conventional radiocarbon ages are assumed to be almost 2000 years older than actual ages based on the ages of the core top samples and of the intercalated age-known tephras.

Many deep-sea turbidites were intercalated in the cores. They are considered to be seismo-turbidites regarding the sedimentary structures, grain compositions and surrounded topographic conditions. Age differences between hemipelagic and turbidite muds suggest that remobilization of surface sediments by the earthquake is the important process for turbidite deposition on the terrace.

Keywords: earthquake, Japan Trench, turbidite, tephra, 14C age

MIS33-07 Room:102B Time:May 26 10:30-10:45

Sub-bottom environmental change around the Sanriku coastal area after the 3.11 Tohoku Earthquake and tsunami.

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The recent 2011 Tohoku tsunami strongly affected the coastal area of the Pacific coast of Tohoku. Tokai University investigated the Tohoku coastal area as a part of Tohoku Ecosystem-Associated Marine Sciences (TEAMS). Our purpose will be to get the knowledge of distribution of rabble, bottom sediment environment and tsunami information in the coastal local area.

We researched using acoustic equipments (Multi narrow beam echo sounder : MNB, Sub bottom profiler : SBP and Side scan sonar : SSS), bottom sampler and ROV.

Some gigantic crescent marks were observed around shallow bottom area (-10m to -30m in depth) from the Toni and Okirai bay. These marks were estimated that they formed by erosion caused around the rubble at the down flow stage of tsunami. We are trying to observe these marks by MNB again for changing forms in a secular variation.

In the Hirota bay, NW-SE trending high reflector zone with 1.5km in length is formed at the front of the mouth of Kesen river, by SSS survey. We have also the bottom sediment sampling by grab sampler in 50m interval (total 100 samples), along the high reflector zone, on twice a year from 2012 to 2014. As the result of grain analysis for the bottom samples, gravels an coarse sand sediment consist the high reflector zone, and become coarse year by year. However, inner and central areas of the Hirota bay become fine. Large-scale restoration construction is developed at a coastal region around the Sanriku area. It's expected that the sea-bottom environment changes with these restoration construction.

Keywords: tsunami, sub-bottom environmental change

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MIS33-08 Room:102B Time:May 26 11:00-11:15

A Physical Oceanographic Study of the Sanriku Coastal Seas

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There are a dozen or more small bays on the Sanriku ria coast, located in the northeastern part of Japan. The bays have lengths of several to a few tens of kilometres, and depths of several tens to a few hundred meters, and they are well known important areas of inshore fisheries, where a variety of seaweeds and shellfish are farmed. The farming is characterized by a non-feeding type.

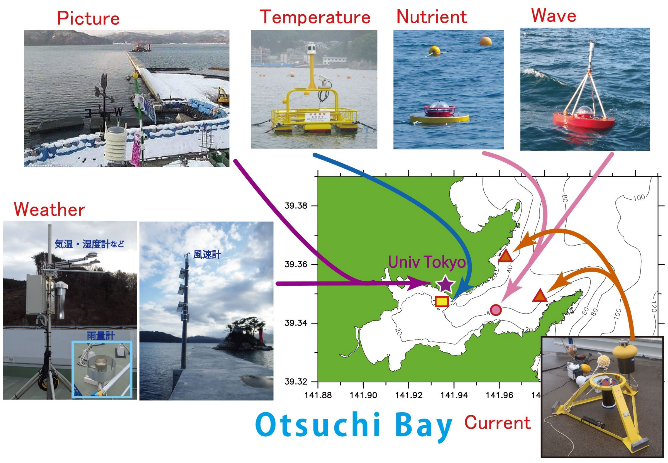
After the 2011 off the Pacific coast of Tohoku Earthquake, the Atmosphere and Ocean Research Institute (AORI) of the University of Tokyo launched a research program to clarify the factors controlling the dynamics of the ecosystems in the Sanriku coastal seas, which will clarify what is needed to restore the area's fishing industry. The program consists of multidisciplinary researches with scientists in the fields of physics, chemistry, and biology, and it has been supported by Tohoku Ecosystem-Associated Marine Sciences (TEAMS) from Ministry of Education, Culture, Sports, Science, and Technology of Japan (MEXT).

We have investigated the seawater circulation in this area, especially from a view-point of physics (physical oceanography): Shipboard surveys were conducted many times in Otsuchi, Kamaishi, and Hirota Bays, using a ship-mounted acoustic Doppler current profiler (ADCP) and a conductivity-temperature-depth profiler (CTD profiler). Moreover, a variety of monitoring instruments, such as current profilers, thermometers, wave sensor, and so on, have been deployed in Otsuchi Bay (see Figure). Furthermore, oceanic observations were also conducted outside the bays, using a research vessel.

As a result, a large amount of hydrographic data were collected to successfully provide clear images of the seawater circulation in the Sanriku coastal seas: In summer, for example, a prominent baroclinic circulation with a three-layer structure extends over the greater part of the ria bay, and its flow directions change on time scales of several to a few tens of hours.

In addition, we continue to find a way to solve not only academic problems, but also social problems simultaneously and synergistically, together with the local community. This is because the hydrographic observations over the inshore fishery areas cannot be made without support from fishermen and their cooperative associations. At the same time, there are many fishery problems that cannot be solved without an academic approach; for example, the physical oceanography is needed to reveal the seawater circulation that conveys nutrients into the "non-feeding" sea farming areas.

Keywords: Seawater Circulation, Sanriku, Physical Oceanography, Tohoku Ecosystem-Associated Marine Sciences



MIS33-09 Room:102B Time:May 26 11:15-11:30

Whait kind of disturbance have Great East Japan Earthquake and Tsunamis given?

KITAZATO, Hiroshi[1*]

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March 11, 2011, Megaearthquake and Tsunamis took place at Tohoku Region. Marine Ecosystems have totally damaged due to Earthquake and Tsunamis. Tohoku Region is a rich in marine biodiversity. Thus, the region is famous for fisheries. Together with Tohoku University and AORI, University of Tokyo, JAMSTEC is going to make research on disturbances and recovary processes of marine ecosystems off Tohoku. The project is supported by MEXT. This project aims to make crear disturbances of marine ecosystems by Earthquake and Tsunamis and to monitor recovery processes from ecosystem disturbances. We plan to transfer and/or share research results to fisheries, local governments and citizens at Tohoku Areas. In my talk, I try to introduce about Tohoku marine sciences. I also show what kind of disturbances have taken place at bottom ecosystems of Tohoku Region.

Keywords: Great East Japan Earthquake, Tsunami, Marine Ecosystems, Sediment liquification, Turbidite, Repopulation

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MIS33-10 Room:102B Time:May 26 11:30-11:45

Bioturbation in shallow marine deposits along Sanriku Coast after the 2011 tsunami disturbance

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The huge tsunami waves induced by the 2011 M9.0 Tohoku-Oki Earthquake severely affected shallow marine ecosystems along the Pacific coast of northeastern Japan (Seike et al., 2013). This study focuses on sedimentary features (physical and biogenic sedimentary structures) of shallow marine deposits along Sanriku Coast, i.e., Funakoshi and Onagawa bays, northeastern Japan after the 2011 tsunami disturbance. Core samples were observed using X-ray radiography, computed tomography scanning, and grain size analysis to identify temporal changes in the physical and biogenic sedimentary structures following the 2011 tsunami disturbance. At Funakoshi Bay, Iwate Prefecture, sediment coring was conducted in September of 2014. The seafloor sediments of this bay were composed of laminated sandy deposits (tsunami-induced deposits). The upper section (between the surface and a depth of 20 cm) was totally mixed (bioturbated) by burrowing activity of the heart urchin *Echinocardium cordatum*, and contained no physical sedimentary structures. At Onagawa Bay, Miyagi Prefecture, sediment coring was conducted between October 2012 and April 2013 (three observations). The seafloor sediments of this bay consisted of two lithological layers. The upper section was composed of muddy sediments whereas the lower part of the cores (below a depth of 8 cm) consisted of laminated sandy deposits (tsunami-induced deposits). In 2012 and 2013 observations of the bay, burrows produced by benthic animals were seen only in the upper mud layer. In contrast, in 2014 observation, abundant burrows were seen in both the upper mud and lower sand layers. These results from Funakoshi and Onagawa bays indicate that recolonization of large and deep-burrowing animals began within three years of the 2011 tsunami. Also, the intense sediment mixing by large burrowing animals will homogenize the seafloor sediment.

Seike K, Shirai K, Kogure Y (2013) Disturbance of Shallow Marine Soft-Bottom Environments and Megabenthos Assemblages by a Huge Tsunami Induced by the 2011 M9.0 Tohoku-Oki Earthquake. PLoS ONE 8(6): e65417. doi:10.1371/journal.pone.0065417

Keywords: tsunami, bioturbation, burrow, Sanriku, sediment, shallow marine

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MIS33-11 Room:102B Time:May 26 11:45-12:00

Long term monitoring of bottom environments off Ohtsuchi Bay

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[1]JAMSTEC

The 2011 off the Pacific coast of Tohoku Earthquake induced heavy disturbances on sea floor environments in wide areas from coastal zone to the hadal trenches in the northerastern Japan (Kawagucci et al,. 2012; Noguchi et al., 2012; Arai et al., 2013; Oguri et al., 2013). On the sea floor, strong turbid layers were developed presumably by strong shaking or intensified hydrodynamic surges by tsunami (Toyofuku et al., 2014). To investigate environmental changes or the recovery from the disturbances, we conducted long term monitoring at 300m and 998m in water depth off Ohtsuchi bay.

For the monitoring, two monitoring stations were constructed to mount ADCP-CTD-DO-turbidity sensors (Aanderaa RDCP600), combinations of LED light, HDTV camera and lithium-ion battery (handmade) on a titanium frame. The hydrodynamic and chemical data were acquired every one hour interval. The still images were taken every day and the 4.5 minutes videos were recorded every week, respectively. The station was deployed at 300 m depth from 2013/3/12. Although this station was unexpectedly captured by a trawling boat, the data and the photographs recorded for five and half months were recovered. At 998 m depth, the other station was deployed from 2012/8/12, and it was safely recovered during R/V Natsushima NT13-21 cruise.

At 300 m depth, dominated current direction was NNE to SSW. The 25 hours averaged current intensity was 0-30 cm/sec. Decrease of water temperature from 8 to 2 oC was observed on May/2013. Salinity decrease from 33.3 to 32.8 was also synchronized with the temperature variation. These changes seemed to reflect contribution of Oyashio water. Dissolved oxygen (DO) ranged from 290˜250 μM, but it was suddenly decreased to ˜100 μM, and recovered in a few hours to a few days. Turbidity showed increased trend in a short time on April to May/2013, reflecting phytoplankton blooming observed by remote sensing. This period, strong turbidity by marine-snow was also recorded by the camera. Photographs taken at the sea floor recorded high density habitats of brittle star. A few fishes and other organisms (sea anemone etc.), were also observed.

At 998 m depth, dominated current direction was also NNE-SSW. The averaged intensity was 0˜15 cm/sec. Water temperature was 3 oC and the salinity was 34, which ranged almost constant values throughout the deployment. DO was 25˜29 μM, indicating just in the DO minimum zone. Turbidity was increased after Feb/2013, but it seemed to reflect biofauling, because bottom water was not turbid from the photographs.

On 2012/12/7, strong earthquake (M=7.3) supposed as an aftershock of the Tohoku earthquake occurred. The camera recorded the turbulences of sea floor and benthic habitats. Turbidity was intensified just after the earthquake and brittle stars were buried. However, the turbidity and the activity of the benthic habitats were recovered quickly and the effect of the earthquake seemed to be small for the organisms.

Keywords: sea floor, long term monitoring, earthquake, benthic habitat

MIS33-12 Room:102B Time:May 26 12:00-12:15

Unexpected type of biodiversity disturbances of benthic ecosystem of off Shimokita after 3.11

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On March 11th, 2011 the Mw 9.0 2011 T?hoku-Oki earthquake resulted in a tsunami which caused major devastation in coastal areas. Along the Japanese NE coast, tsunami waves reached maximum run-ups of 40 m, and travelled several kilometers inland. Whereas the devastation was clearly visible on continental areas, the underwater impact was much more difficult to assess. Here, we report unexpected results during a research cruise targeting the marine floor off Shimokita (NE Japan), five months after the disaster. The geography of the studied area is characterized by smooth coastline and a gradually descending shelf slope. Although high-energy tsunami waves caused major sediment reworking in shallow-water environments, shelf ecosystems were characterized by surprisingly high benthic diversity and showed no evidence of mass mortality. Conversely, just beyond the shelf break, the benthic ecosystem was dominated by a low-diversity, opportunistic fauna indicating an ongoing colonization of massive sand-bed deposits.

Keywords: tsunami

MIS33-13 Room:102B Time:May 26 12:15-12:30

Impacts on the deep-sea ecosystem off Sanriku from the mega-earthquake and tsunami of 2011: Research by the TEAMS

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The Great East Japan Earthquake of March 11, 2011 generated a massive tsunami wave that severely damaged coastal areas of Japan. The earthquake and tsunami of the Great East Japan Earthquake also caused extensive damage to the marine ecosystem including deep-sea off Sanriku region. It means that local fisheries received the devastating damage from this catastrophe. The deep-sea fishing is one of the most important fisheries in this region. In order to help understand and utilize marine ecosystems and fisheries including deep-sea fisheries, JAMSTEC has conducted multidisciplinary researches under the project, Tohoku Ecosystem-Associated Marine Sciences: TEAMS as a decadal program beginning in FY 2011 with the Tohoku University and the Tokyo University. JAMSTEC subjects are:

- to estimate the influence of debris on ecosystems and fisheries,
- to reveal the ecology of organisms living on the seafloor in offshore areas,
- to explain how the seafloor environment will change,
- to reveal the state of pollution in the sea by monitoring levels of PCB,
- to create habitat and ecosystem maps,
- to share TEAMS activities and results known to the public (Database).

For progress of these subjects, we have carried out investigations and research mainly in offshore waters using a range of tools and equipment, such as research ships, ROVs and IT technology.

We will present progress activities of TEAMS by the JAMSTEC and would like to discuss how to contribution for reconstruction of local fisheries from science aspects.

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MIS33-14 Room:102B Time:May 26 14:15-14:30

Effect of the 2011 Tohoku Earthquake on meiofauna inhabiting the landward slope of the Japan Trench off Sanriku

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Deep-sea floors contain high levels of biodiversity, which is sometimes comparable to tropical rain forests, despite the apparent uniformity of its environment (Hessler & Sanders 1967; Grassle 1989). It is explained that small-scale disturbances, such as predation and near-bottom currents, frequently occur and cause a patchy distribution of different successional stages across an area (Rex 1981; Levin et al. 2001). The effect of small-scale disturbance on deep-sea assemblages has been studied for several taxa (Kaminski 1985; Hall 1994; Paterson & Lambshead 1995; Thistle 1998). On the other hand, turbidity current, which is a bottom-flowing current laden with suspended sediments generated by tsunamis and earthquake-induced landslides, is an example of a catastrophic disturbance (cf. Harris 2014) and expected to cause a large effect on meiofaunal assemblages. However, little is known how the deep-sea benthic meiofauna respond to such a catastrophic disturbance.

On 11 March 2011, an earthquake of Mw9.0 known as the 2011 off the Pacific coast of Tohoku Earthquake occurred off the coast of Miyagi Prefecture. Sedimentation caused by the turbidity current was documented over an extensive area (Ikehara et al. 2011; Arai et al. 2013). Therefore, the 2011 Tohoku Earthquake probably impacted not only the shallow-water (e.g. Kanaya et al. 2012; Seike et al. 2013) but also the deep-sea ecosystems. This study evaluated the effect of large-scale disturbance on the deep-sea benthic assemblages inhabiting the landward slope of the Japan Trench using meiofauna, which is most abundant metazoan in deep sea, especially on benthic copepods (harpacticoid copepods).

Sediment samples were collected on the landward slope of the Japan Trench off Sanriku during 3 cruises. Two cruises were conducted from late July to early August 2011 (4.5 months after the 2011 Tohoku Earthquake); specifically the KT11-17 cruise of the R.V. Tansei Maru and the YK11-E06 cruise of the R.V. Yokosuka. The third cruise, KT12-18 of the R.V. Tansei Maru, was conducted in late July 2012 (1.5 years after the earthquake). Meiofaunal specimens were extracted from sediments and they were then sorted into higher taxa and counted. We compared the total meiofaunal densities obtained from this study to those before the earthquake in the study area (Shirayama & Kojima 1994). Benthic copepod (harpacticoid) specimens were further identified at the genus level.

During the present study, it is indicated that major disturbances to deep-sea sediments mainly influenced the vertical distribution, but meiofaunal densities remained similar through the earthquake or quickly recovered within 4.5 months of the event. In addition, harpacticoid community structure did not change in 1 year after the earthquake even between before and after the earthquake. These results suggest that the strong resilience of meiofauna inhabiting the landward slope of the Japan Trench, where high-magnitude earthquakes frequently occur, against disturbance. In the presentation, we will explain the results and background of this study in more detail.

Keywords: earthquake, disturbance, meiofauna, harpacticoid, community structure

MIS33-15 Room:102B Time:May 26 14:30-14:45

Impact of Tohoku Earthquake on Macrobenthic Fauna: Sanriku Waters

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Sanriku experienced the impacts of the Tohoku earthquake, Mw 9.0, and associated tsunami on March 11, 2011. This study investigates the effect of the Tohoku earthquake on the macrobenthos of the Sanriku area (depth range: 120m to 5600m). Core samples were taken 4.5 months after the earthquake struck. Turbidites were prominent in the core samples (Ikehara et al., 2014). To begin with, the macrobenthos in the cores were examined. This was followed by a comparison of this macrobenthic fauna with those before the earthquake (Kojima and Ohta, 1989). The decreasing macrobenthos abundance with water depth at Sanriku is a common observation around the globe (Rex et al., 2006). Post earthquake examinations of the Sanriku small macrobenthos (0.5mm to 1mm) show increased abundance in depths greater than 2000m. In addition, although the thickness of turbidites are not related to the water depth, observations from the current study show that as the thickness of the layer increases the abundance of macrobenthos decreases. There was an absence of large Nematoda ($>$1mm) in areas covered by more than 3cm thick turbidite layers. While large Arthropoda and mollusks ($>$1mm) were absent from areas covered by 5cm thick turbidite layers. It is inferred that these may have been transported by erosion or buried by the turbidities.

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Dynamics of the brittle star population in the continental slope off Sanriku, Northeast Japan

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Ophiuroidea are the dominant species at the sea bottom of the upper bathyal zone from 200 m to 600 m off the Sanriku region. The region has been estimated to have 373 individuals, with 124 g per m^2 (Fujita and Ohta, 1989). Brittle stars potentially play an important role in submarine matter flow and in the food chain in this region. Because of their importance in ecosystem functions, brittle stars have gained attention, particularly for large-scale conservation planning and sustainable fishery (Yamakita et al., 2015 a). To reveal the temporal dynamics of brittle stars in the Sanriku region, the number of brittle stars and their size composition were observed. We used an interval video system for long-term sea-bottom observation platforms (lander systems) at 300- and 1000-m-deep sites off Otsuchi Bay. Furthermore, we collected literature, pictures, and videos using a remotely operated vehicle (ROV) and conducted a geological survey to evaluate the spatial distribution of brittle stars before and after the earthquake.

Three ophiuroid species (*Ophiura sarsii* Lutken, 1855; *Ophiura leptoctenia* Clark, 1911; and *Ophiophthalmus normani* Lyman, 1879) were observed, and the dominant species differed with site. *O. sarsii* was the dominant species at the 300-m site, and *O. normani* dominated at the 1000-m site with apparently lower density.

At the 300-m study site, a trend of decreasing population number and increasing body size was observed. At the 1000-m study site, a sporadic change in the body size and population number was observed despite the stable environmental conditions.

The growth rate of the shallow brittle star community in our study corresponded to that reported previously. Increase in turbidity and burial of organisms were the probable causes of the decrease in population number at the deeper site. Some of the turbidity was related to another medium-sized earthquake. Higher-resolution images were needed for the detection of the recruitment process and hidden environmental changes at the deeper site. Although there were no obvious changes in the distribution of species before and after the earthquake except for an increase in marine debris in the deep-sea valley (Yamakita et al. 2005 b), the preliminary result showed a difference in the size histogram. Further analysis and collection of additional samples are needed to examine these changes.

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Keywords: Population dynamics, Spatial distribution, Ophiuroidea, The 2011 Great East Japan Earthquake, Long-term sea-bottom observation platforms lander