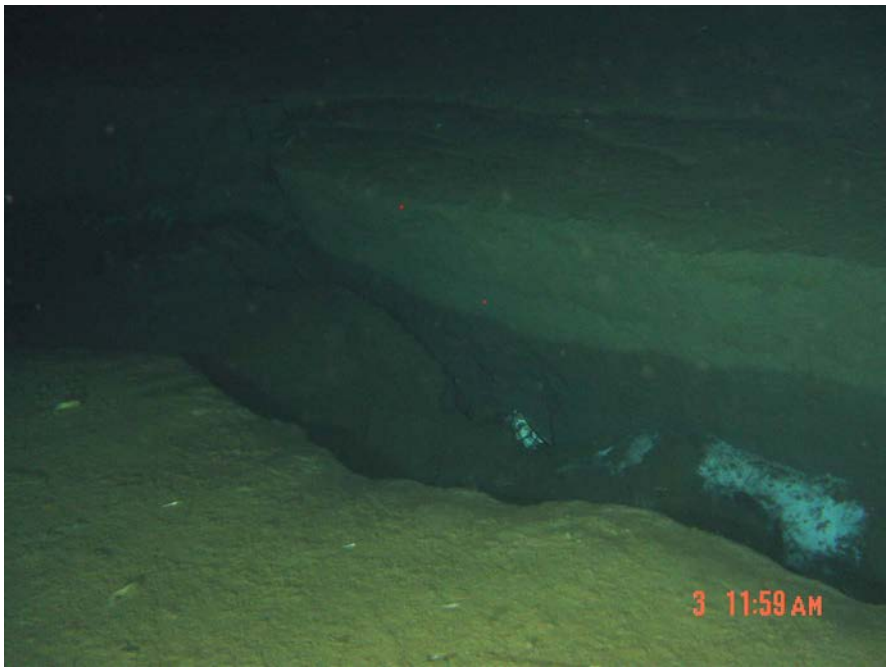
doi : 10.17596/0003178

Cruise Report

YK11-E06-Leg 2

Off Sanriku, Japan Trench

Impact by the mega-earthquake on marine ecosystem including chemical, physical, geology and geophysics in Off Sanriku area



R.V. Yokosuka/H.O.V. Shinkai 6500

July 30, 2011-Aug 14, 2011

JAMSTEC

Contents

1. Cruise Information

1-1. Cruise ID: YK11-E06-Leg2

1-2. Name of vessel: R/V Yokosuka

1-3. Title of the cruise: Impact by the huge earthquake on marine ecosystem including chemical, geology and geophysics in Off Sanriku area

1-4. Title of proposal:

Impact by the huge earthquake on marine ecosystem including chemical, ocean physics, geology and geophysics in Off Sanriku area (K. Fujikura: JAMSTEC)

底生無脊椎動物、特に軟体動物群集を用いた海底環境の撹乱の評価(長谷川　和範: 国立科学博物館・動物研究部)

津波により流失したがれき類の漂流および深海底への蓄積状況とがれきに含まれる有害物質の解析(三宅裕志:北里大学・海洋生命科学部)

巨大津波発生域における断層変動メカニズムの解明に向けた海底露頭調査(辻　健:京都大学・大学院工学研究科)

地震・津波による乱泥流の発生とそれによる海底地形の形成(成瀬　元:千葉大学・大学院理学研究科)

海底に堆積したセシウム(放射性元素)のメイオベントス(有孔虫)による擾乱と捕集能力(野村　律夫:島根大学教育学部・汽水域研究センター)

東日本大震災の震源域周辺海底における海底下深部流体起源物質の検出(土岐　知弘:琉球大学・理学部)

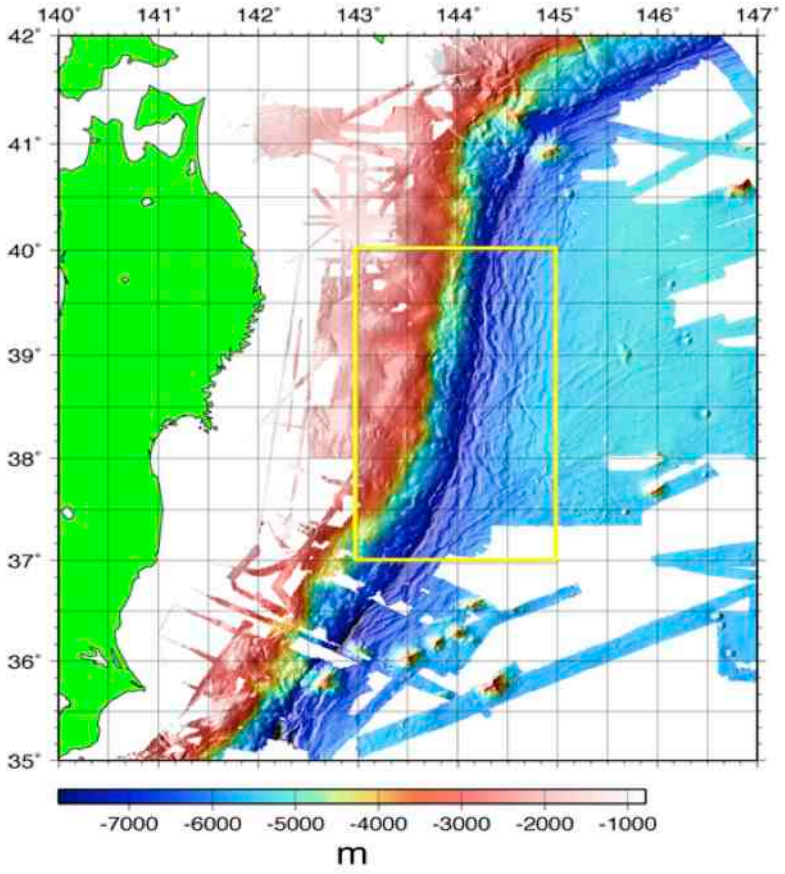
大規模撹乱が小型底生生物(メイオファウナ)に与える影響(嶋永　元裕:熊本大学　沿岸域環境科学教育研究センター)

地震と地滑りに伴う濁度上昇と硫黄循環に関する微生物研究(砂村　倫成:東京大学・大学院理学系研究科)

1-5. Cruise period: July 30, 2011-Aug 14, 2011

1-6. Ports of call: Yokosuka, JAMSTEC July 30, 2011 - Hachinohe Aug 14, 2011

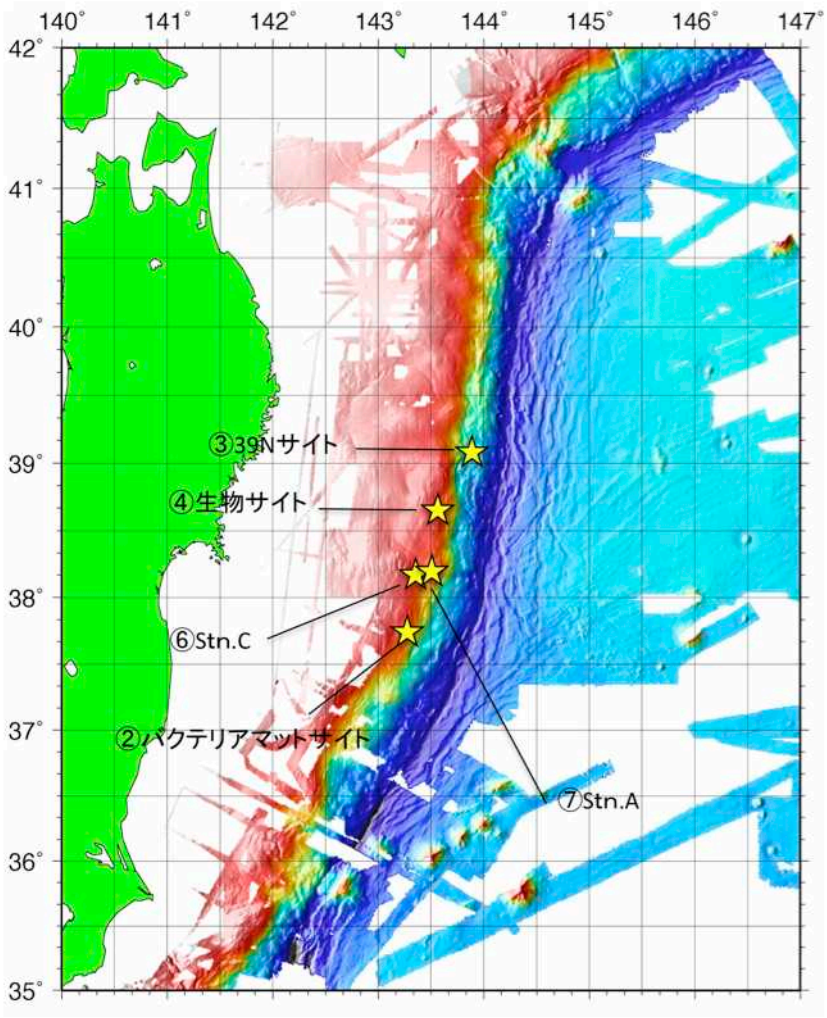
1-7. Research area: Off Sanriku, Japan



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

1-8. Research map



2. Participants

2-1. Chief scientist: Katsunori Fujikura (BioGeos, JAMSTEC)

2-2. Science party (List)

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	Marine Technician	Nippon Marine Enterprises, Ltd.

2-3.Shinkai 6500 operation team

Operation Manager	Toshiaki Sakurai	Sub Operation Manager	Satoshi Ogura
Sub Operation Manager	Kazuhiro Chiba	1st Submersible Staff	Keita Matsumoto
1st Submersible Staff	Masanobu Yanagitani	2st Submersible Staff	Keigo Suzuki
2st Submersible Staff	Yosuke Chida	2nd Submersible Staff	Akihisa Ishikawa
3rd Submersible Staff	Hitomi Ikeda	3rd Submersible Staff	Yudai Tayama
3rd Submersible Staff	Masaya Katagiri		

2-4.Ship crews

Captain	Kouji Sameshima	Chief Officer	Takafumi Aoki
2nd Officer	Shouzou fujii	3rd Officer	Yumihiko Kobayashi

Chief Engineer	Hiromi Kikkawa	1st Engineer	Takashi Ota
2nd Engineer	Takahiro Mori	3rd Engineer	Kenta Ikeguchi
Chief Radio Operator	Tokinori Nasu	2nd Radio Operator	Yoshikazu Kuramoto
3rd Radio Operator	Ryousuke Komatsu	Boat Swain	Shouichi Abe
Able Seamen	Shuuji Takuno	Able Seamen	Masanori Ohata
Able Seamen	Nobuyuki Ichikawa	Able Seamen	Nao Ishizuka
Sailer	Shinsuke Uzuki	Sailer	Shou Suzuki
No.1 Oiler	Kazuaki Nakai	Oiler	Masayuki Fujiwara
Oiler	Souta Misago	Oiler	Ryou Sato
Oiler	Kazuho Murase	Chief Steward	Teruyuki Yoshikawa
Steward	Shinsuke Tanaka	Steward	Hiroshi Wada
Steward	Takahiro Abe	Steward	Mizuki Nakano
Steward	Katsuhiro Kawase		

3. Investigations

3-1. Introduction

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.

3-2. Facilities

3-2-1. HOV Shinkai 6500

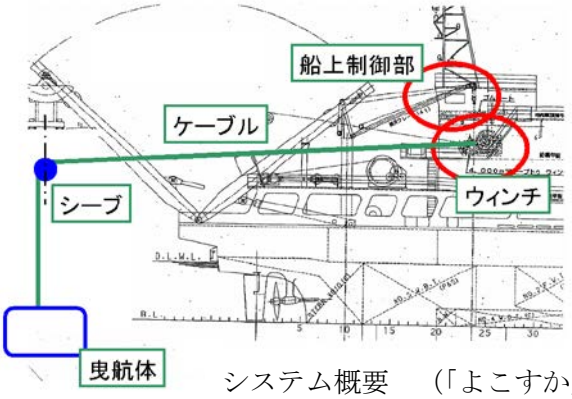
システムの特徴
潜水調査船「しんかい 6500」
全長：9.5m
巾　：2.7m
高さ（着底脚下面から上構上面）：3.2m
空中重量：約 26 トン
潜航最大深度：6,500m
乗員：3 名
耐圧殻径： 2.0m
最大潜航時間（潜航開始から浮上まで）：8 時間
ライフサポート時間：129 時間
ペイロード：150 kg（空中重量）
水中速力：0～2.0Kt　乗　員
3 名の乗員の内訳は、パイロットが 2 名と研究者が 1 名。 (3)　潜航時間最大潜航深度(6,500m)での潜航作業

の場合は、最大潜航時間を 8 時間

3-2-2. 4500m-class deep towing TV camera system (4000YKDT)

Operation and specification of the 4500m-classYokosuka Deep Tow Camera（YKDT）are following in Japanese.

本システムは、観測装置を鉄パイプ製のフレームに固定し、海中に吊り下げて海底・海中の観測を行う装置であり、曳航体、曳航ケーブル、ウインチ、シーブ、船上制御部よりなる。カラーＴＶ映像、白黒ＴＶ映像、カラー写真（デジタルカメラ）、CTD データなどが取得できる。曳航中の測位は母船に装備されている D-GPS および音響航法装置によるハイブリッド測位により行う。なお本航海ではケーブル長さの制約から、曳航体を繰り出せるのは最大 4500m である。



システム概要　（「よこすか」の船尾）

曳航体

曳航体は TV カメラ、デジタルスチルカメラ、CTD 等を装備し、船上制御部との間で光ファイバーを経由したシリアル通信を行っている。また、切離装置、方位計等を装備可能となっている。

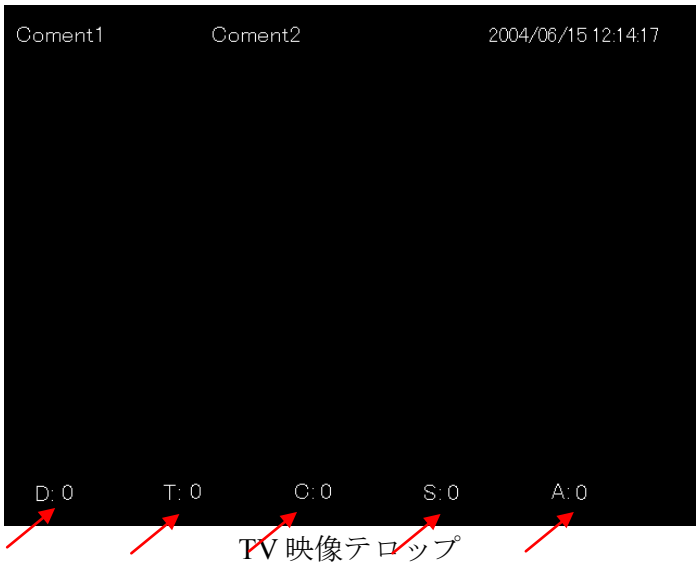
Deep Tow Fish

- Size：3,000×1,200×1,200mm（L×W×H）
- Weight　：650kg（air）、400kg（in water）
- Max. depth：4500m
- Speed　：～1.0kt
- Towing height　：2～5m
- Dredge：1

specifications

Color TV camera	SONY DXC-990, NTSC
B/W TVcamera	SONY XC-ST50, NTSC

Still Camera	AquaPix SeaSnap (3.34Mpixel)
Light	500W×2 灯 250W×2 灯
CTD	Seabird SBE49
Altimeter	MESOTECH 1007 型
Transpondar	Oki SB-1023(7kHz 帯)
Releaser	Inter Ocean MR5000



TV 映像テロップ

① コメント１表示
② コメント２表示
③ 日時表示
④ 深度表示（m）「DEPTH」
⑤ 水温（℃）「Temperature」
⑥ 電気伝導度（S/m）「Conductivity」
⑦ 塩分濃度（psu）「Salinity」
⑧ 高度（m）「ALTITUDE」

3-3. Cruise log

YK11-E06 Leg2 Shipboard Log:
2011/7/30
Weather: Overcast/ Wind direction: NE/ Wind force: 3/ Wave: 0.5 m/
Visibility: 5 miles (12:00 JST)

09:00	Onboard
10:39	Loaded Shinkai6500
11:00	Departure from YOKOSUKA (JAMSTEC)
11:10-11:26	Scientific Meeting (1 Lab.)
13:00-13:30	Briefing about ship's life and safety
14:00-14:30	Scientific meeting with 6K team (1 Lab.)
16:40	Praying for the safety of this cruise (Konpira ceremony)
19:00-19:15	Scientific meeting (1 Lab.)

2011/7/31
Weather: Fine but cloudy/ Wind direction: NE/ Wind force: 4/ Wave: 1.25 m/
Visibility: 8 miles (12:00 JST)

12:45 Arrival at survey area
12:57 XBT
13:00-13:20 Scientific meeting (1 Lab.)
13:35-14:21 MBES

2011/8/1
Weather: Fine and cloudy/ Wind direction: NE/ Wind force: 4/ Wave: 1.25 m/
Visibility: 12 miles (12:00 JST)
08:57 Launch Shinkai6500 (Shinkai#1254)
11:38 Shinkai6500 lands (5,349 m)
15:08 Shinkai6500 leaves the bottom (5,331 m)
17:29 Shinkai6500 on deck
19:00-19:30 Scientific Meeting (1 Lab.)

2011/8/2
Weather: Overcast/ Wind direction: ESE/ Wind force: 3/ Wave: 0.50m/
Visibility: 8 miles (12:00 JST)
09:53 Launch Shinkai6500 (Shinkai#1255)
12:15 Shinkai6500 lands (5,343 m)
16:02 Shinkai6500 leaves the bottom (5,132 m)
18:25 Shinkai6500 on deck
19:00-19:30 Scientific Meeting (1 Lab.)

2011/8/3
Weather: Fine but cloudy/ Wind direction: SE/ Wind force: 4/ Wave: 0.50m/
Visibility: 10 miles (12:00 JST)
08:57 Launch Shinkai6500 (Shinkai#1256)
11:22 Shinkai6500 lands (5,350 m)
15:08 Shinkai6500 leaves the bottom (5,353 m)
17:34 Shinkai6500 on deck
19:00-19:30 Scientific Meeting (1 Lab.)

2011/8/4
Weather: Fine but cloudy/ Wind direction: SE/ Wind force: 3/ Wave: 1.25m/
Visibility: 10 miles (12:00 JST)
06:30 XBT
06:59-07:49 MBES
09:27 Launch Deeptow (YKDT#106)
10:40 DT lands (3,735 m)
15:00 DT leaves the bottom (3,485 m)
16:07 DT on deck
19:00-19:30 Scientific Meeting (1 Lab.)

2011/8/5
Weather: Fine/ Wind direction: SSE/ Wind force: 4/ Wave: 1.25m/
Visibility: 10 miles (12:00 JST)
09:57 Launch Shinkai6500 (Shinkai#1257)
11:40 Shinkai6500 lands (3,566 m)
15:48 Shinkai6500 leaves the bottom (3,450 m)
17:41 Shinkai6500 on deck
19:30-19:50 Scientific Meeting (1 Lab.)
19:52 Start SSB

2011/8/6
Weather: Fine/ Wind direction: South/ Wind force: 5/ Wave: 2.5m/
Visibility: 10 miles (12:00 JST)
06:38 End SSB
09:50 Launch Shinkai6500 (Shinkai#1258)
11:03 Emergency surfacing of Shinkai6500
12:51 Shinkai6500 on deck
13:30-14:00 Scientific Meeting (1 Lab.)
16:10-22:02 SSB

2011/8/7
Weather: Rain/ Wind direction: South/ Wind force: 2/ Wave: 0.50m/
Visibility: 5 miles (12:00 JST)
08:00 Arrival at Sendai Harbor
9:45 A ferry boat goes to Seidai port
18:00-18:20 Scientific Meeting (1 Lab.)

2011/8/8
Weather: Fine but cloudy/ Wind direction: East/ Wind force:2/ Wave: 0.1~0.5m/
Visibility: 7 miles (12:00 JST)
08:30 Launch Deeptow (YKDT#107)
09:15 DT lands (3,265 m)
11:30 DT leaves the bottom (3,032 m)
12:20 DT on deck
14:00-15:30 Briefing on boarding on Shinkai6500 for inexperienced scientists
13:38 Launch Deeptow (YKDT#108)
15:00 DT lands (3,118 m)
16:30 DT leaves the bottom (3,118 m)
17:30 DT on deck
19:00-19:30 Scientific Meeting (1 Lab.)

2011/8/9
Weather: Overcast/ Wind direction: SW/ Wind force: 1/ Wave: 0~0.1m/
Visibility: 5 miles (12:00 JST)
07:00 Launch Deeptow (YKDT#109)
08:00 DT lands (3,050 m)
09:55 DT leaves the bottom (2,870 m)
10:45 DT on deck
12:00 Launch Deeptow (YKDT#110)
13:13 DT lands (3,782 m)
15:00 DT leaves the bottom (3,700 m)
16:13 DT on deck
19:00-19:30 Scientific Meeting (1 Lab.)

2011/8/10
Weather: Fine but cloudy / Wind direction: SW/ Wind force: 3/ Wave: 0.1~0.5m/
Visibility: 5 miles (12:00 JST)
09:57 Launch Shinkai6500 (Shinkai#1259)
11:16 Shinkai6500 lands (3,203 m)
15:48 Shinkai6500 leaves the bottom (3,230 m)
17:30 Shinkai6500 on deck

19:00-19:30 Scientific Meeting (1 Lab.)

2011/8/11
Weather: Fine but cloudy / Wind direction: SW/ Wind force: 5/ Wave: 1.25~2.5m/
Visibility: 5 miles (12:00 JST)
6:45 OBEM release
8:00 OBEM recovery
11:10 Launch Deeptow (YKDT#111)
12:34 DT lands (3,546 m)
14:30 DT leaves the bottom 3,504 m)
10:45 DT on deck
19:00-19:30 Scientific Meeting (1 Lab.)

2011/8/12
Weather: Fine but cloudy / Wind direction: SW/ Wind force: 3/ Wave: 0.1~0.5m/
Visibility: 7 miles (12:00 JST)
10:00 Launch Shinkai6500 (Shinkai#1260)
12:08 Shinkai6500 lands (3,585 m)
15:48 Shinkai6500 leaves the bottom 3,547 m)
17:30 Shinkai6500 on deck
19:00-19:30 Scientific Meeting (1 Lab.)

2011/8/13
Weather: Fine but cloudy / Wind direction: SSE/ Wind force: 2/ Wave: 0~0.1m/
Visibility: 8 miles (12:00 JST)
09:00 Launch Shinkai6500 (Shinkai#1261)
10:30 Shinkai6500 lands (3,577 m)
14:40 Shinkai6500 leaves the bottom (3,420 m)
16:00 Shinkai6500 on deck
18:00-18:30 Scientific Meeting (1 Lab.)

2011/8/14 (JST)
09:00 Arrival at Hachinohe Harbor, YK11-E06 Leg2 finish and disembarkation

3-4. General investigation results

Shinka 6500 Dive

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

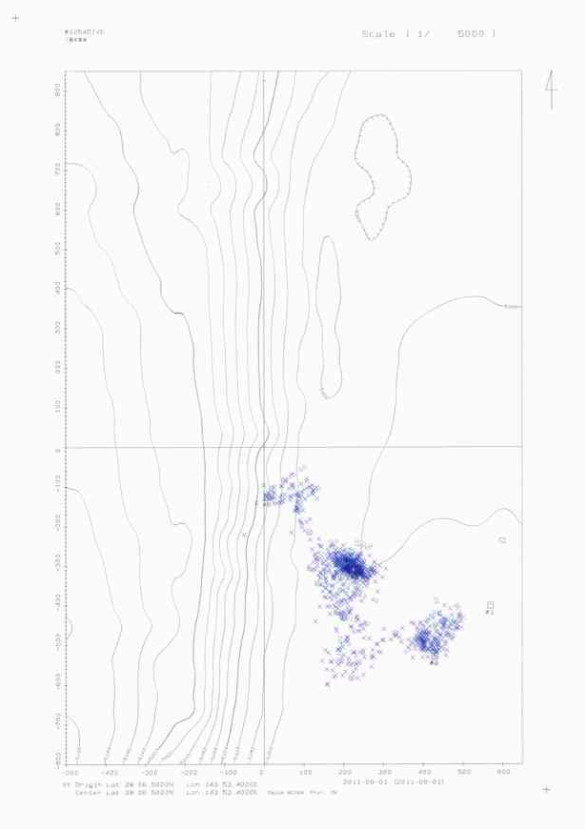
Leaving Point: 39-06.4314'N 143-32.4062'E, 5332m

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.



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

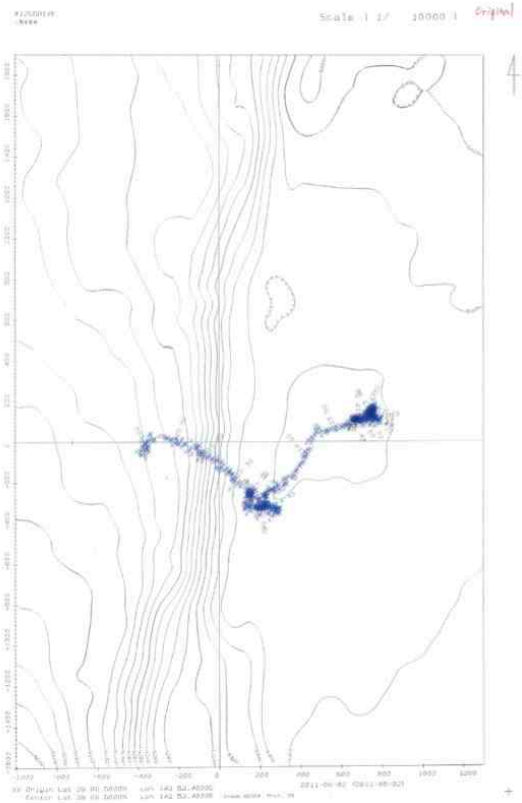
Leaving Point: 39-06.4708'N 143-53.1433'E, 5332m

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 quadrate for the nearby bacterial mat. *Calyptogena faseoliformis* could not be observed around these bacterial mats.
- To retrieve SAHF and observe quadrate, 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, quadrate and maker), 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.



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

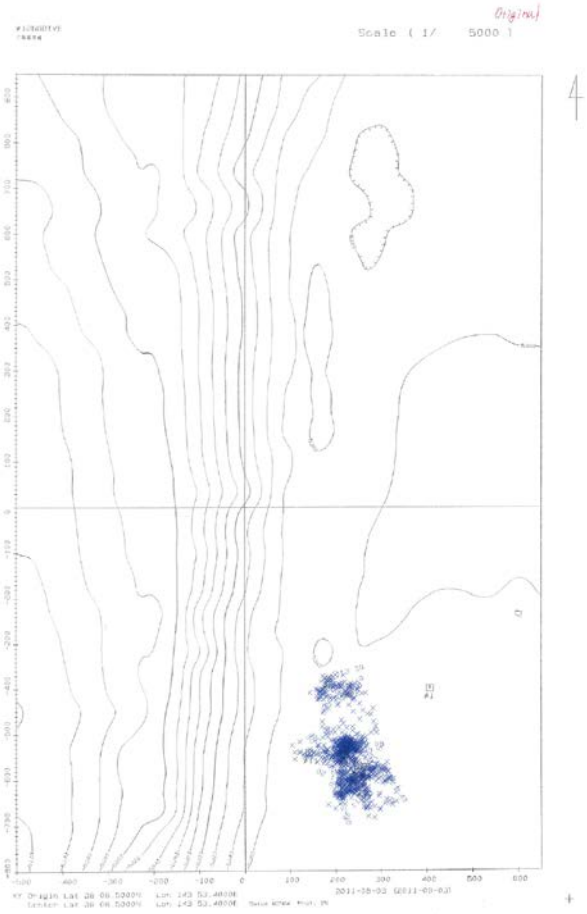
Leaving Point: 39-06.2078'N 143-53.4985'E, 5353m

Dive Summary:

The purpose of the Shinkai6500 #1256 dive was 1) Biological samplings using suction sampler and scoop sampler, 2) samplings at the *Calyptogena 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 *Calyptogena* 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.



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

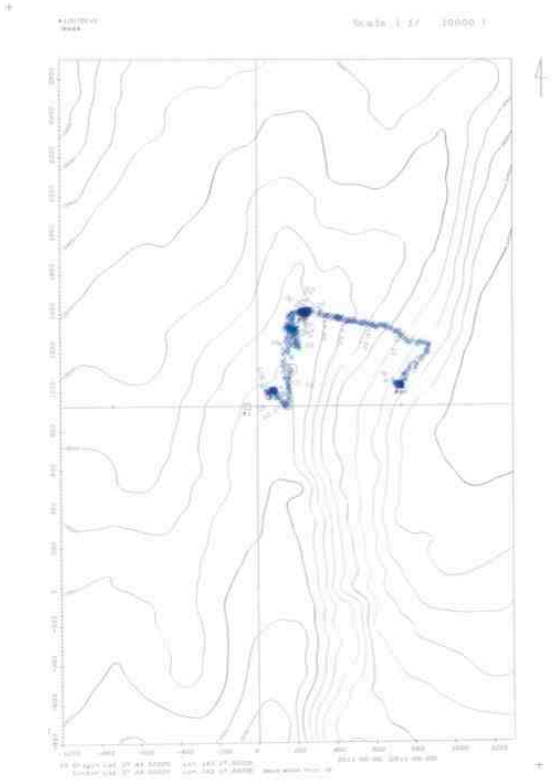
Leaving Point: 37-44.5550N, 143-17.4937E 3451m

Dive Summary:

- The purpose of *Shinkai6500* #1257 was to survey microbial mat distribution along the hidden faults activated by the Tohoku Megaearthquake 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, noting 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 conduced a series of operation: Niskin sampling, SAHF measurement, MBARI coring, C-WHATS sampling, Bag sampling and Quadrate 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 Megaearthquake.
- 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.



Shinkai 6500 #1258

Date: 2011. 8. 6

Researcher: Takafumi Kasaya (IFREE, JAMSTEC)

Survey site: Off Miyagi, Japan Trench, Bacterial mat site, Site 2
Planed landing Point：37-44.40N 143-17.10E
Dive Summary

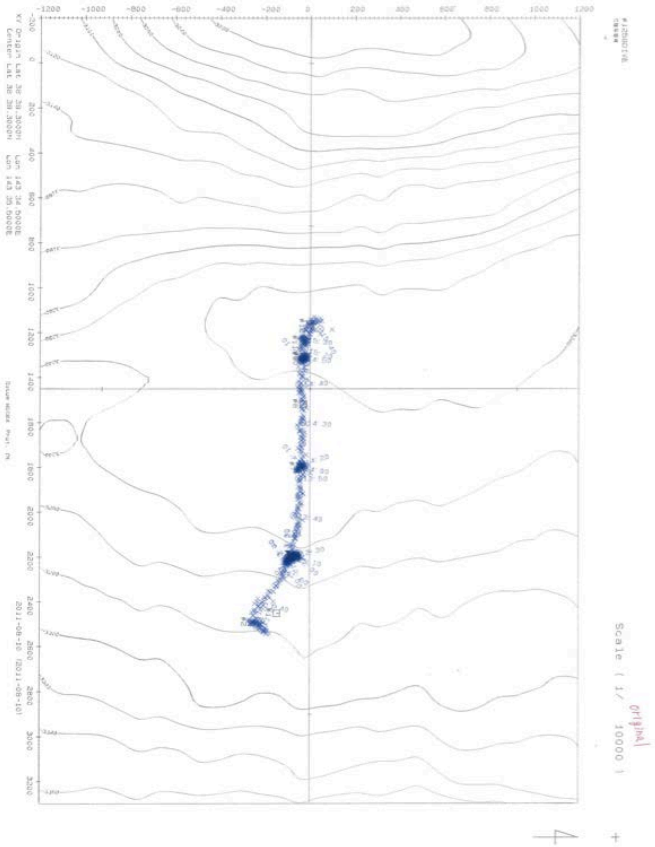
The purpose of *Shinkai6500* #1258 was to survey some fissures and faults formed by the 2011 Tohoku earthquake and obtain some samples to investigate for a chemical composition and characteristics of fluids through the faults. At the depth of 3150 meters, an alarm of a part of buoyancy system was sounded.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

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 faecol 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.



4000YKDT

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

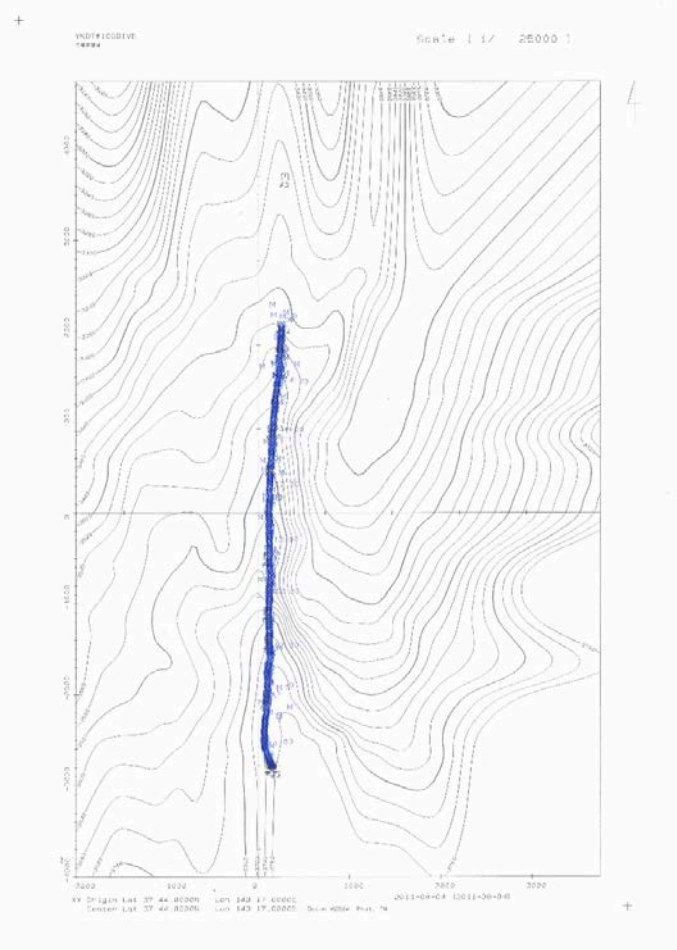
Leaving (Finish towing) Point: 37-45.1249'N 143-17.1725'E, 3472m

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.



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

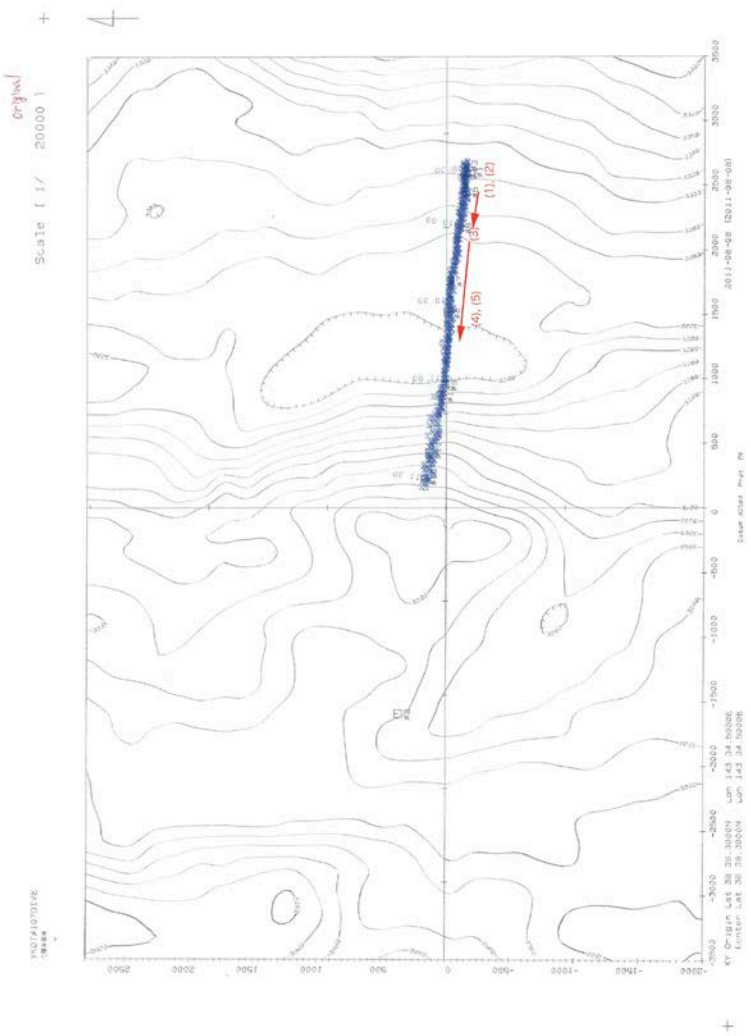
Landing (Start towing) Point: 38-39.2222'N 143-36.3346'E, 3263m

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.



4500YKDT #108

Date: 2011/8/8

Researcher: Takafumi KASAYA (IFREE/JAMSTEC)

Survey site: Off Sanriku, Japan Trench

Landing on water point: 38-’N ’E

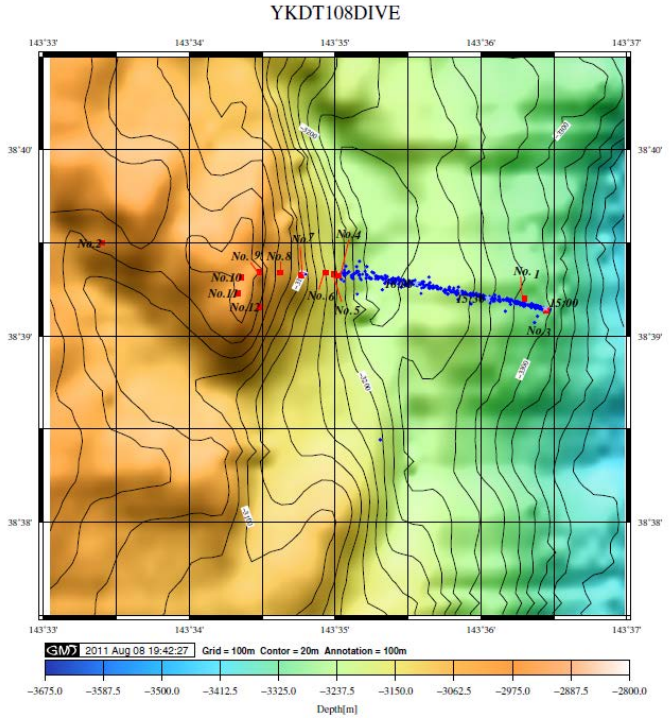
Landing (Start towing) Point: 37-42.4797’N 143-17.1348’E, 3731m

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

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.



4500YKDT #109

Date: 2011/8/9 (Tue)

Researcher: Wataru TANIKAWA (JAMSTEC/KCC)

Survey site: Off Sanriku, Japan Trench

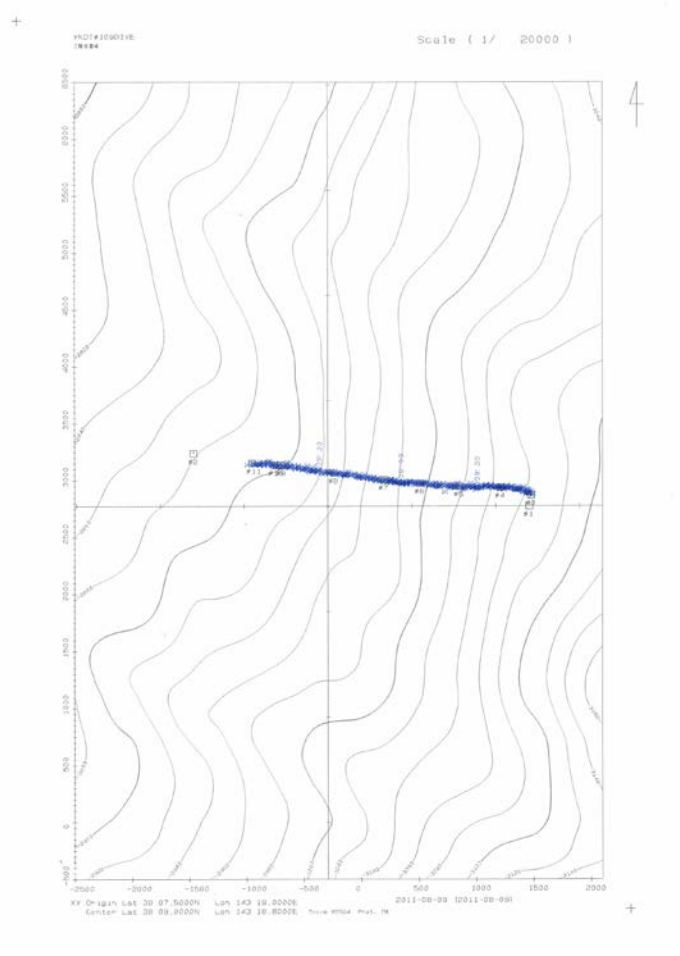
Landing (Start towing) Point: 38-09.0526'N 143-20.0110'E, 3049m

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.



4500YKDT #110

Date: 2011/8/9

Observer: Takuroh Noguchi

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

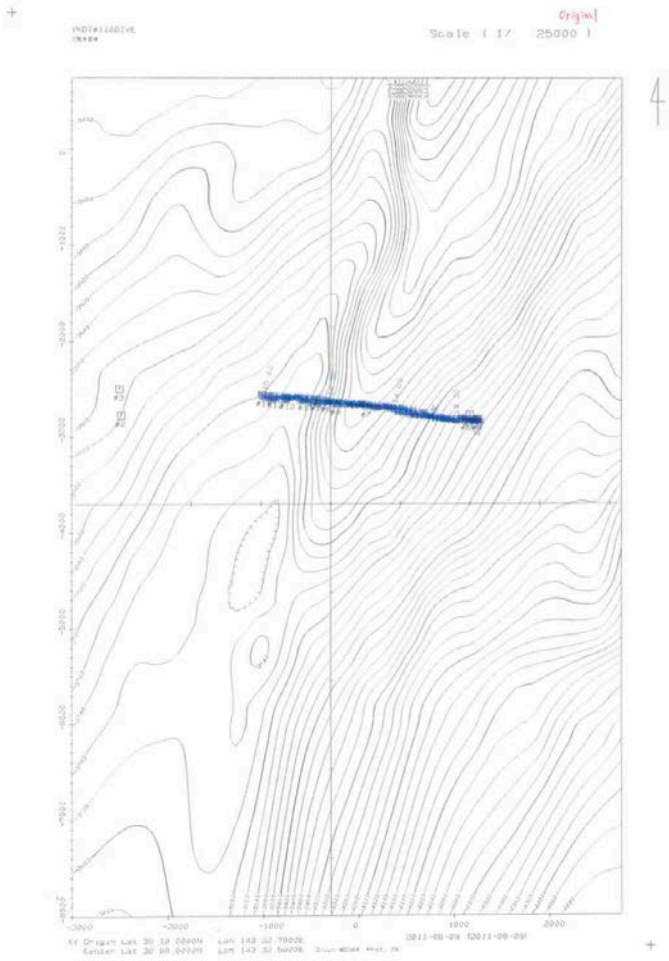
Landing (Start towing) Point: 38º 08.4748’ N, 143º 33.5591’E

Leaving (Finish towing) Point: 38º 08.6139’ N, 143º 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.



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.

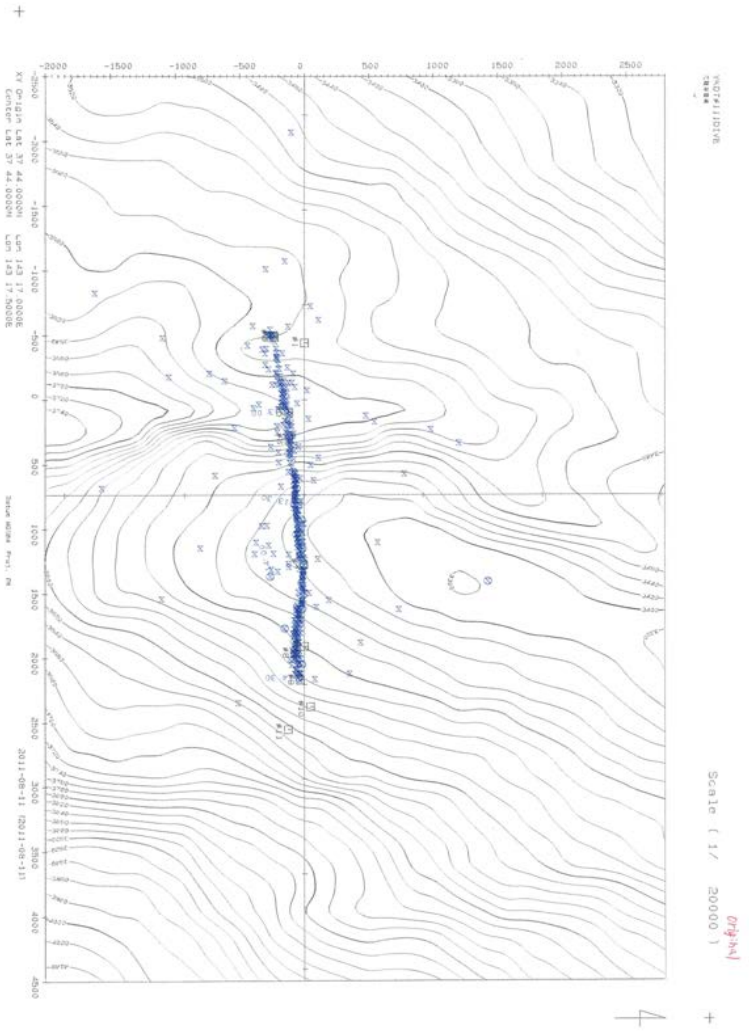
We carried out the following research.

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.



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.

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 Megaearthquake and have been occurring since the earthquake.

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 faults zones (or bacteria mat sites) were smaller than those at a distance from fault zones.

Heat flow

Heat flow was measured at the fault trances using Stand-Alone Heat Flow meter (SAHF) in order to evaluate dynamic fault activity. Because fluid passes through the fault plane (fracture) associated with dynamic fault rupture, the degree of fault activity as well as rupture mechanics should influence to the heat flow value measured on the seafloor. In this cruise, we measured heat flow for seafloor traces of the predominant faults identified on the reflection seismic profiles. We usually measured heat flow using SAHF about 20 minutes for each measurement point. We further measured heat flow at one measurement point (Dive #1154) during ~48 hours and obtained accurate values. Heat flow was mainly measured within the bacterial mats as well as outside of the bacterial mats. The measured heat flow values at the fault traces are anomalously high, suggesting dynamic rupture of the faults.

Natural gamma ray

Natural gamma ray was measured at the fault traces using Gamma-ray spectrometers attached with the submersible. Since the intensity of gamma ray at the cold seep sites in the Nankai Trough is higher than those at normal seafloor, it should be related to the fluids derived from the accretionary prism through the fault zone. Therefore, we expected that the measured gamma ray reflect the fluid flow as well as fault activities associated with the 2011 Tohoku earthquake.

OBEM operation

OBEM was installed on previous YK11-E06 Leg1 cruise. A calculated OEBM 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.

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.

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).

4. Future plan

Katsunori Fujikura

Based on collected data and sample during this cruise, I will present about cruise summary and impact by mega-earthquake on the deep-sea ecosystems in the symposiums and workshops with cruise participants. We found unique or new setting potential of deep-sea chemosynthetic communities, such as mixture methane seeps and organism decomposition. I will study about succession of this biological community. Additionally, I will investigate comparison of benthic faunal composition and distribution between before and after the mega-earthquake. To continually investigate in the Japan Trench, we should propose for next investigation cruise using the ROV Kaiko or HOV Shnkai6500.

Tanikawa & Arai

M9.0 off Tohoku earthquake might have caused deformation and movement of shallow sediment due to submarine landslide, liquefaction and fluidization. Mechanical and fluid transport properties of shallow sediments are key parameters to evaluate the potential of these processes triggered by the earthquakes. Detail observation of deformation structures of sediment will show the evidence of the large subsurface disturbance occurred after earthquake.

Arai, Kazuno

We attempt to reconstruct hydraulic conditions of turbidity currents due to the Earthquake and Tsunami. As a result of the investigations of YK11-E04 leg1 and YK11-E06 leg2, it is highly possible that large- and/or

small-scale turbidity currents have occurred. In this study, first, the detailed characteristics (such as sediment structure, grain-size distribution) of soft sediment layers and other layers are investigated in the core sediment samples. Second, inverse analysis of hydraulic conditions of turbidity currents based on the characteristics of the soft sediments layers is conducted. Reconstructions of flow processes of the turbidity currents will become an important data of the earthquake and tsunami-generated turbidity currents.

T. Toki, T. Noguchi, Y. Nishio, K. Okamura, K. Takai, M. Sunamura

We will analyze major and minor elements (Na, Ca, K, Mg, Sr, Ba, B, Si, Mn, Fe, Cl^-, SO_4^{2-}) in the fluid samples, and boron and lithium isotopes, as well as oxygen and hydrogen isotopes of water. Gas samples will be analyzed for carbon isotopes of methane and carbon dioxide, and helium isotopes. Especially, we focus on B and Li bearing deep-sourced fluids to investigate the distribution of the active faults and the origin of the seeping fluids.

Isotopic compositions of carbon, hydrogen, and nitrogen of organic matter from bacterial mats will be measured in order to identify the organic matter below bacterial mats emitting a vile smell.

To test a hypothesis that deep subseafloor extremophiles may be transported into the deep-sea water through the fault activity, the 16S rRNA genes of *Thermococcus* will be checked by using seawater samples on the microbial mats and *Calyptogena* colonies.

To test a hypothesis that H_2- and CH_4-enriched deep sedimentary fluids may foster the microbial communities in the shallow sediments and deep seawater, nucleic acid-based analyses and activity measurement using radioactive tracers will be conducted.

To test a hypothesis that turbulent of shallow sediments enriched with H_2S, soluble iron and organics may foster the microbial communities in the deep seawaters, FISH analyses and nucleic acid-based analyses will be performed.

Takeshi Tsuji

以下に示すデータを使って、日本海溝の陸側斜面において、地震に伴って生じたダイナミックな変動を議論する。

・Heat flow と自然ガンマ線から断層運動の活動度を議論。（正断層の部分で高い熱流量）
・海底露頭写真（亀裂など)を使って、地震に伴って引張場が生じたことを示す。
・サブボトムプロファイラーから海底下の構造を調べる。（笠屋さんと）
・バラストの位置から海底地形変動を調べる。

FURUSHIMA, Yasuo

Continuous survey is necessary to monitor physical environment around focal region. Therefore, we will carry out similar survey in future and examine how physical environment changed for time series. In addition, in event area observed in deep-sea bottom (e.g., bacteria mat, distribution of organisms area, etc.), anomaly of physical environmental data is probed. When abnormality was confirmed, we clarify cause of fluctuation. In marine litter survey, we carry out sampling of litter as well as observation by a video image. We clarify organism adhering to litter and we consider about effect to marine ecosystem of marine litter (drift litter and deep sea litter).

WATANABE, Hiromi

- Comparison of species composition among the megafauna

- Species identification of the buried megafauna using DNA
- Genetic diversity and population connectivity analyses of the megafauna

MIYAMOTO, Norio

In the present cruise, we found several changes of deep sea benthic ecosystem probably caused by 3.11 off Tohoku earthquake. In order to evaluate ecological responses after such catastrophic damages on the deep sea ecosystem, we will successively observe the transition of fauna of macrobenthos. We will also analyze the population dynamics of benthic invertebrates, such as echinoderms and mollusks, in order to reveal how animals immigrate into the damaged area and new seeps.

HASEGAWA, Kazunori

Shell-bearing gastropods (both live- and dead-collected),
which were obtained at the depths of 3000-5350 m off Sanriku coast during the present survey,
will be compared with a set of specimens previously collected from the corresponding
areas and deposited in the National Museum of Nature and Science prior to the earthquake.
Precise identification of each species, with habitat information, may elucidate the
changes in the bottom environment.

NOMAKI, Hidetaka

- Faunal and molecular analyses of metazoan meiofauna (Kitahashi and Shimanaga)
- Faunal and molecular analyses of benthic foraminifera (Beatrice, Kitazato and Nomaki)
- Foraminiferal population changes over 100 years (Nomura and Tsujimoto)
- Age determination of sediments using radionuclides (Nomura)
- Viral and microbial numbers in the sediments (Nunoura)
- Microbial communities and porewater chemistry (Nunoura)
- Organic geochemical analyses of sediments (Nomaki)

5. About data

Include any information that may be necessary for analysis and QC planning and secondary use (publications, provisions, etc.)

Notice on Using

Notice on using: Insert the following notice to users regarding the data and samples obtained.
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.