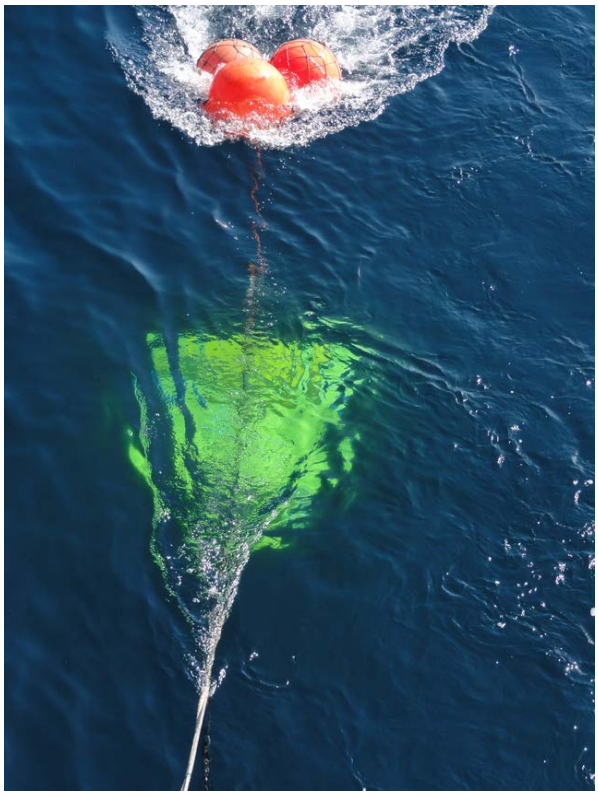
doi : 10.17596/0003008

R/V Natsushima Cruise Report

NT13-21 Leg2



Cruise Proposal

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

20 Oct. 2013 (Shiogama) – 4 Nov. 2013 (Yokosuka)

Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Acknowledgements

We would like to thank Captain Mr. Tanaka and all ship crew of R/V Natsushima for their safe cruise. We appreciate with MARITEC/JAMSTEC staffs for their support during our cruise. This study was supported partly by the Tohoku Ecosystem-Associated Association of Marine Sciences.

NT13-21 Leg2 Cruise report contents

1. Objectives and Cruise summary of NT13-21 Leg2 cruise

Cruise information

Cruise number	NT13-21 Leg2
Name of the vessel	R/V Natsuahima
Chief scientist	Takafumi Kasaya (TEAMS, JAMSTEC)
Representative of the proposal	Yoshihiro Fujiwara (TEAMS, JAMSTEC)
Title of the cruise	Marine Ecosystems Investigation, Impact by the mega-earthquake (the 2011 Earthquake off the Pacific coast of Tōhoku) and Tsunami: For Recover and Rebuild of Sanriku Fisheries Activities
Cruise period	20 Oct. 2013 – 4 Nov. 2013
Ports of call	Shiogama port – Yokosuka port
Research Area	Off Tohoku region (Fig.1)

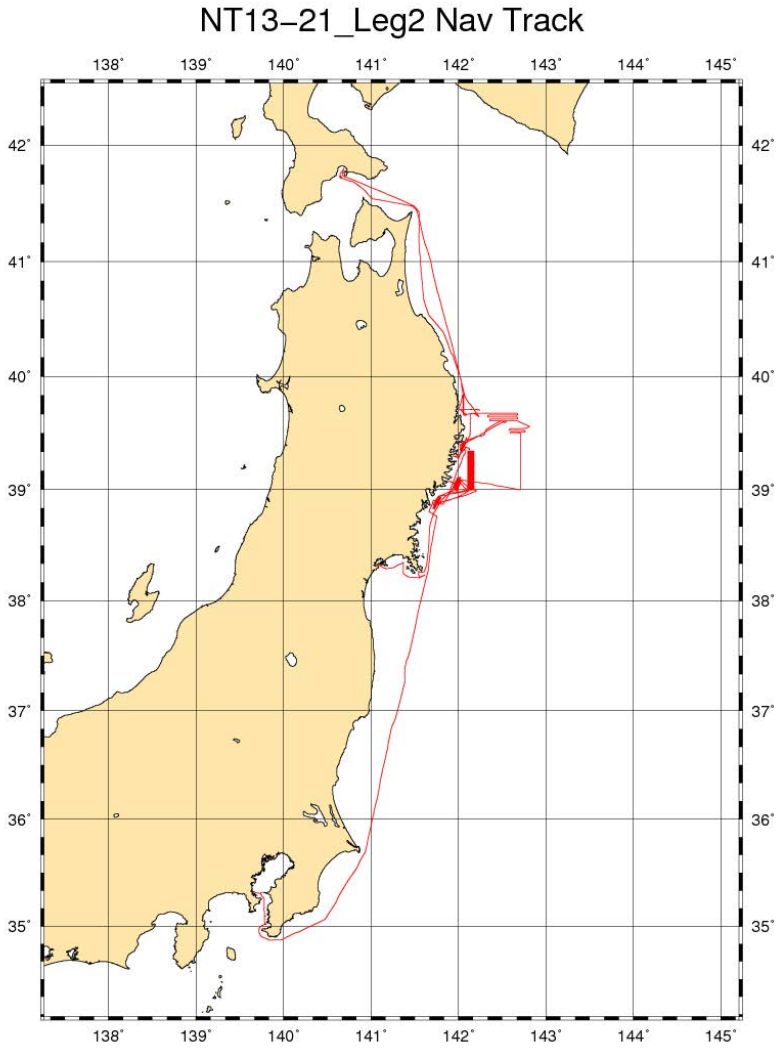


Fig.1 Ship track of this cruise.

Cruise summary

Cruise proposal

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

The purpose of this cruise is to understand the impacts to marine ecosystems by the 2011 Earthquake off the Pacific coast of Tohoku) and Tsunami, and to contribute by marine science aspects to recover and rebuild of Sanriku fisheries activities. Target areas are sea bottom layers off Sanriku. This cruise is conducted under the TEAMS project, namely Tohoku Ecosystem Array of Marine Sciences. Detail investigation subjects are topographic surveys, mapping of scattered debris, distribution patterns and diversity of benthic organisms, seawater and sediments chemical and sediment components. Based on these data and samples, we will construct habitat map for ecosystem management in Sanriku areas. In this leg, we obtained acoustic data to fully understand the recent bathymetry, seafloor condition and sub-bottom structure. To obtain higher accuracy data for correcting the current seafloor condition including marine earthquake debris, we used a towing side scan sonar with 120 kHz and 410 kHz acoustic signals.

2. List of Participant

NAME	
TAKAFUMI KASAYA	JAMSTEC
SHURO YOSHIKAWA	JAMSTEC
AYA NITTA	Yamaguchi University
MITSUTERU KUNO	Nippon Marine Enterprises, LTD
TANAKA HITOSHI	Captain
MASUJIMA HIROAKI	Chief Officer
KATSUMATA MOTOI	2nd Officer
FUJII SYUNSUKE	3rd Officer
KANEDA KAZUHIKO	Chief Engineer
TADOOKA NAOHITO	1st Engineer
IKUTA SHINITI	2nd Engineer
YAMAGUCHI KATSUTO	3rd Engineer
SUDA FUKUO	Chief Electronics Operator
SHIROZUME TAKATOMO	2nd Electronics Operator
TAKAKUWA TATSUHIRO	3rd Electronics Operator
HOSOKAWA SEIJI	Boat Swain
FUJII YOSHITSUGU	Able Seaman
KONNO YASUO	Able Seaman
NAGAI HIROAKI	Able Seaman
KAWAMURA KOSEI	Sailor
NAKANISHI TORU	Sailor
KAWABE YASUNOBU	Sailor
IKEDA TOSHIKAZU	No.1 Oiler
SATO KAZUO	Oiler
TANAKA MASAKI	Oiler
MATSUUCHI RYO	Oiler
SUMITOMO SHOTARO	Oiler
YOSHIKAWA TERUYUKI	Chief Steward
OKADA YOSHIO	Steward
OHBA HIROYUKI	Steward
ITO KEI	Steward
NAKANO MIZUKI	Steward

3. Ship Log

Date	Local Time	Note	Position/Weather/Wind/ Sea condition
20-Oct-13		**Sail out and proceeding to Ishinomaki port**	10/20 12:00 (UTC+9h)
	08:00	Boarded at shiogama port.	38-20.9'N, 141-22.2'E
	09:00	Proceed to Ishinomaki port for avoiding rough sea.	Ishinomaki Port
	10:00-11:00	Briefing about ship's life and safety.	o (Overcast)
	11:00	Arrived at Ishinomaki port.	ENE-2 (Light breeze)
	11:15-12:00	Tested for landing on the water of SSS.	2 (Sea smooth)
21-Oct-13		**Avoiding rough sea**	10/21 12:00 (UTC+9h)
	09:00	Left Ishinomaki port and proceed to research area.	38-20.9'N, 141-22.2'E
	11:00	Turned around off kinkasan for avoiding rough sea.	Off Kinkasan
	11:40	Arrived at Kinkasan.	c (Cloudy)
	15:00	Left off kinkasan and proceed to research area.	ENE-5 (Fresh breeze)
			4 (Sea Moderate)
22-Oct-13		**Avoiding rough sea**	10/22 12:00 (UTC+9h)
	06:00	Arrived at the research area.	39-17.8''N, 141-56.5'E
	08:20	Left the research area and proceed to Ryoishi port for avoiding rough sea.	Ryoishi Port
	09:20	Arrived at Ryoishi port.	o (Overcast)
			NW-4 (Moderate breeze)
			3 (Sea slight)
			3 (Moderate Short)
			Visibly: 8'
23-Oct-13		**SSS and MBES survey**	10/23 12:00 (UTC+9h)
	07:45	Arrived at the research area.	39-17.0'N, 142-00.0'E
	07:54	Released XBT.	Off Sanriku, research
	08:30	Launched SSS.	area
	09:16-11:44	Line 20131023-1 surveyed by SSS.	o (Overcast)
	12:05-14:15	Line 20131023-2 surveyed by SSS.	NNW-3(Gentle breeze)
	14:31	Line 20131023-3 started.	3 (Sea slight)
	15:43	Line 20131023-3 cut off because many fishing gears.	3 (Moderate Short)
	15:44-15:49	Recovered SSS.	
	15:50	Proceed to North of research area.	
24-Oct-13		**SSS and MBES survey**	10/24 12:00 (UTC+9h)
	06:00-07:01	Surveyed fishing gears.	39-57.3'N, 142-01.9'E
	07:18	Released XBT.	Off Sanriku, research
	08:01	Launched SSS.	area
	08:10:09:25	Line 20131024-1 surveyed by SSS.	o (Overcast)
	09:26	SSS control PC was rebooted due to intermittent.	SE-6(Strong breeze)
	09:27-10:51	Line 20131024-2 surveyed by SSS.	4 (Sea Moderate)
	10:58-11:06	Recovered SSS.	4 (Moderate Average)
	11:10-	Proceed to Hakodate port for avoiding rough sea.	Visibly: 7'

25-Oct-13		**Avoiding rough sea**	10/25 12:00 (UTC+9h) 41-48.2'N, 140-41.4'E Hakodate port r (Rain) SE-3(Gentle breeze) 2 (Sea smooth)
	06:40-	Arrived at Hakodate port and started anchoring.	
26-Oct-13		**Avoiding rough sea**	10/26 12:00 (UTC+9h) 41-48.2'N, 140-41.4'E Hakodate port o (Overcast) WNW-4 (Moderate breeze)
		Anchored at Hakodate port for avoiding rough sea.	
27-Oct-13		**Avoiding rough sea**	10/27 12:00 (UTC+9h) 41-48.2'N, 140-41.4'E Hakodate port o (Overcast) WNW-6(Strong breeze) 4 (Sea Moderate)
		Anchored at Hakodate port for avoiding rough sea.	
	15:00-	Proceed to research area.	
28-Oct-13		**SBP ,SSS and MBES survey.**	10/28 12:00 (UTC+9h) 41-48.2'N, 140-41.4'E Off Sanriku, research area bc (Fine but Cloudy) SE-2 (Light breeze) 2 (Sea smooth) 3 (Moderate Short) Visibly: 8'
	06:00-07:35	Arrived at research area and then surveyed fishing gears.	
	07:49	Released XBT	
	08:11-08:16	Launched SBP.	
	08:17-12:15	Line 20131028-01 surveyed by SBP.	
	12:17-12:24	Recovered SBP.	
	13:57-14:08	Launched SSS.	
	14:10-15:41	Line 20131028_SSS-1 surveyed by SSS.	
	15:45-15:59	Recovered SSS.	
	15:59-	Proceed to MBES survey area.	
	16:52-	Started MBES survey.	
	19:24	Released XBT.	
29-Oct-13		**SBP ,SSS and MBES survey.**	10/29 12:00 (UTC+9h) 39-22.5'N, 142-02.5'E Off Sanriku, research area bc (Fine but Cloudy) South-5 (Fresh breeze) 4 (Sea Moderate) 3 (Moderate Short) Visibly: 8'
	-02:30	Finished MBES survey.	
	06:00-07:20	Arrived at research area and then surveyed fishing gears.	
	08:07-08:12	Launched SBP.	
	08:14-09:45	Line 20131029-01 surveyed by SBP.	
	09:50-09:54	Recovered SBP.	
	10:22-10:31	Launched SSS.	
	10:31-11:34	Line 20131029_SSS-1 surveyed by SSS.	
	11:41-12:55	Line 20131029_SSS-2 surveyed by SSS.	
	13:04-13:58	Line 20131029_SSS-3 surveyed by SSS.	
	14:08-15:20	Line 20131029_SSS-4 surveyed by SSS.	
	15:27-15:41	Recovered SSS.	
	15:41-	Proceed to MBES survey area.	
	18:13-	Started MBES survey.	
	19:40	Released XBT	
30-Oct-13		**SSS and MBES survey.**	10/30 12:00 (UTC+9h)

	-02:58	Finished MBES survey.	39-00.9'N, 141-59.2'E Off Sanriku, research area bc (Fine but Cloudy) SW-3(Gentle breeze) 3 (Sea slight) 2(Low swell long) Visibly: 8'
	06:00-07:30	Arrived at research area and then surveyed fishing gears.	
	07:59-08:10	Launched SSS.	
	08:15-09:23	Line 20131030_SSS-1 surveyed by SSS.	
	09:34-11:00	Line 20131030_SSS-2 surveyed by SSS.	
	11:05-12:05	Line 20131030_SSS-3 surveyed by SSS.	
	12:11-13:43	Line 20131030_SSS-4 surveyed by SSS.	
	13:49-14:58	Line 20131030_SSS-5 surveyed by SSS.	
	15:03-15:11	Recovered SSS.	
	15:11-	Proceed to MBES survey area.	
	19:14	Released XBT.	
	19:25	Started MBES survey.	
31-Oct-13		**SSS and MBES survey.**	10/31 12:00 (UTC+9h) 39-02.7'N, 141-58.2'E Off Sanriku, research area bc (Fine but Cloudy) SSW-2 (Light breeze) 2 (Sea smooth) 2(Low swell long) Visibly: 8'
	-05:18	Finished MBES survey.	
	06:00-07:20	Arrived at research area and then surveyed fishing gears.	
	07:55-08:03	Launched SSS.	
	08:05-09:27	Line 20131031_SSS-1 surveyed by SSS.	
	09:35-11:01	Line 20131031_SSS-2 surveyed by SSS.	
	11:11-12:34	Line 20131031_SSS-3 surveyed by SSS.	
	12:41-13:57	Line 20131031_SSS-4 surveyed by SSS.	
	14:05-15:30	Line 20131031_SSS-5 surveyed by SSS.	
	15:40-16:30	Line 20131031_SSS-6 surveyed by SSS.	
	16:31-16:41	Recovered SSS.	
	16:41-	Proceed to MBES survey area.	
	17:43	MBES survey.	
01-Nov-13		**SSS and MBES survey.**	11/1 12:00 (UTC+9h) 38-55.5'N, 141-47.1'E Off Sanriku, research area c (Cloudy) West-3(Gentle breeze) 2 (Sea smooth) 2(Low swell long) Visibly: 8'
	-04:08	Finished MBES survey.	
	06:00-07:10	Arrived at research area and then surveyed fishing gears.	
	07:57-08:05	Launched SSS.	
	08:06-10:11	Line 20131101_SSS-1 surveyed by SSS.	
	10:19-11:47	Line 20131101_SSS-2 surveyed by SSS.	
	11:54-13:54	Line 20131101_SSS-3 surveyed by SSS.	
	14:03-15:29	Line 20131101_SSS-4 surveyed by SSS.	
	15:37-16:30	Line 20131101_SSS-5 surveyed by SSS.	
	16:31-16:41	Recovered SSS.	
	16:41	Proceed to MBES survey area.	
	18:06	Released XBT	
02-Nov-13		**SBP and MBES survey.**	11/2 12:00 (UTC+9h) 38-52.6'N, 141-48.0'E Off Sanriku, research area bc (Fine but Cloudy) SW-2 (Light breeze) 2 (Sea smooth) 2(Low swell long) Visibly: 8'
	-04:45	Finished MBES survey.	
	06:00-07:30	Arrived at research area and then surveyed fishing gears.	
	07:56-08:01	Launched SBP.	
	08:02-09:50	Line 20131102-01 surveyed by SBP.	
	09:13-10:39	Line 20131102-02 surveyed by SBP.	
	10:40-10:43	Recovered SBP and Proceed to next line.	
	11:33-11:37	Launched SBP.	
	11:39-13:30	Line 20131102-03 surveyed by SBP.	
	13:30-13:05	Recovered SBP and Proceed to next line.	
	14:15-14:20	Launched SBP.	
	14:21-15:38	Line 20131102-04 surveyed by SBP.	
	15:39-15:45	Recovered SBP.	
	15:45-	Proceed to Yokosuka.	
03-Nov-13		**Proceed to Yokosuka.**	11/3 12:00 (UTC+9h)

		Proceed to Yokosuka port.	35-13.8'N, 140-35.6'E
			Off Inubouzaki
			c (Cloudy)
			NW-3(Gentle breeze)
			2 (Sea smooth)
			2(Low swell long)
04-Nov-13		**Disembarked at SHIOGAMA**	
	09:00	Disembarked at Yokosuka port.	

4. Instruments

4.1 Side scan sonar

We used the Edgetech 4200-MP side scan sonar system (Fig. 4.1.1) to collect the seafloor condition including the earthquake debris. This system used the full spectrum chirp signal for high resolution and good signal to noise ration. This is also available with two dual simultaneous frequency sets (120 and 410 kHz). The collected sonar data are digitized in the towfish body, and then are transmitted to a deck unit through a coaxial cable with 200 meters. Transmitted data are recorded that the laptop PC installed the Edgetech's control software.

Fig. 4.1.1 Side scan sonar (Edgetech 4200MP)

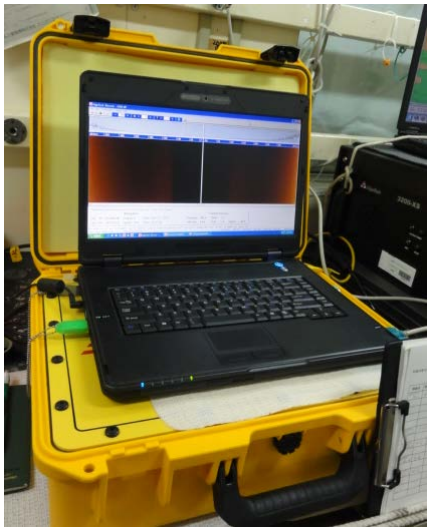


Fig. 4.1.2 Deck unit of a 4200MP system in the control room.

Table 4.1.1 Specification of side scan sonar system

Frequency	120 / 410 kHz
Modulation	Full Spectrum CHIP frequency modulated pluse
Resolution Across Track	100 kHz: 8 cm, 400 kHz: 2cm
Resolution Along Track	100 kHz: 2.m5 @ 200 meter range, 400 kHz: 0.5 @ 100 meter range
Weight in Air/Saltwater	48 / 36 kg (Stainless Steel)
Diameter / Length	11.4 cm / 125.6 cm
Operating Depth	2000 meters

4.2 Sub bottom profiler

To obtain the subsurface image, we used the EdgeTech 3200 sub bottom profiling system (SBP). This system is a full spectrum chirp frequency modulated signal. The SB-512 towed body we choose has the ability to transmit an acoustic signal in a wideband frequency range (0.5 – 12 kHz) with 2 kW output power.

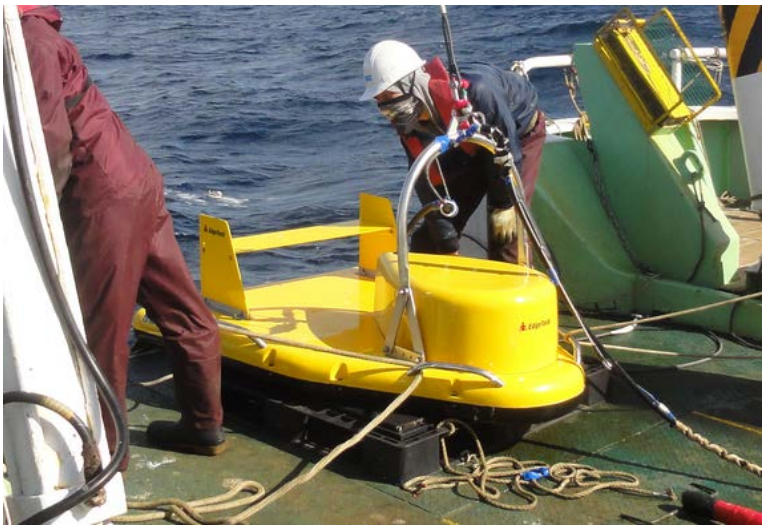


Fig. 4.2.1 Sub bottom profiler (Edgetech 3200 and SB-512i towed body)

Fig. 4.2.2 Deck unit of a sub bottom profiler system in the control room.

Table 4.2.1 Specification of sub bottom profiler system

Modulation	Full spectrum chirp frequency modulation
Frequency range	0.5-12 kHz
Resolution	8-20 cm
Length / Width / Height	1.6 m / 1/24 m / 0.47 m
Weight in Air / in Water	204 kg / 68 kg

5. Operation summary

5.1 Bathymetric survey

The objective of MBES survey is collecting continuous bathymetric data as basic seafloor condition off Tohoku datasets. The “SEABAT 8160” on R/V Natsuahima was used for bathymetry and seafloor mapping during the NT13-21 Leg2 cruise. Bathymetric data were collected by a hull-mounted multi-narrow beam echo sounder “ SEABAT 8160” of the R/V Natsushima. The SEABAT 8160 system used 50 kHz signal and has hydrophone arrays that synthesize narrow, fan-shaped beams. The width of the sea floor mapping in a single swath is generally ca.0.7 times the local water depth, and the resolution of the depth measurement is generally within 0.25 % of the water depth. It can collect up to 126 soundings on each ping cycle over depths varying from 10 to 3,000 meters, providing swath width coverage up to 150°. To get the accurate sound velocity of water column for ray-path correction of acoustic multi-beam signal, we used the deeper depth sound velocity profiles that were calculated from temperature and salinity profiles from XBT data by the equation in Mackenzie (1981) during the cruise. Figure 5.1.1 shows the track lines of bathymetric survey. The preliminary result of bathymetric data is shown Fig. 5.1.2.

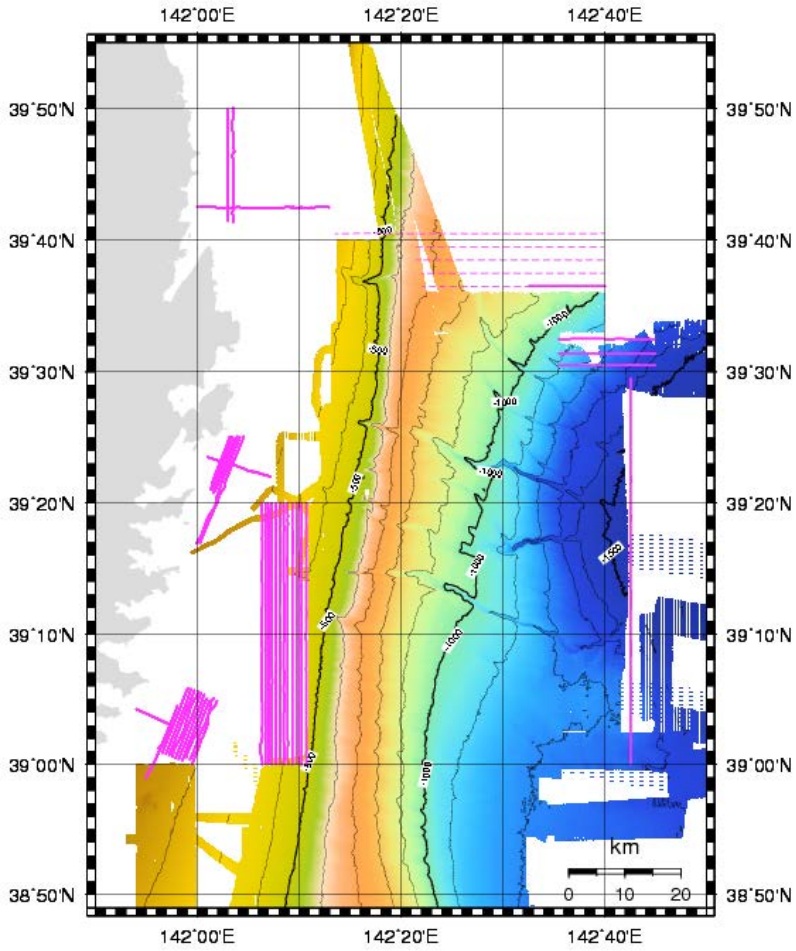


Fig. 5.1.1 Survey lines on this cruise. Dashed lines show survey lines of insufficient quality data. Plotted bathymetric data were the compiled data obtained in previous cruises this project.

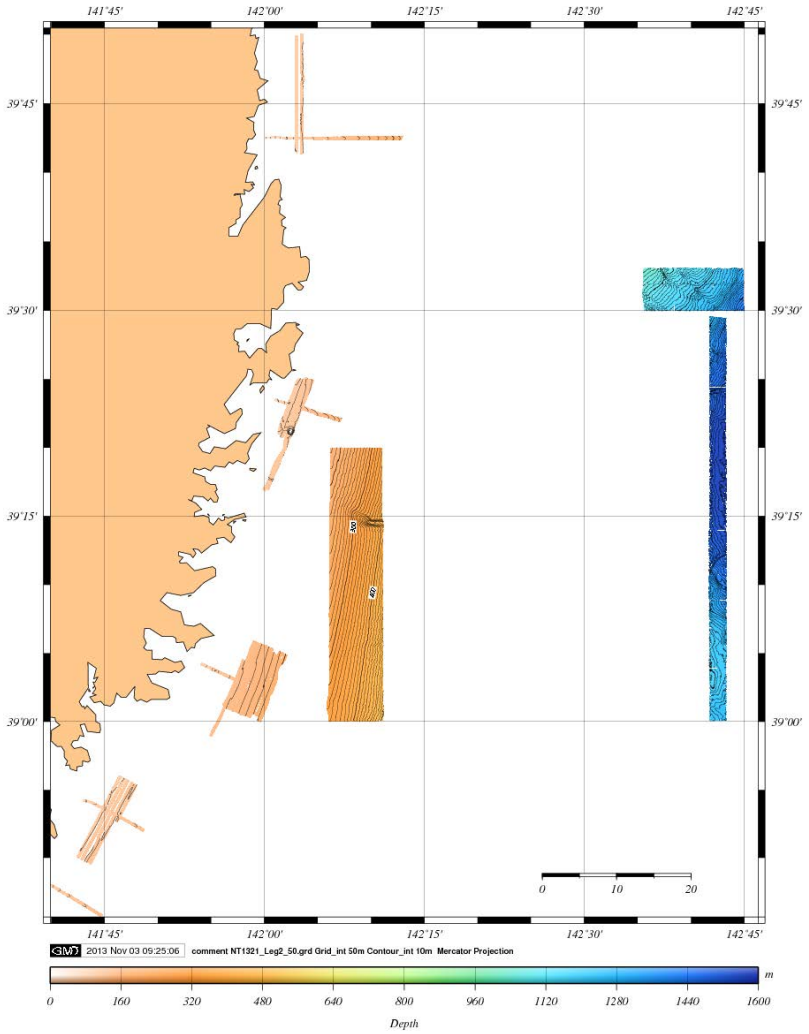


Fig. 5.1.2 Preliminary results obtained MBES data in this cruise.

5.2 Towed side scan sonar and sub bottom profiler survey

5.2.1 Side scan image

To understand the distribution of rubbles, woods, sunken ships, and other concrete wastes transported offshore by backwash of the tsunami, detailed shallow seafloor imagery off the Sanriku Coast was obtained by the towed side scan sonar (SSS). The track lines and its information (e.g. A number of the survey lines) are shown in Fig. 5.2.1.1 to 5.2.1.8, and Table 5.2.1.1, respectively. The illustration of this survey is shown in Fig. 5.2.1.9. The acoustic frequency of the SSS was 120 KHz or 400 KHz. We will analyse the obtained data carefully.

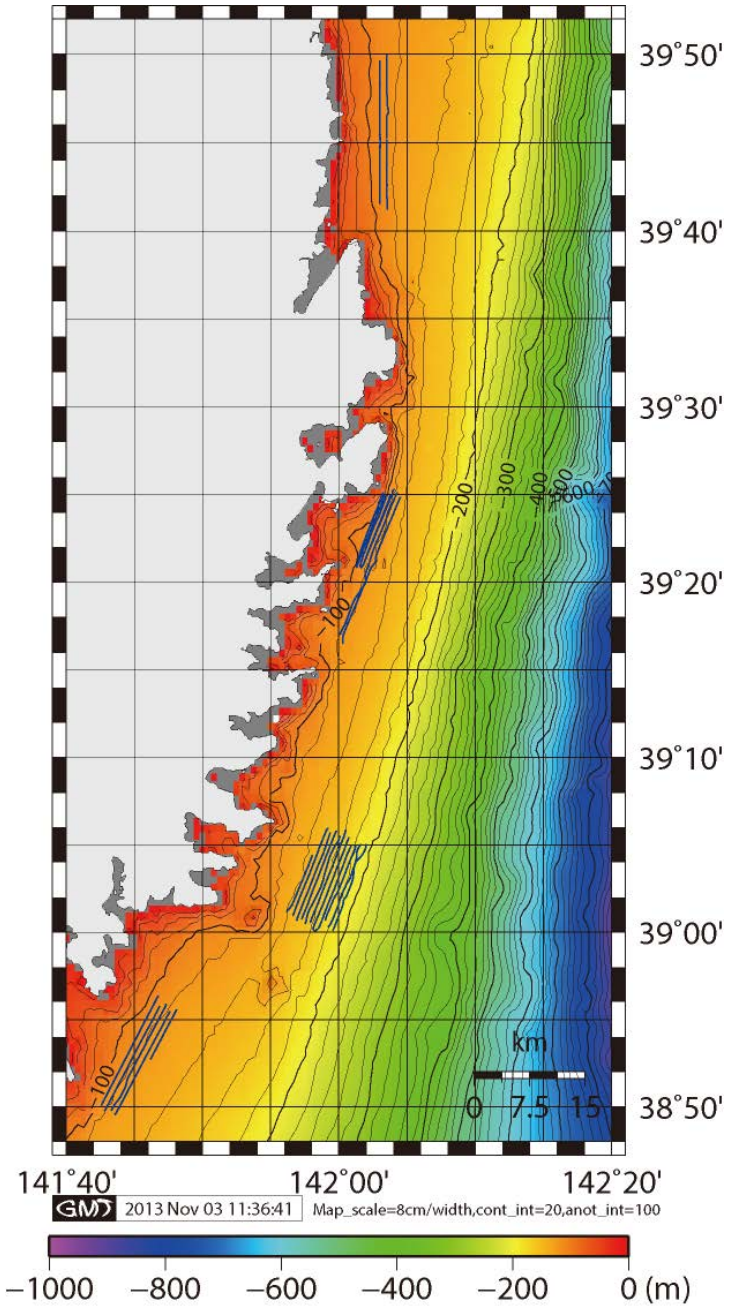


Fig. 5.2.1.1 All track lines (blue) of the SSS survey during this cruise. The J-EGG500 data set by JODC (Japan Oceanographic Data Center) were used as background bathymetric data.

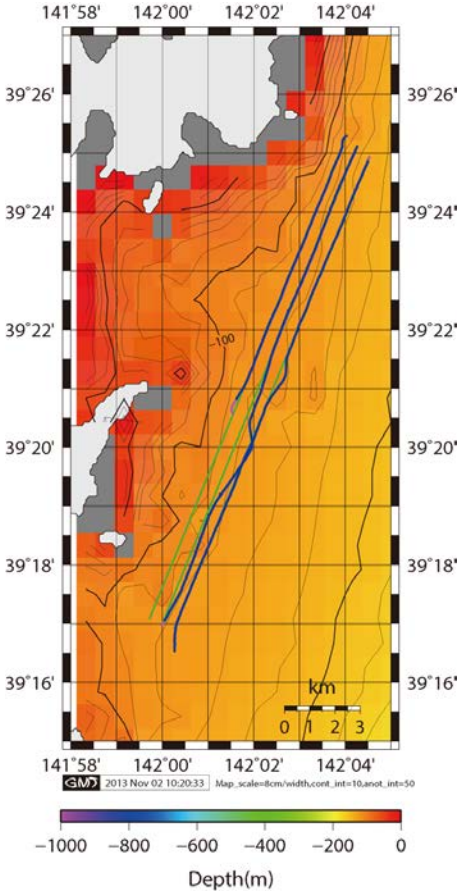


Fig. 5.2.1.2 Track lines (blue) of the SSS survey on 23 Oct. 2013

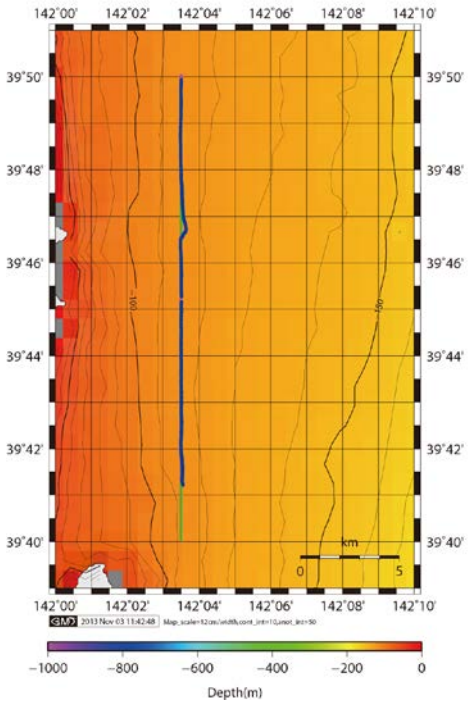


Fig. 5.2.1.3 Track lines (blue) of the SSS survey on 24 Oct. 2013

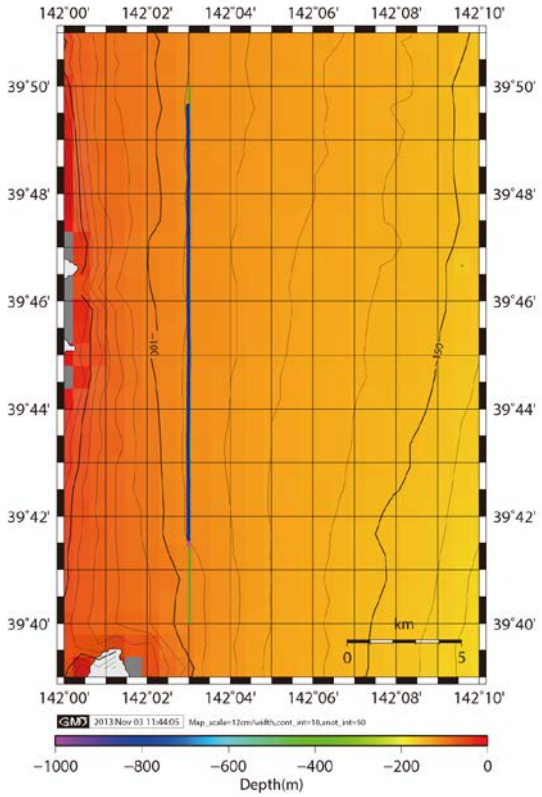


Fig. 5.2.1.4 Track lines (blue) of the SSS survey on 28 Oct. 2013

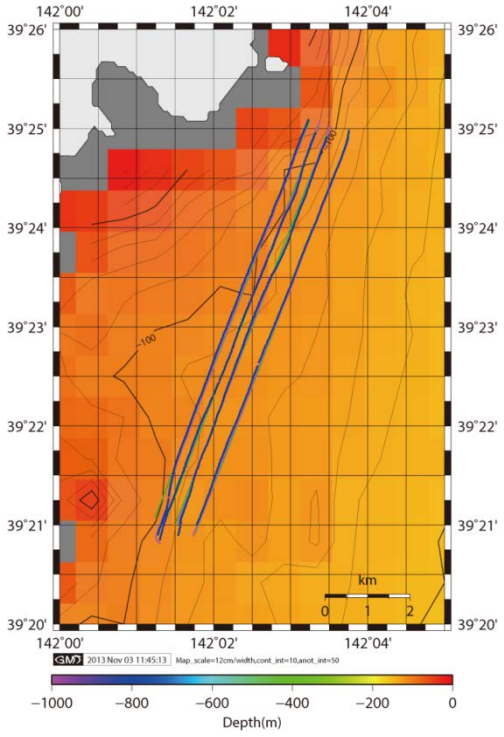


Fig. 5.2.1.5 Track lines (blue) of the SSS survey on 29 Oct. 2013

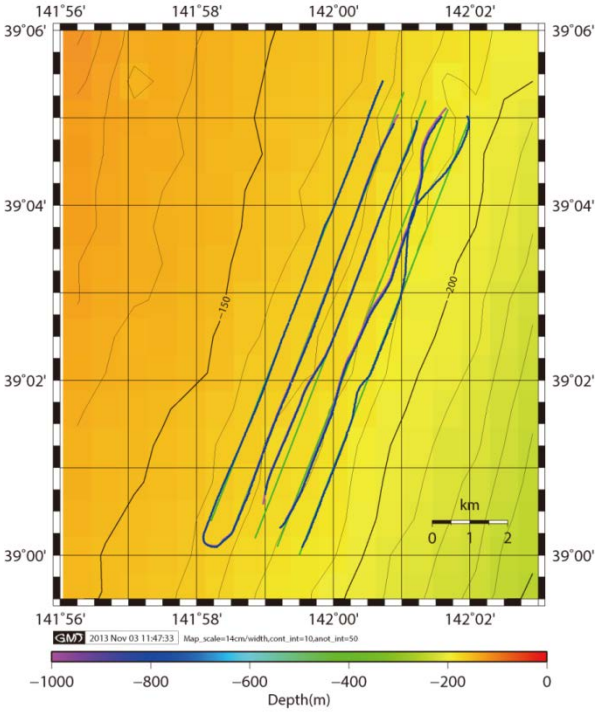


Fig. 5.2.1.6 Track lines (blue) of the SSS survey on 30 Oct. 2013

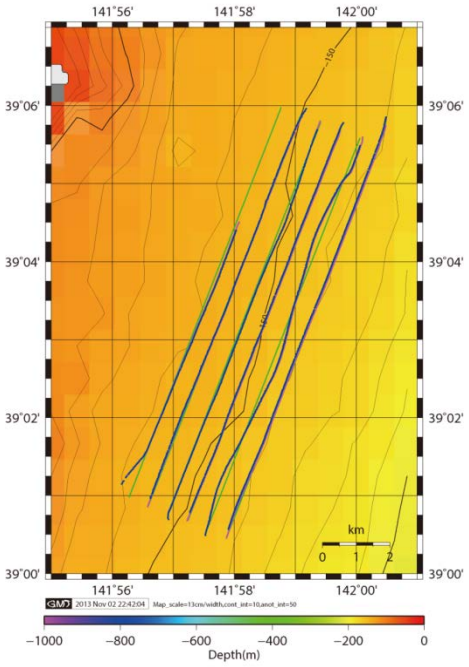


Fig. 5.2.1.7 Track lines (blue) of the SSS survey on 31 Oct. 2013

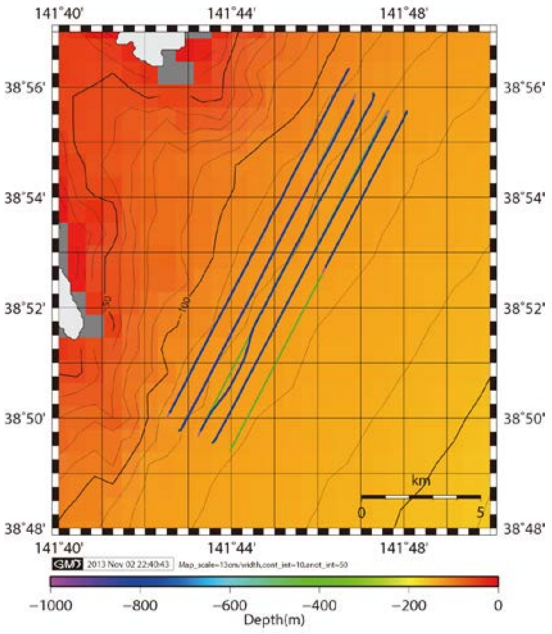


Fig. 5.2.1.8 Track lines (blue) of the SSS survey in 1 Nov. 2013

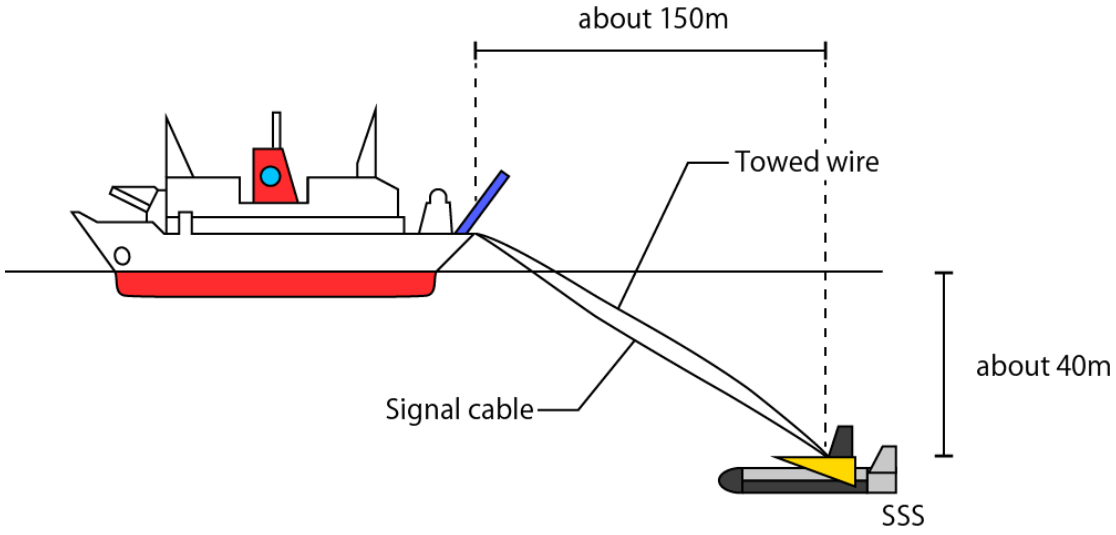


Fig. 5.2.1.9 Illustration of the towed survey using SSS

Table 5.2.1.1 List of the SSS survey lines

Number of the survey line	Start		End		note
	Date[UTC]	Latitude	Date[UTC]	Latitude	
	Time[UTC]	Longitude	Time[UTC]	Longitude	
20131023-1	2013/10/23	39-25.82430N	2013/10/23	39-16.93540N	
	0:05:00	142-04.64070E	2:44:55	141-59.94150E	
20131023-2	2013/10/23	39-16.61510N	2013/10/23	39-24.93030N	
	3:01:00	142-00.25980E	5:15:00	142-04.52920E	
20131023-3	2013/10/23	39-25.22920N	2013/10/23	39-20.57920N	
	5:29:10	142-03.94970E	6:46:40	142-01.54190E	
20131024-1	2013/10/23	39-41.30230N	2013/10/24	39-45.16990N	
	23:10:00	142-03.51420E	0:23:31	142-03.50060E	Data during this line is divided into two files.
	2013/10/24	39-45.33400N	2013/10/24	39-49.97920N	
	0:26:30	142-03.50520E	1:51:07	142-03.50280E	
20131028_SSS-1	2013/10/28	39-49.53010N	2013/10/28	39-41.46200N	
	5:11:00	142-02.99240E	6:41:54	142-03.00490E	
20131029_SSS-1	2013/10/29	39-24.99580N	2013/10/29	39-20.81280N	
	1:31:10	142-03.19360E	2:37:44	142-01.31390E	
20131029_SSS-2	2013/10/29	39-21.00440N	2013/10/29	39-25.01630N	
	2:42:15	142-01.54930E	3:55:00	142-03.51260E	
20131029_SSS-3	2013/10/29	39-24.87760N	2013/10/29	39-20.88440N	
	4:05:00	142-03.74820E	4:58:18	142-01.73250E	
20131029_SSS-4	2013/10/29	39-20.96000N	2013/10/29	39-25.06580N	
	5:07:38	142-01.33380E	6:19:56	142-03.37760E	
20131030_SSS-1	2013/10/29	39-05.31360N	2013/10/30	39-00.37620N	
	23:16:00	142-00.66350E	0:24:05	141-58.16860E	
20131030_SSS-2	2013/10/30	39-00.29360N	2013/10/30	39-05.03870N	
	0:34:05	141-58.54200E	2:00:05	142-00.94740E	
20131030_SSS-3	2013/10/30	39-04.86720N	2013/10/30	39-00.58860N	
	2:05:45	142-01.21170E	3:05:00	141-58.97140E	
20131030_SSS-4	2013/10/30	39-00.40270N	2013/10/30	39-05.11360N	
	3:12:30	141-59.30330E	4:43:53	142-01.65000E	
20131030_SSS-5	2013/10/30	39-04.91720N	2013/10/30	38-59.98320N	
	4:49:15	142-01.98240E	5:58:35	141-59.48120E	
20131031_SSS-1	2013/10/30	39-05.74570N	2013/10/31	39-00.45870N	
	23:05:00	142-00.48210E	0:27:50	141-57.87350E	
20131031_SSS-2	2013/10/31	39-00.60340N	2013/10/31	39-05.60390N	

	0:35:20	141-57.56120E	2:01:18	142-00.10500E	
20131031_SSS-3	2013/10/31	39-05.67550N	2013/10/31	39-00.68100N	
	2:11:00	141-59.73810E	3:34:30	141-57.22800E	
20131031_SSS-4	2013/10/31	39-00.78910N	2013/10/31	39-05.80400N	
	3:41:32	141-56.91400E	4:57:15	141-59.41120E	
20131031_SSS-5	2013/10/31	39-05.85960N	2013/10/31	39-00.85450N	
	5:05:10	141-59.10940E	6:30:25	141-56.57730E	
20131031_SSS-6	2013/10/31	39-01.24510N	2013/10/31	39-04.51170N	
	6:40:00	141-56.22790E	7:30:25	141-58.08350E	
20131101_SSS-1	2013/10/31	38-56.23560N	2013/11/1	38-49.99360N	
	23:06:45	141-46.65110E	1:11:18	141-42.49420E	
20131101_SSS-2	2013/11/1	38-49.85520N	2013/11/1	38-55.86460N	
	1:19:30	141-42.86960E	2:47:42	141-46.88010E	
20131101_SSS-3	2013/11/1	38-55.78160N	2013/11/1	38-49.67980N	
	2:54:54	141-47.27840E	4:54:10	141-43.23450E	
20131101_SSS-4	2013/11/1	38-49.63560N	2013/11/1	38-55.57010N	
	5:03:05	141-43.64250E	6:29:00	141-47.64050E	
20131101_SSS-5	2013/11/1	38-55.45630N	2013/11/1	38-52.64590N	
	6:37:50	141-48.00880E	7:30:30	141-46.12420E	

5.2.2 Sub-bottom profile

The sub-bottom profiler (SBP) was mainly used for the examination of the subsurface geological structures beneath the area where the strong acoustic reflection was recognized on the seafloor by the SSS images. When the reflections arise from the exposure of the concrete fragments and woods etc. transported by the tsunami, the shallow seismic reflector does not correlate with the geological framework in the given region. The SBP data may also provide the sedimentary process in the shallow strata. The track lines and its information are shown in Fig. 5.2.2.1 to 5.2.2.4, and Table 5.2.2.1, respectively. The illustration of this survey is shown in Fig. 5.2.2.5.

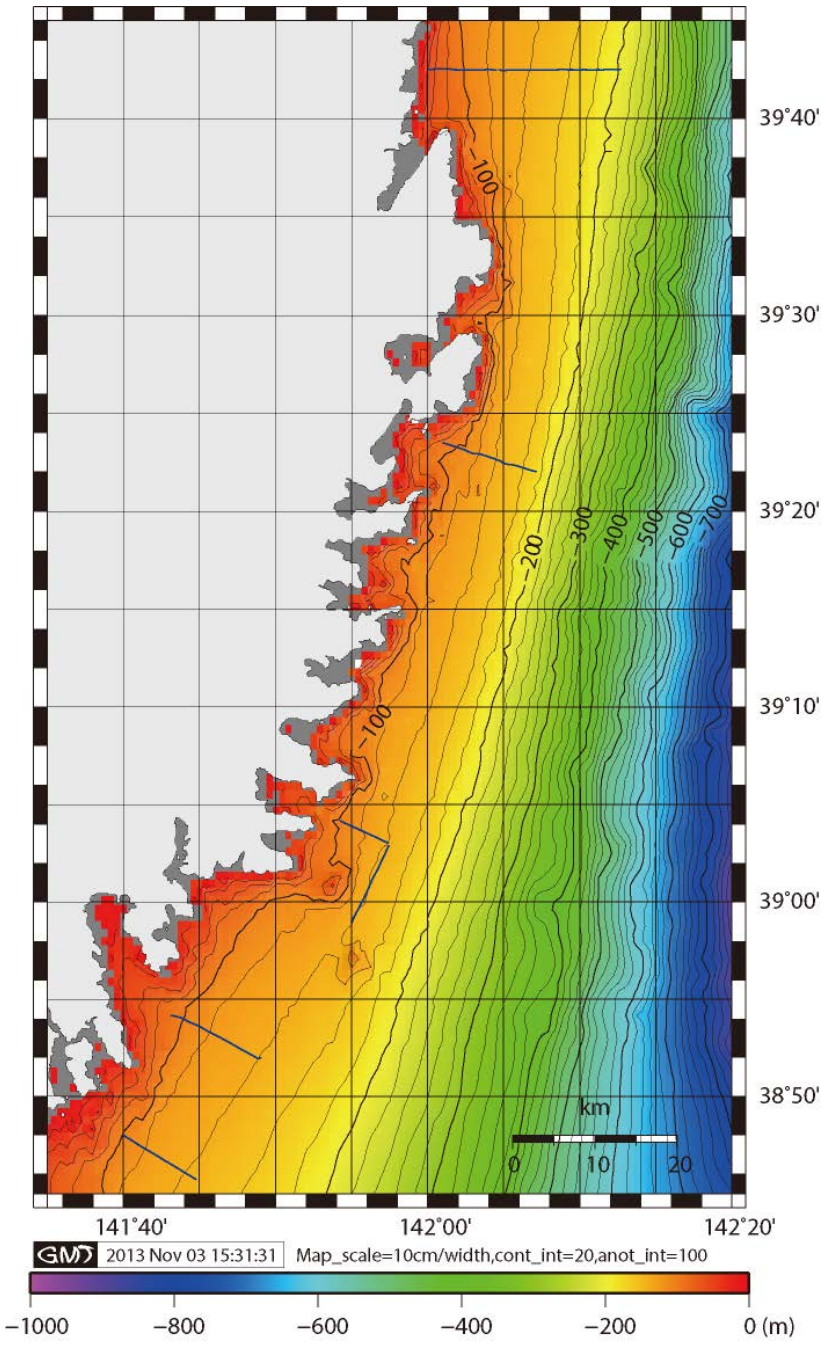


Fig. 5.2.2.1 All track lines (blue) of the survey using SBP during this cruise

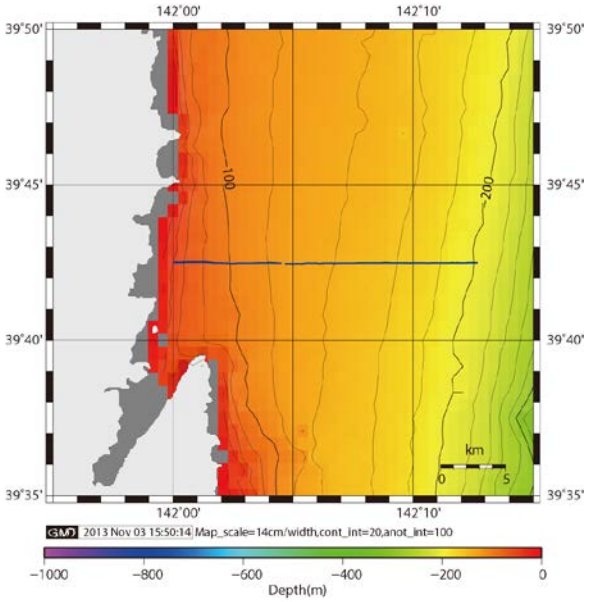


Fig. 5.2.2.2 Track lines (blue) of the survey using SBP on 28 Oct. 2013

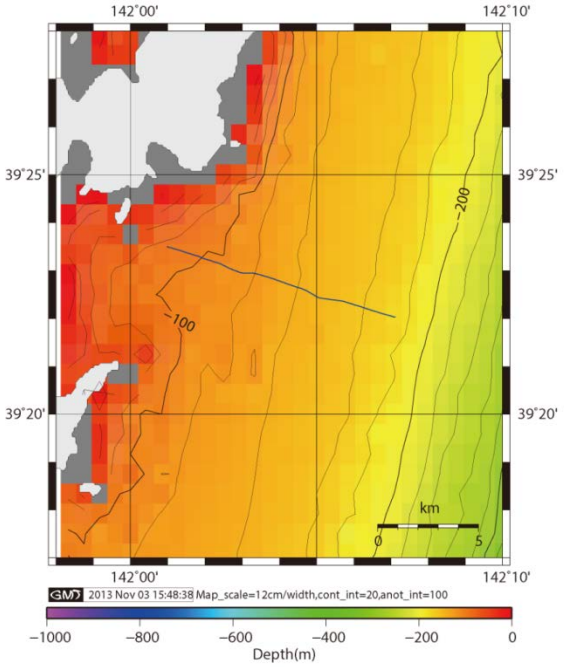


Fig. 5.2.2.3 Track lines (blue) of the survey using SBP on 29 Oct. 2013

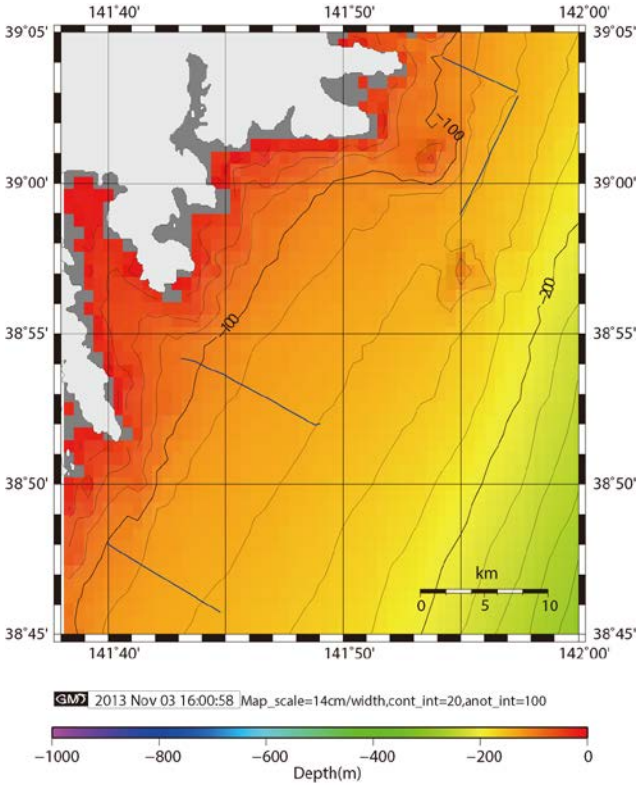


Fig. 5.2.2.4 Track lines (blue) of the survey using SBP on 2 Nov. 2013

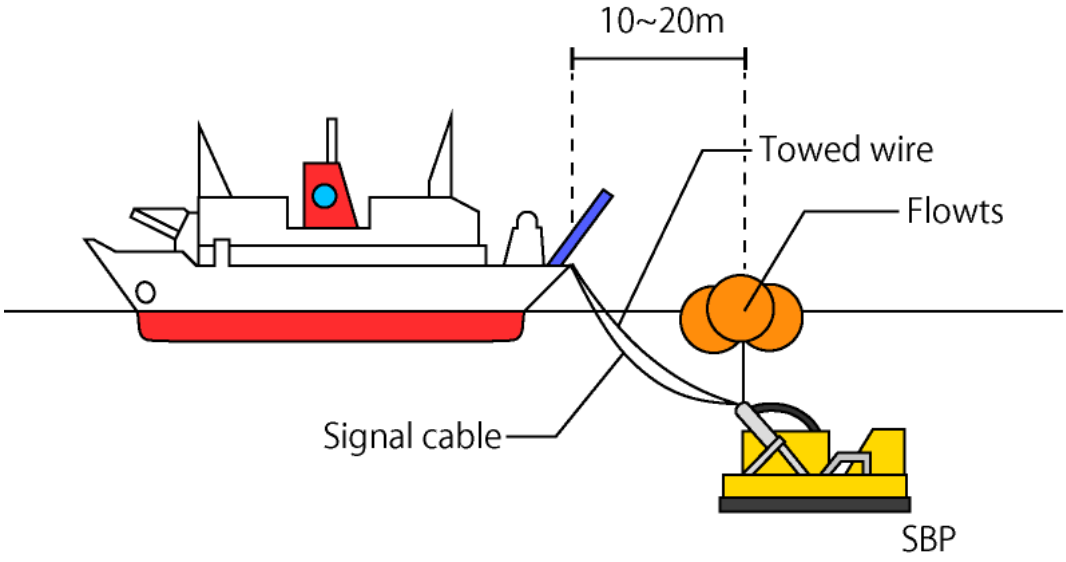


Fig. 5.2.2.5 Illustration of the towed survey using SBP

Table 5.2.2.1 List of the SBP survey lines

Number	Start		End		Note
	Date[UTC]	Latitude	Date[UTC]	Latitude	
	Time[UTC]	Longitude	Time[UTC]	Longitude	
20131028-01	2013/10/27	39-42.50480N	2013/10/28	39-42.47610N	Data during this line is divided into two files.
	23:23:00	142-12.66250E	1:54:12	142-04.67730E	
	2013/10/27	39-42.48560N	2013/10/28	39-42.51350N	
	1:57:33	142-04.49420E	3:14:28	142-00.01640E	
20131029-01	2013/10/28	39-22.02820N	2013/10/29	39-23.50130N	
	23:15:30	142-07.11540E	0:46:01	142-00.98620E	
20131102-01	2013/11/1	39-04.16600N	2013/11/2	39-03.03620N	
	23:06:10	141-54.23240E	0:09:50	141-57.39210E	
20131102-02	2013/11/2	39-02.89110N	2013/11/2	38-58.97600N	
	0:13:30	141-57.44240E	1:39:10	141-54.97080E	
20131102-03	2013/11/2	38-52.00840N	2013/11/2	38-54.17480N	
	2:39:00	141-49.01700E	4:30:00	141-43.10270E	
20131102-04	2013/11/2	38-48.04450N	2013/11/2	38-45.74850N	
	5:21:00	141-39.96210E	6:39:15	141-44.75990E	

Appendix

A.1 R/V Natsushima

R/V Natsushima

Ocean research vessel Natsushima has been built as a support vessel of submersible SHINKAI 2000 in 1980s. R/V Natsushima was reconstructed as a support vessel of Hyper Dolphin.

General information about NATSUSHIMA

Length:67.4m Bow thruster: 4T/1.4T×220kw/110kw×1 1
Width:13.0m Maximum speed:12.0kt
Depth:6.3m Duration:5000 mile
Max capacity: 55 persons (18 scientists)
Gross Tonnage:1739t
Main prop: Variable pitch propeller 2 axis×4 Wing CPP,540N

Research equipment

(1) MBES

Bathymetric data were collected by the SEABAT 8160 (RESON). The SEABAT is a multibeam survey system that generates data for and produces wide-swath contour maps and side scan images. It transmits a sonar signal from projectors mounted along the keel of the ship. The sonar signal travels through the sea water to the seafloor and is reflected off the bottom. Hydrophones mounted across the bottom of the ship receive the reflected sonar signals. The system electronics process the signals, and based on the travel time of the received signals as well as signal intensity, calculate the bottom depth and other characteristics such as S/N ratio for echoes received across the swath. Positioning of depths on the seafloor is based on GPS and ship motion input. The data is logged to the hard disk for post processing which allows for additional analysis. Plotters and side scan graphic recorder are also included with system for data recording and display.

Max depth: 3000 m
Frequency: 50 kHz
Number of beams: 126
Swath angle: 150 degree (depend on depth)
Each beam width: 1.5 x 1.5, 3.0, 4.5, or 6.0 degree
Minimum resolution: 1.4, 2.9, 8.9 cm (depend on above beam width)
Maximum transmit rate:15 ping/sec

(2) PDR

This can record a water depth at right below and make contour map together with navigation data.

Max depth: more than 3000m
Record Range: 200～800m (changeable)
Frequency: 12kHz +/-5%

Output: more than110dB (0dB unbar at 1m)
Directivity: conical beam pattern
Beam width: 15deg. +/-5 deg. (-3dB)
Pulse width: 1, 3, 10, 30msec

(4) XBT equipment

XBT profile a vertical water temperature by free-fall probe.
Maximum measurable depth:1830m
Measure range:-2 deg.～+35 deg.

(5) Navigation equipment

Position of the ship is measured by DGPS within about 3m error. ROV and transponder are measured by acoustic positioning system.

(6) Laboratory

There are laboratories at the back part of second deck. Each room has AC100V power supply and LAN. The video of HPD diving and deck-camera video are distributed to the laboratories and every cabin.

・Second laboratory: There are two desktop PCs (windows and Mac), equipment for video editing, color copy with printer, meeting desk and white board. Hi-definition video of HPD is distributed to this laboratory. You can copy from a digital ßcam and S-VHS to S-VHS/VHS, Hi8 and DV.

・Third laboratory: There are two sinks, refrigerator (-80deg. low temperature refrigerator, Incubator, domestic refrigerator, ice maker, ice crasher) and reagent water system (ORGANO, Milli-QSPTOC). And sea water for experiment is supply to the sink.

・Dry laboratory: There are a work desk and a shelf for baggage. This room has 4 beds to be used as a private one in case that there are many researchers.

At the work deck, there are rock-cutter rooms

・Rock-cutter room: There are a rock cutter and two grinders. And exclusive video player is set to describe rocks with playing video of ROV diving.