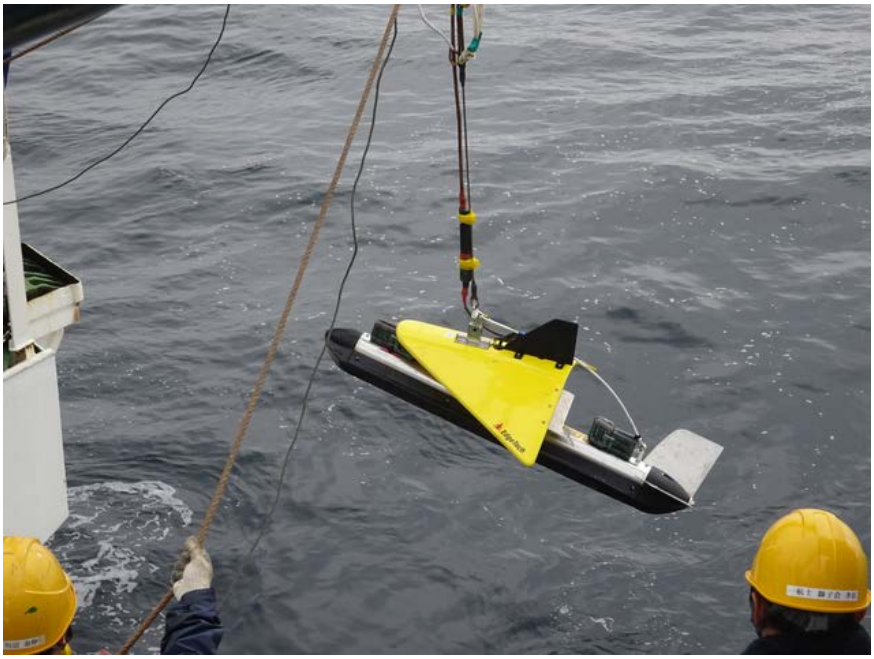
doi : 10.17596/0002849

R/V Natsushima Cruise Report

NT15-06



Cruise Proposal

Elucidation of the marine ecosystem fluctuation mechanism in the Sanriku offshore area

3 Apr. 2015 (Yokosuka) – 13 Apr. 2015 (Sendai Shiogama)

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

Acknowledgements

We would like to thank Captain Mr. Ukekura 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.

NT15-06 Cruise report contents

1. Objectives and Cruise summary of NT15-06 cruise

Cruise information

Cruise number	NT15-06
Name of the vessel	R/V Natsushima
Chief scientist	Takafumi Kasaya (TEAMS, JAMSTEC)
Representative of Scientice Party	Shinji Tsuchida (TEAMS, JAMSTEC)
Title of the cruise	

Elucidation of the marine ecosystem fluctuation mechanism in the Sanriku offshore area

Cruise period	3 Apr.2015 – 13 Apr. 2015
Ports of call	Yokosuka port – Sendai-Shiogama port
Research Area	Off Tohoku region (Fig.1)

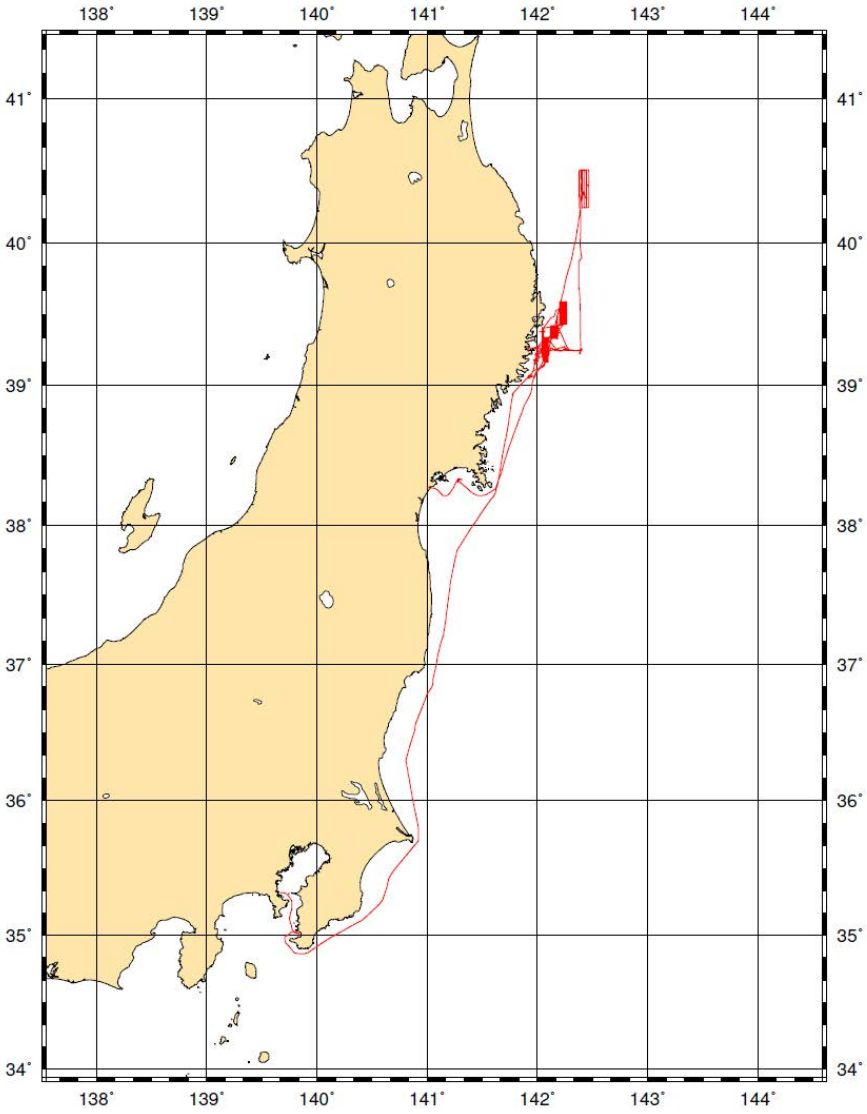


Fig.1 Ship track of this cruise.

Cruise summary

Cruise proposal

Elucidation of the marine ecosystem fluctuation mechanism in the Sanriku offshore area

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. 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. Moreover, the synthetic aperture sonar (SAS) system developed by JAMSTEC was also used around the shallow area to obtain very fine acoustic images of seafloor. We also conducted the shipboard MBES survey.

2. List of Participant

Scientists

Takafumi KASAYA	JAMSTEC
Takao SAWA	JAMSTEC
Shinpei GOTOH	JAMSTEC
Tatsuro IMAI	MARIMEX JAPAN K.K.
Kunihiko NAKATSUKA	SAS CO.,LTD

Marine Technician

Satomi MINAMIZAWA	Nippon Marine Enterprises, LTD.

R/V NATSUSHIMA Crew

Captain	EIKO UKEKURA
Chief Officer	TAKAAKI SHISHIKURA
2nd Officer	SHOZO FUJII
3rd Officer	TOMOAKI YUKAWA
Chief Engineer	TADASHI ABE
1st Engineer	YOSHINOBU HIRATSUKA
2nd Engineer	KENICHI SHIRAKATA
3rd Engineer	KAZUKI ONO
Chief Electronics Operator	YOHEI YAMAMOTO
2nd Electronics Operator	HIROKI ISHIWATA
3rd Electronics Operator	TAKAYUKI MABARA
Boat Swain	HATSUO ODA
Able Seaman	SHUICHI YAMAMOTO
Able Seaman	HIROAKI NAGAI
Able Seaman	YOSHIAKI MATSUO
Able Seaman	TORU NAKANISHI
Sailor	YASUNOBU KAWABE
Sailor	TOSHIYA SAGA
No.1 Oiler	KEITA FUNAWATARI
Oiler	MASAKI TANAKA
Oiler	EIJI ARATAKE
Oiler	SHOTARO SUMITOMO
Oiler	DAIKI SATO
Chief Steward	TOYONORI SHIRAISHI
Steward	SHINSUKE TANAKA
Steward	AKIO SUZUKI
Steward	SHINOBU OYU
Steward	KOICHIRO KASHIWAGI

3. Ship Log

2015/4/3 Off SUSAKI (35-01.2N, 139-47.5E)

Weather: Overcast / Wind direction: SSE / Wind force: 6/ Wave scale: 3 /

Swell scale: 2 / Visibility: 3 miles (12:00 JST)

09:00 onboard

10:00 let go all shore line, left YOKOSUKA, proceeded to TATEYAMA- WAN due to forecast rough sea

10:30-11:10 carried out education and training for scientist

12:30 let go starboard anchor at TATEYANA WAN

2015/4/4 Off KATSUURA (Chiba) (35-06.0N, 140-22.4E)

Weather: Cloudy / Wind direction: NE/ Wind force: 7 Wave scale: 5 /

Swell scale: 4 / Visibility: 3 miles (12:00 JST)

0630 hove up starboard anchor then proceeded to research area

2015/4/5 Off KESENNUMA (38-54.5N, 141-46.4E)

Weather: Rain / Wind direction: NE / Wind force: 3/ Wave scale: 2 /

Swell scale: 2 / Visibility: 2 miles (12:00 JST)

12:10 arrived at research area (Off SANRIKU)

12:12 released XBT @ 38-55.6043N, 141-46.4465E

12:23-15:12 carried out towing Synthetic Aperture Sonar (SAS)

18:50 released XBT @ 39-19.7321N, 142-10.2467E

18:57 commenced to MBES mapping survey

2015/4/6 Off SANRIKU (39-22.0N, 142-11.0E)

Weather: Fine but cloudy / Wind direction: SE / Wind force: 4 / Wave scale: 2 /

Swell scale: 2 / Visibility: 8 miles (12:00 JST)

08:20 released XBT @ 39-10.6118N, 142-05.7501E

09:28 finished MBES mapping survey

09:58-11:14 carried out towing Side Scan Sonar (SSS)

11:34-12:47 carried out towing SSS

13:54-16:20 carried out towing SSS

16:59 commenced to MBES mapping survey

2015/4/7 Off SANRIKU (39-03.5N, 141-55.5E)

Weather: Overcast / Wind direction: East / Wind force: 3/ Wave scale: 2 /

Swell scale: 1 / Visibility: 7 miles (12:00 JST)

07:04 released XBT @ 39-09.9500N, 142-02.9704E

07:05 finished MBES mapping survey

07:44 released XBT @ 39-03.9015N, 141-58.8425E

07:51-08:09 carried out MBES site survey

09:29-14:54 carried out towing SAS

15:00 commenced to proceeding to research area C (Off KUJI-WAN)

2015/4/8 Off SANRIKU (40-20.5N, 142-25.0E)

Weather: Fine but cloudy / Wind direction: North / Wind force: 4/ Wave scale: 2 /

Swell scale: 1 / Visibility: 8 miles (12:00 JST)

00:00 arrived at research area C (Off KUJI-WAN)

01:53-07:00 carried out MBES site survey

05:46 released XBT @ 40-29.9833N, 142-25.5703E

08:59-11:04 carried out towing SSS

11:24-13:13 carried out towing SSS

13:34-22:58 carried out MBES mapping survey

22:58 proceeding to research area D (Off Ohtsuchi-WAN)

2015/4/9 Off SANRIKU (39-15.0N, 142-19.5E)

Weather: Fine but cloudy / Wind direction: NNE / Wind force: 3/ Wave scale: 2 /

Swell scale: 1 / Visibility: 8 miles (12:00 JST)

03:51 arrived at research area D (Off Ohtsuchi-WAN)

06:02-06:48 carried out MBES site survey

0738 released XBT @ 39-15.2008N, 142-23.7045E

08:43-15:00 carried out towing SSS

16:00 released XBT @ 39-13.4157N, 142-01.2666E

16:06-17:16 carried out MBES site survey

18:41 released XBT @ 39-25.9732N, 142-11.9596E

18:42 commenced to MBES mapping survey

2015/4/10 Off SANRIKU (39-12.5N, 142-00.0E)

Weather: Mist / Wind direction: SE / Wind force: 2/ Wave scale: 2 /

Swell scale: 2 / Visibility: 1 mile (12:00 JST)

04:56 finished MBES mapping survey

08:30-09:46 carried out towing SAS

10:02-13:30 carried out towing SAS

14:15-17:39 carried out MBES site survey

15:42 released XBT @ 39-20.1659N, 142-02.9189E

18:35 commenced to MBES mapping survey

2015/4/11 Off SANRIKU (39-22.5N, 142-02.5E)

Weather: rain / Wind direction: North / Wind force: 4/ Wave scale: 2 /

Swell scale: 1 / Visibility: 3 miles (12:00 JST)

03:22 finished MBES mapping survey

04:47-05:25 carried out MBES site survey

08:29-12:46 carried out towing SAS

13:00 proceeded to SHIOGAMA WAN due to forecast rough sea

14:15 let go starboard anchor at SHIOGAMA WAN

2015/4/12 Off SANRIKU (39-16.0N, 142-08.0E)

Weather: Fine but cloudy / Wind direction: SSE / Wind force: 2/ Wave scale: 2 /
Swell scale: 1 / Visibility: 8 miles (12:00 JST)

0600 hove up starboard anchor then proceeded to research area

0730 arrived at research area D (Off Ohtsuchi-WAN)

08:16 released XBT @ 39-14.4699N, 142-13.6939E

08:30-12:12 carried out towing SSS

12:30 commenced proceeding to SENDAI-SHIOGAMA KO

2015/4/13 Arrive at SENDAI-SHIOGAMA KO

08:00 arrived at SENDAI-SHIOGAMA KO

10:00 disembarked NATSUSHIMA

finished NT15-06 cruise

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 the laptop PC installed the Edgetech's control software.

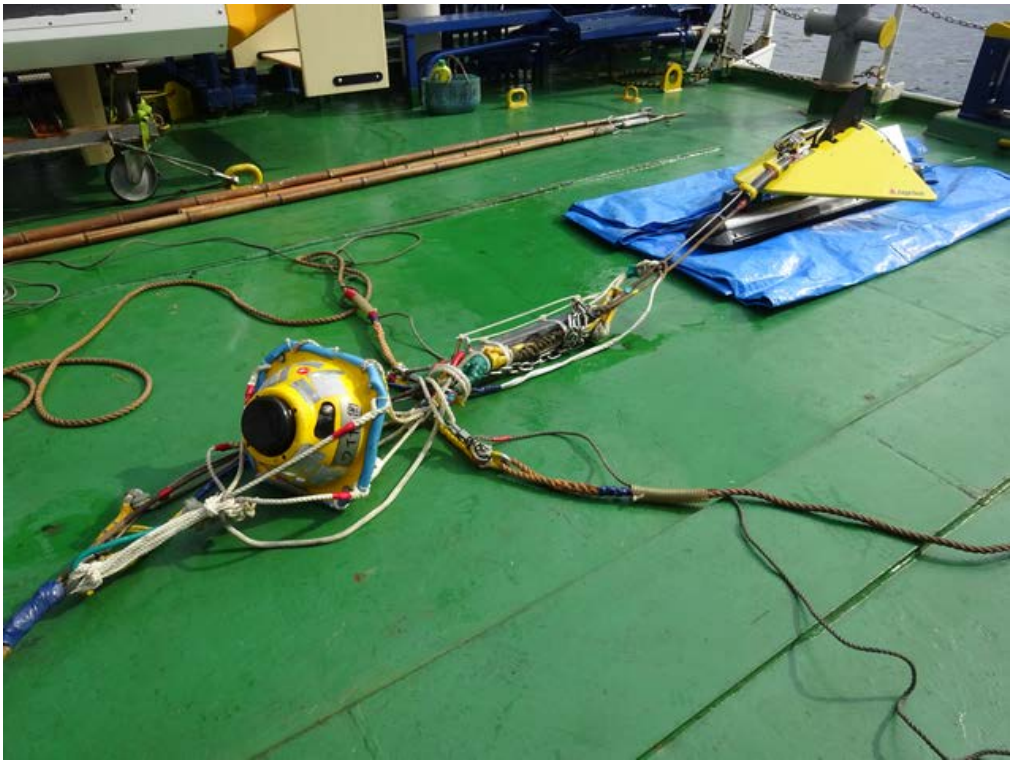


Fig. 4.1.1 Side scan sonar (Edgetech 4200MP) and transponder.

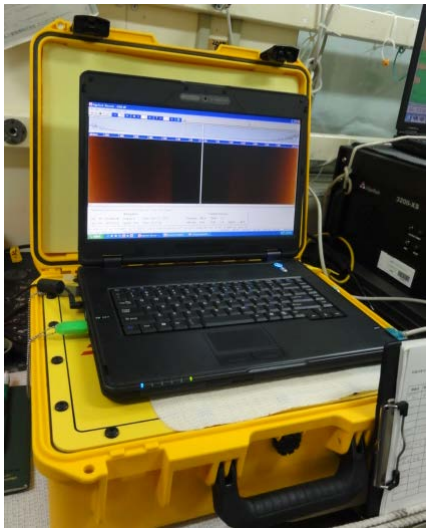


Fig. 4.1.2 Deck unit of a 4200MP system in the control room.

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 Synthetic aperture sonar

To conduct high accuracy survey and distinguish earthquake debris or not in the survey map correctly, we used a synthetic aperture sonar (SAS) system developed by JAMSTEC. This system has the ability to detect double far objects and generate over tenth detail image than conventional side scan sonar. In addition, a motion compensation on array signal processing achieves making stabilized image in bad weather condition when sonar systems is rocked.

The synthetic aperture sonar consist of two TX-RX array transducer, two RX long array receiver, cylinder for underwater electronics and onboard control PC. The TX-RX array transducer sends chirp pulses under controlling vertical beam width and directivity, and receives echo like a multi-beam echo sounder. The RX array is used to synthesize long aperture.

An original neutral buoyancy tow-fish (Fig. 4.2.1) is used to load the SAS in this cruise to avoid waves and bubbles near sea surface. The SAS on the tow-fish was towed by mother ship.

Fig. 4.2.1 Photo of synthetic aperture sonar

Table 4.2.1 Specification of the synthetic aperture sonar system with the original tow-fish

Synthetic Aperture Sonar	
Operating depth	Max. 3000 m
Weight	80 kg without tow-fish
Wave frequency	101.5-106.5 kHz
Pulse width	10 msec
Receiver	8 ch 70 deg. vertical directivity, 0.6 deg. horizontal directivity over -178 dB for 100-120 kHz, in each elements
Projector	4 ch 35-70 deg. vertical directivity, 5 deg. horizontal directivity
Resolutions	Max. 0.14 m in both of range and azimuth
Range	Over 375 m without synthesizing process
Neutral buoyancy tow-fish	
Weight	250 kg in air
Tow speed	3 kt @ cruising, Max.5 kt
On-board processor	
OS	Windows server 2008
Programming language	Matlab with parallel computing toolbox and C#

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 this 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.

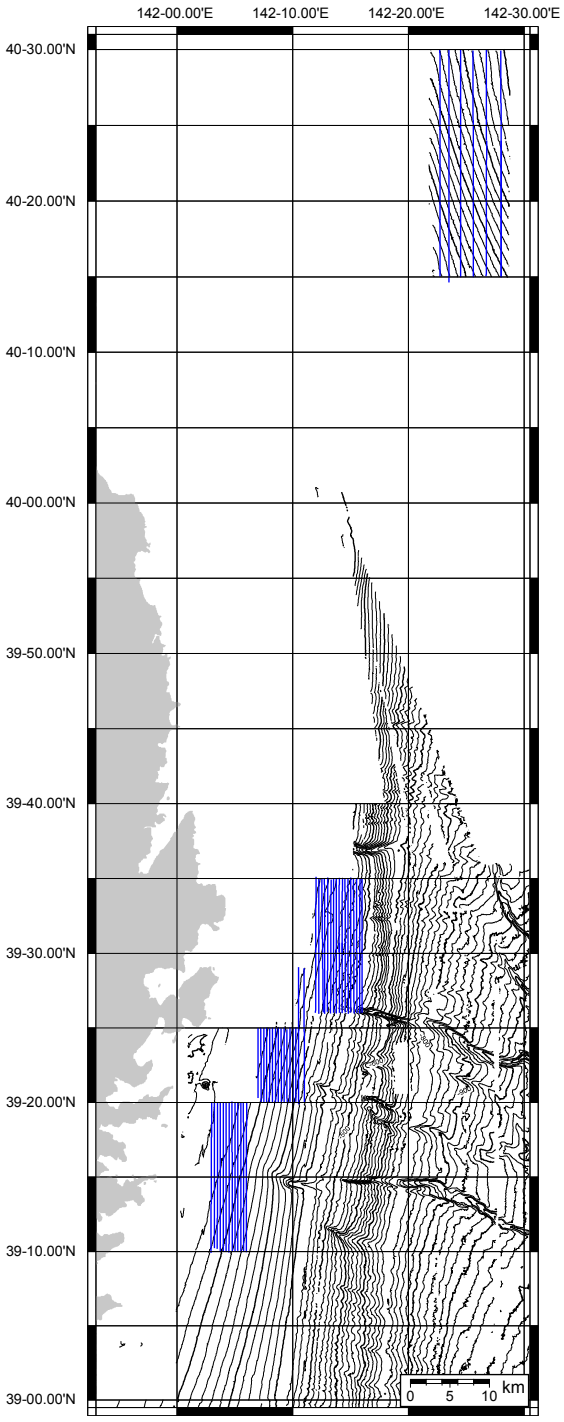


Fig. 5.1.1 Survey lines on this cruise. Dashed lines show survey lines of insufficient quality data. Plotted bathymetric data were the compiled data obtained in previous cruises this project.

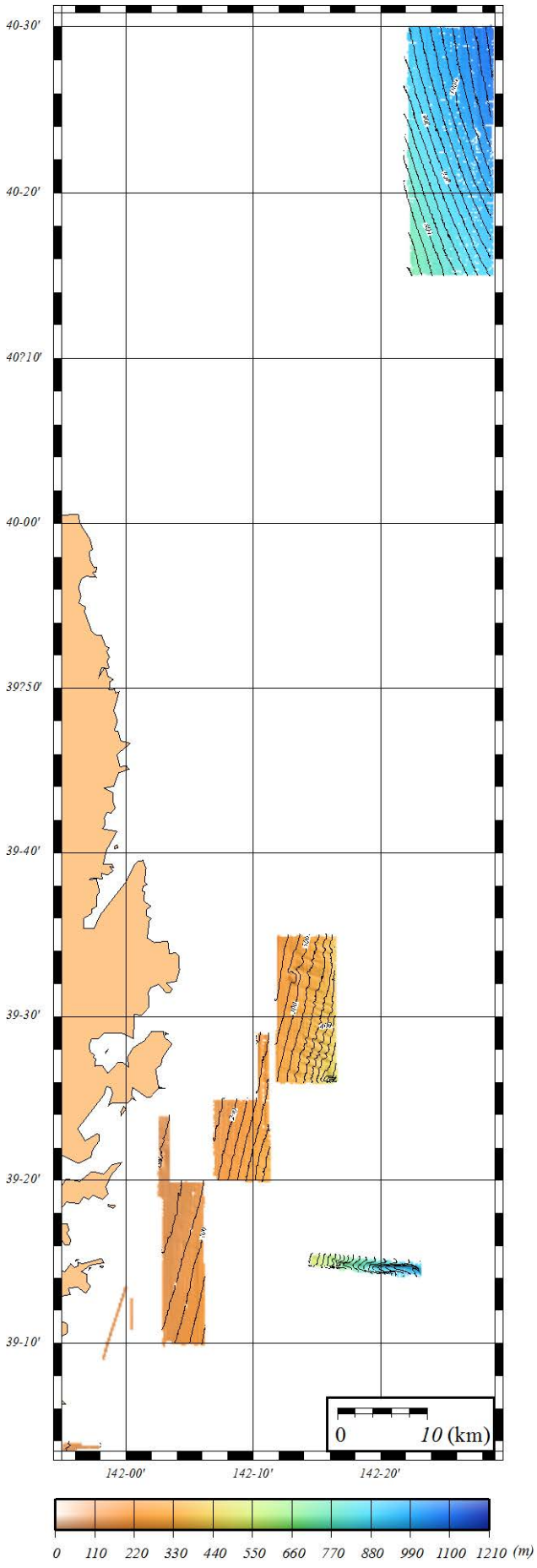


Fig. 5.1.2 Preliminary results obtained MBES data in this cruise.

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). In this cruise, we used the electric winch cable system to tow a sonar at the depth of 1000m (Fig. 5.2.1.6). The track lines and its information (e.g. A number of the survey lines) are shown in Fig. 5.2.1.2 to 5.2.1.5, respectively. The acoustic frequency of the SSS was 120 KHz or 400 KHz. We will analyze the obtained data carefully.

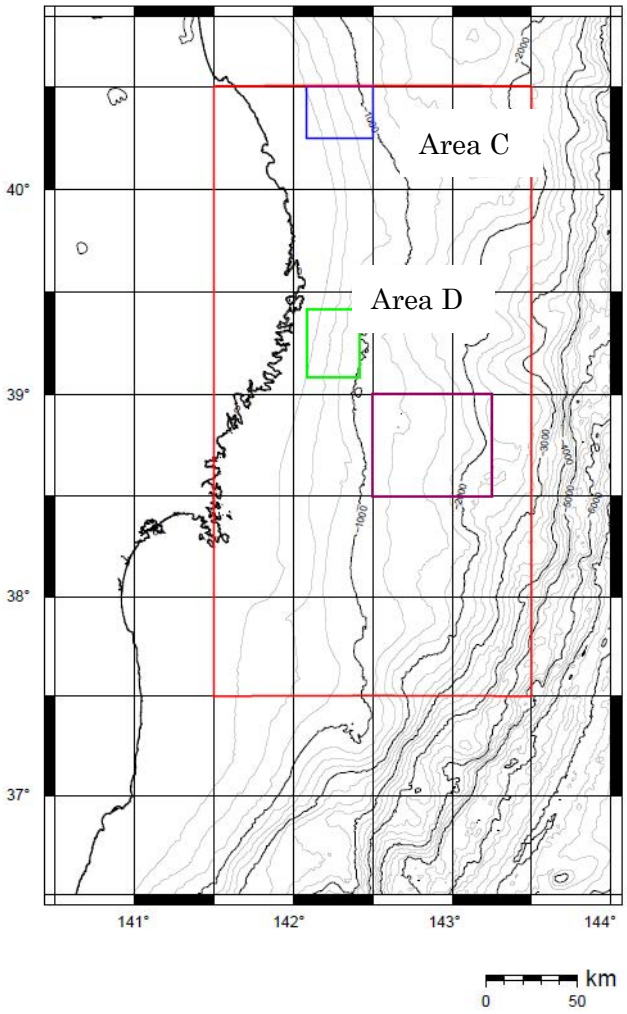


Fig. 5.2.1.1 Area C and D show SSS survey area during this cruise. The J-EGG500 data set by JODC (Japan Oceanographic Data Center) were used as background bathymetric data.

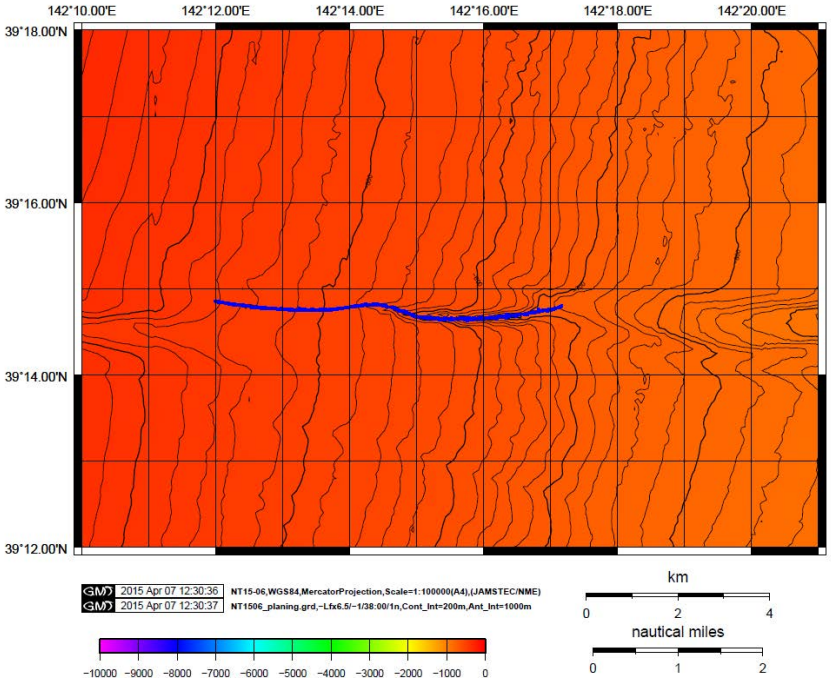


Fig. 5.2.1.2 Track lines (blue) of the SSS survey in the Area Don 6 Apr. 2015

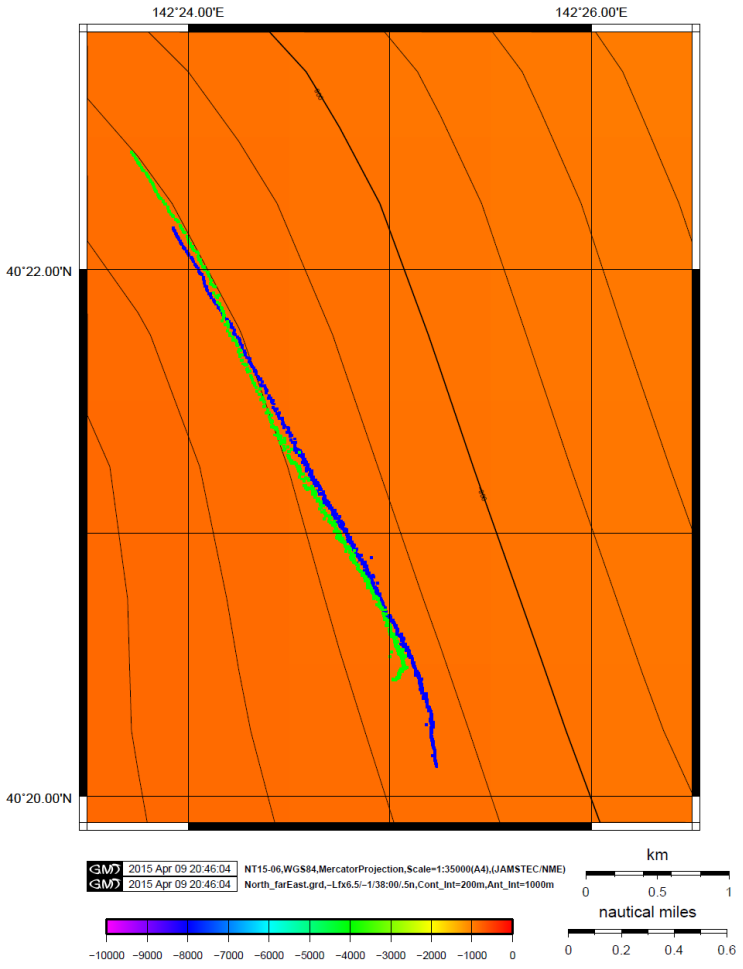


Fig. 5.2.1.3 Track lines (blue) of the SSS survey in the Area C on 8 Apr. 2015

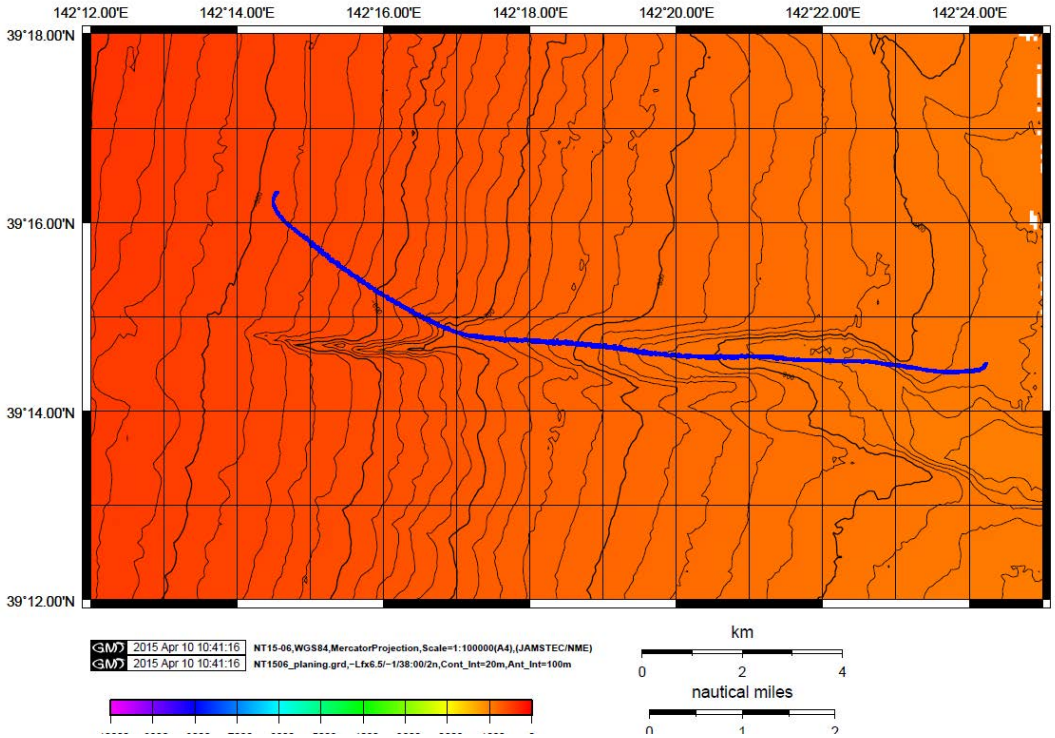


Fig. 5.2.1.4 Track lines (blue) of the SSS survey in the Area Don 6 Apr. 2015

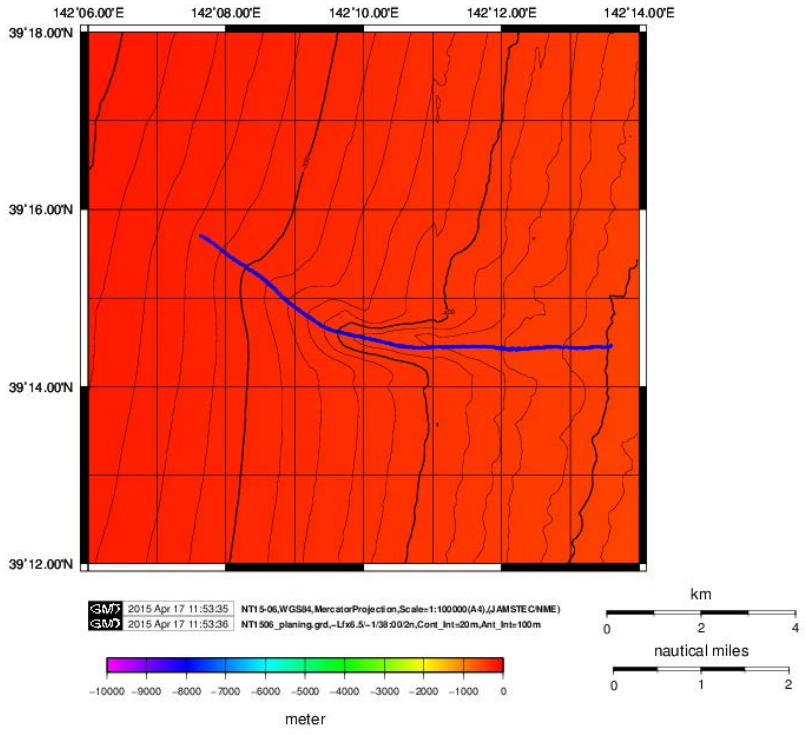


Fig. 5.2.1.5 Track lines (blue) of the SSS survey in the Area Don 6 Apr. 2015

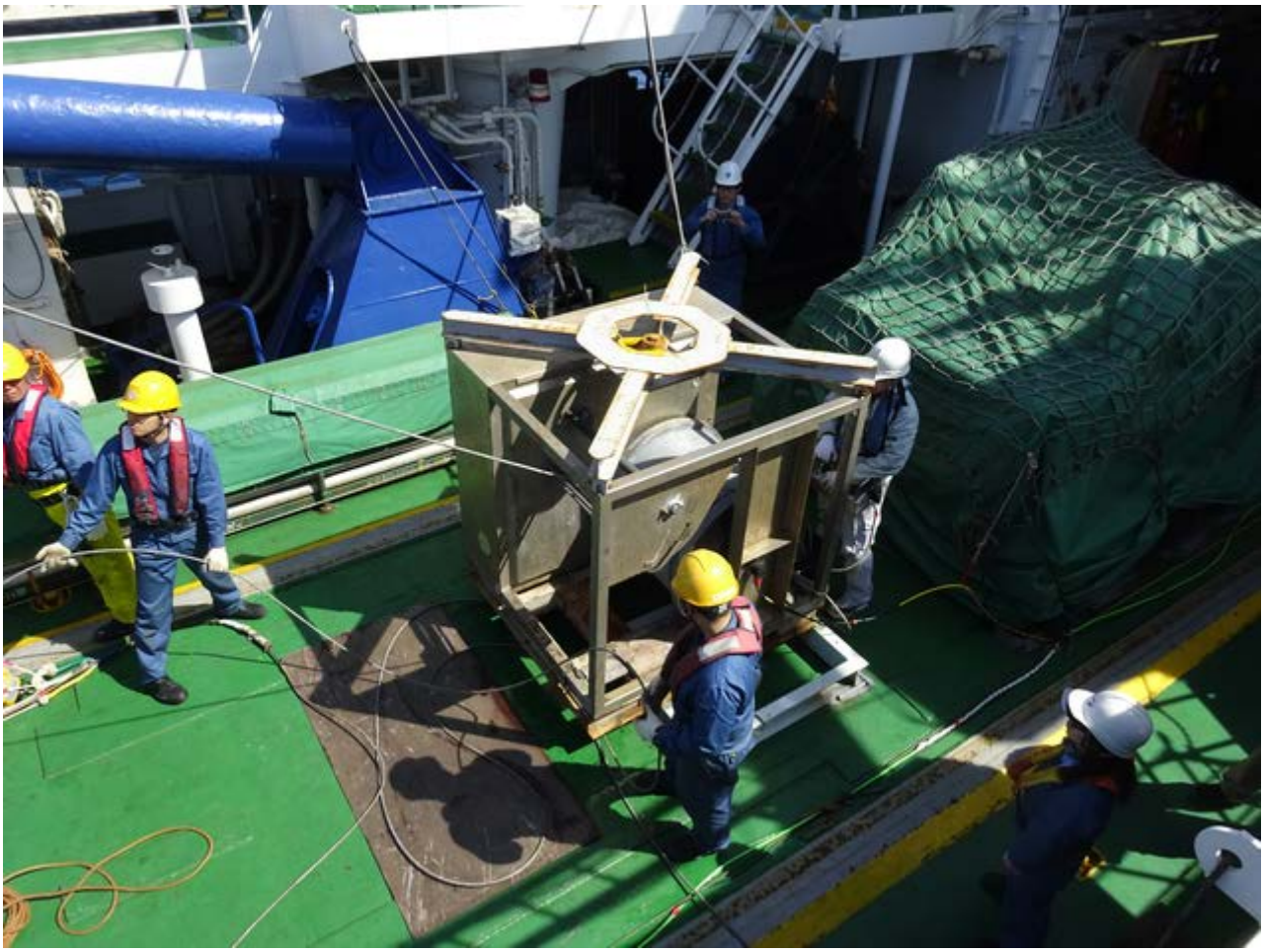


Fig. 5.2.1.6 Photo of the electric winch cable system used in this cruise.

5.2.2 SAS survey

The tow-fish are on the aft deck of the ship in initial. The tow-fish is lift up with a crane and release from the ship aft, and the tow-fish follows the ship going slow. A weight or a depressor is attached tow-cable and is hanged down from the same aft deck second. The ship tows the depressor, then the tow-fish follows the depressor. The towing speed was around 2 kt, and towing depth was around 7 m controlled by means of changing depth of the depressor attached at a middle of the tow-cable (Fig. 5.2.2.1). When the operation is finished, depressor is retrieved first, the tow-fish later. Shores near Kesennuma, Ootsuti and Karani bay were surveyed by the SAS. The track lines are shown in Fig. 5.2.2.2 to 5.2.2.5. Stars in each figure show points where strong echo is detected the sonar, and it is possible as an earthquake debris.

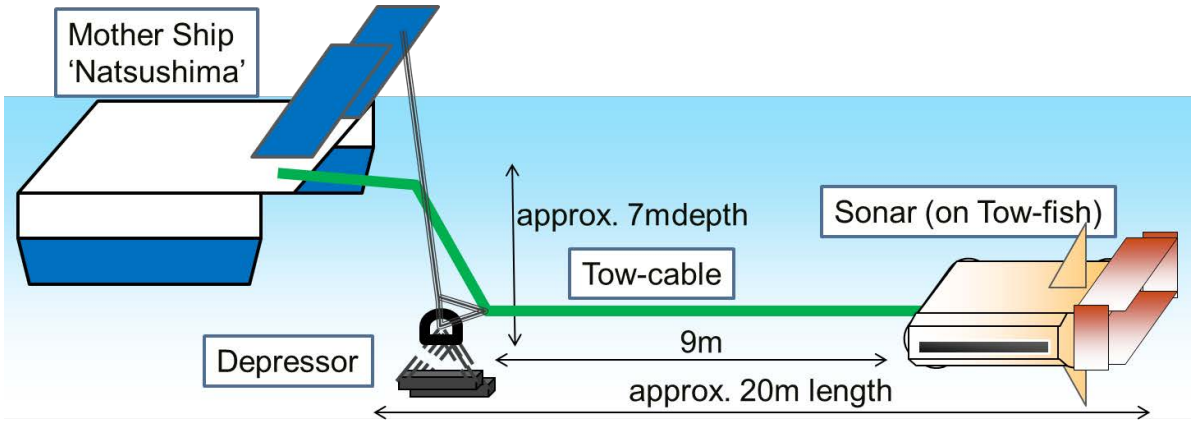


Fig. 5.2.2.1 Illustration of the towed survey using SAS

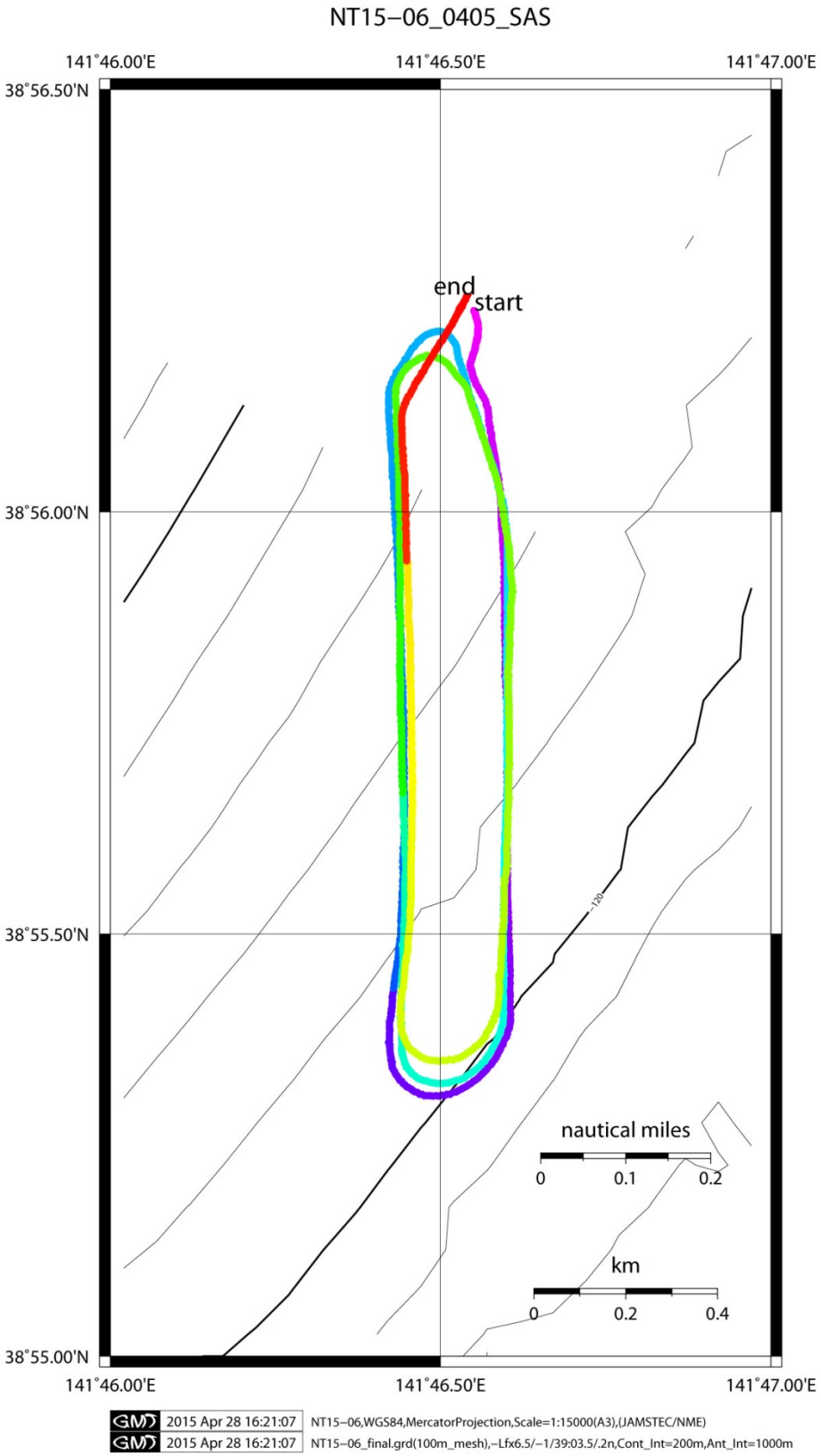


Fig. 5.2.2.1 All track lines of the survey using SAS on 6 Apr. 2015

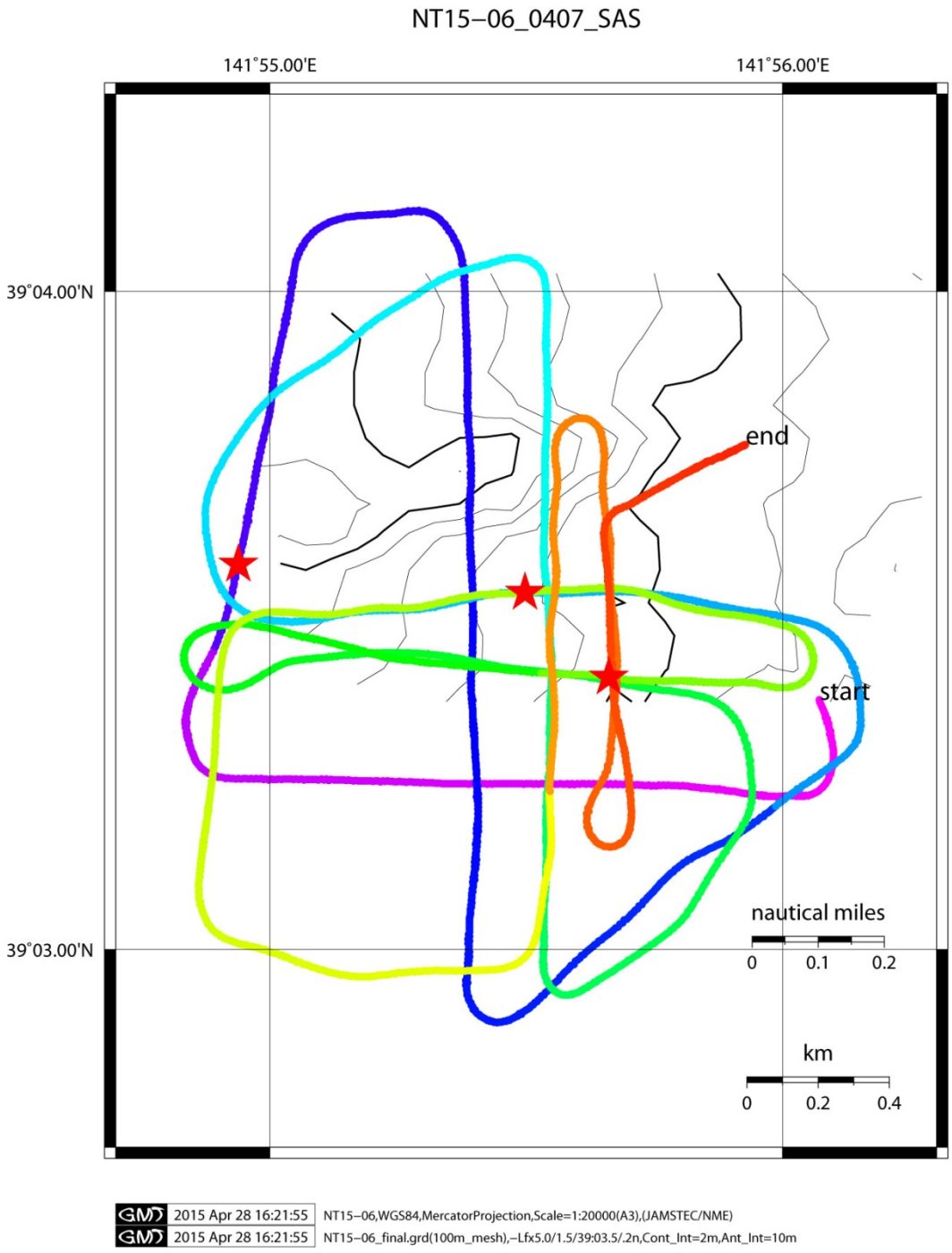


Fig. 5.2.2.2 All track lines of the survey using SAS on 7 Apr. 2015

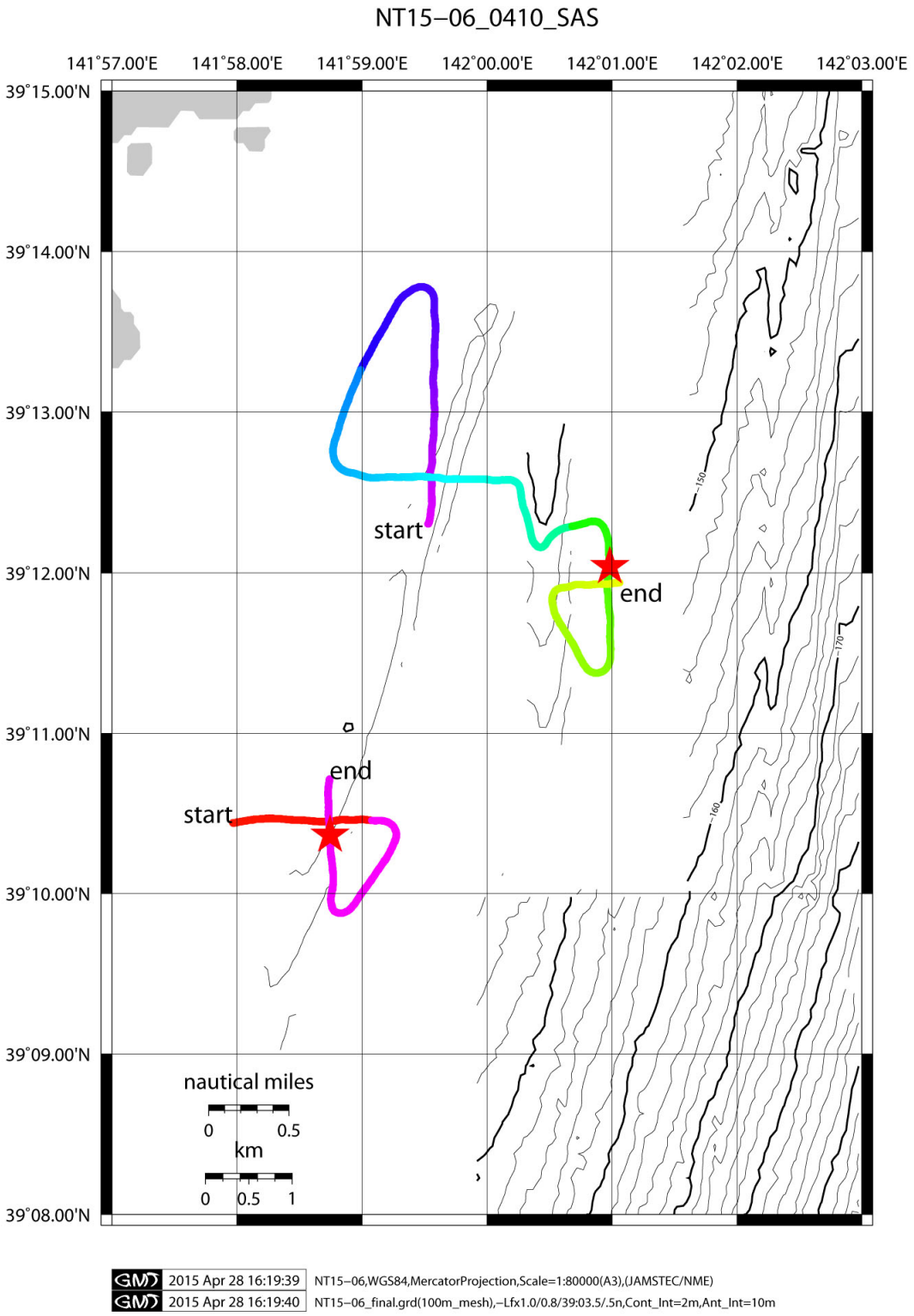


Fig. 5.2.2.3 All track lines of the survey using SAS on 10 Apr. 2015

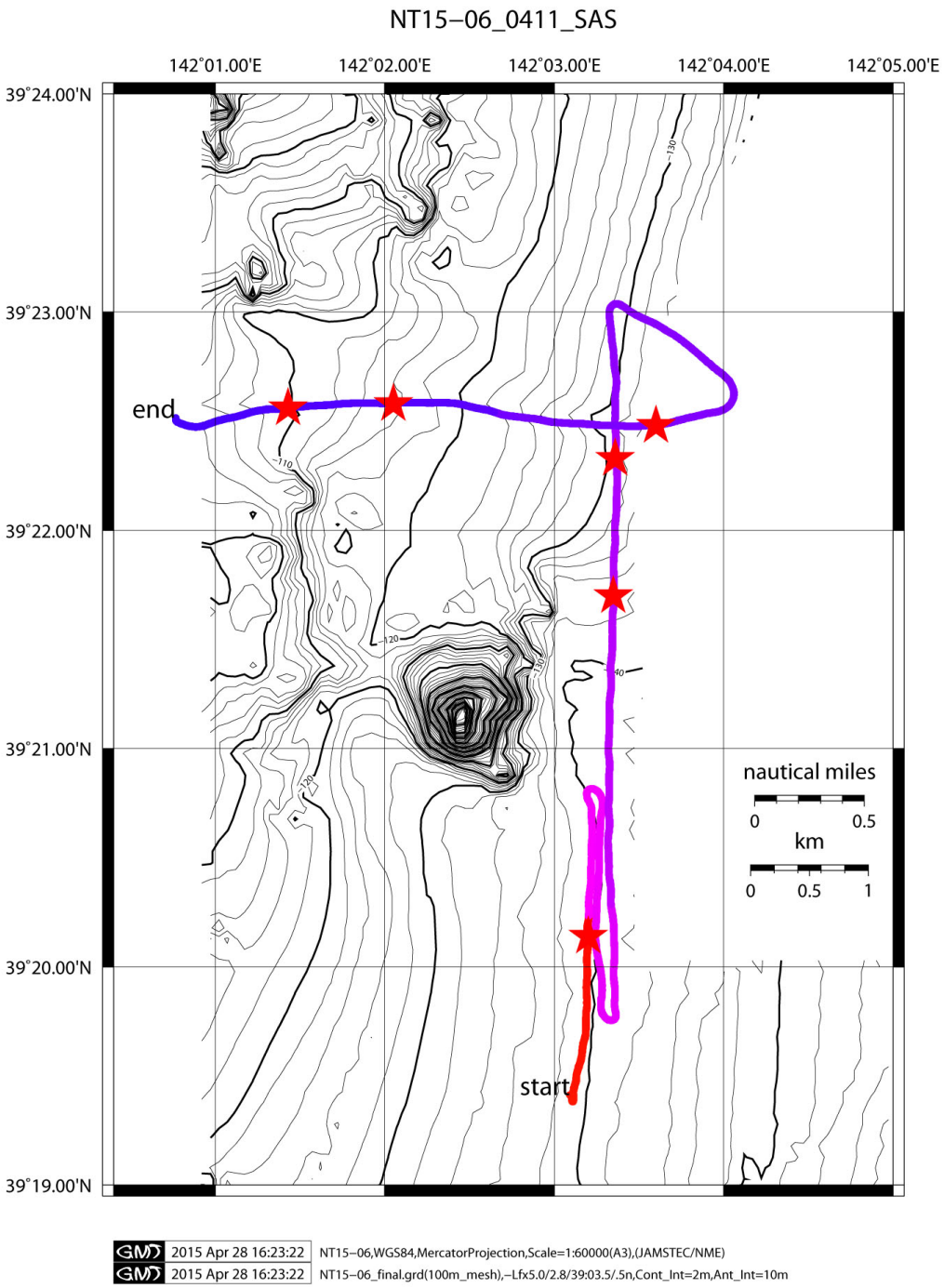


Fig. 5.2.2.4 All track lines of the survey using SAS on 11 Apr. 2015

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

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

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

(5) 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 βcam 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.