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KAIREI and KAIKO Mk-IV Cruise Report

KR17-06

Slow slip events along the shallow plate boundary in the Japan Trench subduction zone

Middle and southern parts of the Japan Trench

Apr. 14 - 20, 2017

Japan Agency for Marine-Earth Science and Technology

(JAMSTEC)

Contents

1. Cruise Information

Cruise ID KR17-06

Name of vessel KAIREI

Title of the cruise

Slow slip events along the shallow plate boundary in the Japan Trench subduction zone

Title of proposal

Slow slip events along the shallow plate boundary in the Japan Trench subduction zone

Cruise period Apr. 14 ~ 20, 2017

Ports of departure / call / arrival Yokosuka / Yokosuka

Research area Japan Trench, off Miyagi Prefecture and off Fukushima Prefecture

Research Map Refer Fig. 1

2. Researchers

Chief scientist Ryota Hino [Graduate School of Science, Tohoku University]

Representative of the science party Ryota Hino [Graduate School of Science, Tohoku University]

Science party (List) [Affiliation, assignment etc.]

Ryota Hino [Graduate School of Science, Tohoku University, chief]

Hajime Shiobara [ERI, University of Tokyo, co-chief]

Aki Ito [D-EARTH, JAMSTEC, chief-support]

Kazuaki Ohta [DEPRI, Kyoto University, support]

Yui Nomagi [Graduate School of Science, Tohoku University, support]

Debebe Kifle Atnaf [Graduate School of Science, Tohoku University, support]

Vessel crew

Captain	TAKAFUMI AOKI
Chief Officer	TATSUO ADACHI
2nd Officer	TAKESHI MURAMATSU
3rd Officer	YUKI ITO
Jr. 3rd Officer	HAYATO OOMOTE
Chief Engineer	MINORU TSUKADA
1st Engineer	TAKASHI OTA
2nd Engineer	YOSHINOBU HIRATSUKA
3rd Engineer	YUNA KAINO
Chief Electronics Operator	HIROYASU SAITAKE
2nd Electronics Operator	TOSHIHIKO YUASA
Boat Swain	KAZUO ABE
Quarter Master	YASUO KONNO

Quarter Master	SHUICHI YAMAMOTO
Quarter Master	YOSHIAKI MATSUO
Quarter Master	DAISUKE YANAGITANI
Sailor	OSAMU MARUO
Sailor	TAKUMI MIURA
No.1 Oiler	JUNJI MORI
Oiler	RYOTA SUZUKI
Oiler	MASAKI TANAKA
Oiler	TAKUYA WATANABE
Oiler	DAIKI SATO
Assistant Oiler	KOUSEI AKIBA
Chief Steward	KAZUHIRO HIRAYAMA
Steward	HIDEO FUKUMURA
Steward	JUN SATO
Steward	SHINOBU OHYU
Steward	KOKI SHINOHARA

KAIKO Mk-IV operation team

Operation Manager	HOMARE WAKAMATSU
2nd ROV Operator	TOMOE KONDO
2nd ROV Operator	KIYOSHI TAKISHITA
2nd ROV Operator	SEIJI SHIGETAKE
2nd ROV Operator	SHOTA IHARA
2nd ROV Operator	KEN YATSU
3rd ROV Operator	TAKUMA GOTO

Marine technician

Yasushi Hashimoto [NME, support & management]

3. Observation

3-1 Background and objectives of Research

The occurrence of the 2011 Tohoku-Oki earthquake (M 9.0), causing devastating tsunami by huge coseismic slip reaching to the Japan Trench axis, drew broad attention to the mechanical behavior of the shallowest part of the plate boundary fault. The large thrusting event at the forefront of the subduction zone is supposed to be revelation of strain accumulated for more than hundreds years and can expected to occur repeatedly taking steady subducting motion of the Pacific plate at a rate of ~8 cm/yr into account. However, recurrence of such the large-scale events requires reconsideration of a widely accepted model of mechanical properties along plate boundary fault, in which the shallowest part slips aseismicly and no

substantial strain is accumulated. One of the most important factors required to be clarified is actual frictional property of the fault where extremely large coseismic slip happened during the 2011 earthquake. Although the activity along the slipped zone after the coseismic slip is expected to put strong constraint on the fault nature, little has been known to date. In the present research cruise, we attempt to establish a network of geodetic instruments in the axial zone of the southern Japan Trench. In the area, substantial afterslip is expected to happen along the shallow plate boundary near to the trench axis, whereas the amount of coseismic slip during the 2011 mainshock was much smaller than the main rupture area located in the middle Japan Trench. The network includes absolute pressure gauges and acoustic extensometers to capture slow motions of the plate boundary fault in the area. Long-term monitoring data provided by the network would clarify if the afterslip reaches to the trench axis as the mainshock coseismic slip did in the central Japan Trench and if any accelerations of the fault slip associated with the steady afterslip. This research cruise is conducted as a part of a comprehensive research project JDASH (Japan trench Deep-sea research project for Assessing Shallow seismic slips and their History) supported by JSPS KAKENHI.

3-2 Observation

In this cruise, we recovered a broad-band ocean bottom seismometer with tilitmeter (BBOBST-NX) by using the KAIKO Mk-IV. The BBOBST-NX was deployed at the AOA40 site off Miyagi prefecture on September 24, 2015, during the KR15-15 cruise to monitor seafloor motions of various kinds with very broad frequency range associated with the fault slip activities along the shallow part of the subduction plate boundary. And, we deployed a new autonoums type borad-band ocean bottom seismometer (NX-2G) at the AOA60 site off Fukushima prefecture, instead of the BBOBST-NX that requires one day for the KAIKO Mk-IV dive, due to bad weather forecast for the return cruise. The result of the triangulation to locate the landing position is shown in Fig. 2.

3-3 Description of observation instruments

Both of the BBOBST-NX and the NX-2G are originally developed at Earthquake Research Institute, University of Tokyo.

3-3-1 BBOBST-NX

The BBOBST-NX was designed to improve signal to noise ratio by penetration of the sensor unit to the sediment and separation of the sensor unit and recording housing. It has a three-component broadband seismic sensor Guralp CMG-3T for NX, having flat velocity response in a frequency range from 2.7 mHz to 50 Hz. Each of the three component sensors of CMG-3T are installed in individual pressure cases so that they are easy to be buried into the seafloor sediment and to be insulated from disturbances caused by the bottom current. Ground velocity outputs are continuously recorded with 100 Hz sampling rate and 24 bits resolution, as well as two horizontal mass position data indicating the change of seafloor tilt. All the components, other than seismic sensors, are installed in an anti-pressure titanium sphere housing whose

diameter is 65 cm, rated to 6,000 m water depth. The recording system is connected to an acoustic tranponder with data communication function, which enables remote controlle by way of acoustic link from a research ship at the sea surface and also from the submersible vessel near the seafloor. The operation of the BBOBST-NX requires a submersible to separate the recording unit that was temporally fixed above the sensor unit after the free-fall deployment and to recover it after the observaiton.

3-3-2 Autonomous BBOBS-NX (NX-2G)

Although the BBOBS-NX (and BBOBST-NX) has high performance in the data quality, but the observation opportunity is strongly restricted its requirement of a submersible vessel. To clear this restriction, the NX-2G is designed to work autonomously like as our standard broad-band ocean bottom seismometer (BBOBS), which is operated by free-fall deployment and self pop-up recovery by its own buoyancy. This NX-2G system is still on the way for practical use, but at the final test level in this cruise. The operation of this system is schematically shown in Fig. 3. During the observation stage, the recording unit, the large Ti sphere housing, should be moved by the bottom current and caused mechanical noise, but it would not be a problem in the data quality as far as the mechanical coupling between the anchor and the sensor unit is weak. The force to extract the sensor unit from the sediment have been measured in-situ several times at different areas.

3-4 Research results

KAIKO Mk-IV dive #742 was conducted on April 16. This dive was intended to recover the BBOBST-NX deployed at the AOA40 site on Sep. 23, 2015 in the KR15-15 cruise. Distance to the BBOBST-NX was continuously monitored just after the vehicle exited from the launcher, which showed the target was located within 100 m horizontal distance at the seafloor by using the acoustic transponder controller for the BBOBST-NX, which was attached to the vehicle. As the sonar of the KAIKO Mk-IV system could not found the echo from the BBOBST-NX, we tried to reach to the target mainly by the distance measurement, which took about 30 minutes until we found the BBOBST-NX by cameras. After visual inspection of the whole BBOBST-NX, we started to measure the required force to extract the sensor unit from the sediment by using the weight scale. The maximum value was 60 kgf, which was smallest compared with previous results we had obtained so far in other areas. After the force measurement, the recovery operation was started by attaching the hook to the titanium loop at the top of the recording unit of the BBOBST-NX. The BBOBST-NX was brought to the sea surface below the vehicle and finally recovered to the rear deck.

Originally, we had plan to deploy a new BBOBST-NX and a NX-2G at the same AOA60 site with help of the KAIKO Mk-IV. The aim of the deployment of the NX-2G is to check the data quality obtained by it by comparing the data provided by the collocated BBOBST-NX, because the quality of the BBOBST-NX has already well known by previous experience. However, another dive (#743) to make the deployment work of them was canceled because of forecasted severly rough sea condition making our

return trip to Yokosuka impossible. To achieve our scientific objective, we determined to deploy only the NX-2G by free-fall from KAIREI in the evening on April 16 so that we will have long-term seafloor observation data, although its quality has not been evaluated very well. The NX-2G showed descending speed of about 80 m per minute with a stand alone deep-sea video camera, and landed almost in level as desired. By the acoustic transponder command from KAIREI, it changed the stage for the observation. Then, we performed the slant range measurement to it from several positions along the circle of 1 km radius, and determined the location of the NX-2G. It is originally designed to be able to self pop-up recovery, but in this deployment, its anchor and the recording unit are connected with a thin and strong rope not to ascending freely after releasing the anchor in the last stage so that we can observe action of the instrument during the recovery operation by using a submersible vessel.

3-5 Cruise log

日付 Date	時間 Local Time	内容 Note	特記事項 Description	本船位置／気象／海象 Position/Weather/Wind/Sea condition
14-Apr-17	8:00	Scientists onboard.		South of Nojimazaki
	9:00	Let go all shore lines & left YOKOSUKA for research area		34-50.8N, 139-51.7E
	10:00-10:40	Carried out education & traning for scientists.		Fine but cloudy
	13:30-14:00	Carried out education(KAIKO) for scientists.		SSE-3 (Gentle breeze)
				2 (Smooth)
				1 (Low swell short)
				Visibly : 8'
15-Apr-17	5:00	Arrived at research area (Japan Trench)		South east of off KINKASAN
	6:06	Released XBT at 36-49.3464N, 142-42.8292E		36-59.7N, 142-47.9E
	6:32	Com'ced MBES mapping survey.		Fine but cloudy
	7:21	Finished MBES mapping survey.		SW-8 (Gale)
				5 (Rough)
				4 (Moderate average)
				Visibly : 8'
16-Apr-17	2:50	Arrived at AOA40		East of off KINKASAN
	6:22	Released XBT at 38-00.0869N, 143-40.5166E		37-59.7N, 143-39.8E
	7:55	Hoisted up 'KAIKO Mk-IV'		Fine but Cloudy
	8:01	Launched 'KAIKO Mk-IV' then it dove & Com'ced her operation #742(1)		SW-5 (Fresh breeze)
	10:54	KAIKO Mk-IV' landed on the sea bottom (D=5,437m)		3 (Slight)
	11:46	KAIKO Mk-IV' left the sea		2 (Low swell long)

		bottom (D=5,444m)		
	14:24	Hoisted up 'KAIKO Mk-IV'		Visibly : 8'
	14:41	Recovered 'KAIKO Mk-IV' & finished her operation		
	14:47	Recovered BBOBST-NX		
	15:30	Proceeded to AOA60		
	21:00	Arrived at AOA60		
	21:26	Deployed BBOBS-NX-2G		
	22:12-23:28	Carried out calibration of BBOBS-NX-2G		
	23:30	Proceeded to Yokosuka		
17-Apr-17	14:30	Arrived at Yokosuka		South of Sunosaki
		Let go port anchor in 25m of water at Yokosuka.	Anchoring at Yokosuka	34-53.0N,139-46.9E
	14:54	Launched traffic boat.		Fog
	15:00	4 scientists disembarked.		SSW-3 (Gentle breeze)
	15:25	Recovered traffic boat		2 (Smooth)
				1 (Low swell)
				Visibly : 1'
20-Apr-17	9:00	Arrived at YOKOSUKA-ko, then completed voy. No.KR17-06.		

3-6 Dive information

3-6-1 Dive Number, date and aim

742 Apr. 16, 2017. Recovery of the BBOBST-NX at the AOA40 site

3-6-2 Payloads

Remote commander for the acoustic communication with BBOBST-NX

Weight scale for measuring extraction force of the NX sensor unit

3-6-3 Dive map

Refer Fig. 4.

3-7 Research Information

3-7-1 Descriptions of retrieved BBOBST-NX

site: AOA40

SI2 transponder code: 549

Deployment: 2015/09/23-14:18 (release for free-fall)

Recovery: 2017/04/16-14:49 (on deck)

Relocated position: 37° 59.7790’N, 143° 39.8772’E, 5,431m

Recorder: LS9100-T6H (ID: 0149, 5ch, 100Hz, 24bit, tg=3h), UD/NS/EW (velocity)+NS/EW (mass position), SDXC (64GBx2: Transcend, TDK)

Sensor: CMG-3T for NX (T34039, 360s, 1000V/m/s), Tilt (Pitch: -5.7°, Roll: 0.6°), Azimuth: 133°N

Controller: NGC #7 (th=50%, used at NM03)

Recording period

start: 2015/09/24-13:29:42 (manual) stop: 2017/04/16-10:52 (manual)

start: 2015/09/28-00:00:00 (timer) stop: 2017/09/25-00:00:00 (timer)

Time correction (JST, OBS-GPS)

2015/09/23-10:35:00 -0.2203936s 2017/04/16-15:34:00 -3.504976s

Thermometer (KTL-6000L, 10 min. interval)

start: 2015/09/23-12:00:00 stop: 2017/04/16-16:29:00 sample #: 82251

3-7-2 Descriptions of installed NX-2G

site: AOA60

SI2 transponder code: 902 (2 step mechanical type)

Deployment: 2017/04/16-21:26 (release for free-fall)

Relocated position: 36° 53.8488’N, 142° 42.9661’E, 4,236m

Recorder: LS9100-T6H (ID: 0132, 3ch, 100Hz, 24bit, tg=4h), UD/NS/EW (velocity), SDXC (64GBx2: DELKIN)

Sensor: CMG-3T for NX (T35679, 360s, 1000V/m/s), Tilt (Pitch: 1.1°, Roll: 1.5°), Azimuth: 240°N

Controller: NGC2 #1 (th=50%, new model)

Recording period

start: 2017/04/16-22:25:30 (manual, send "ad on")

start: 2017/04/20-00:00:00 (timer) stop: 2018/09/30-00:00:00 (timer)

Time correction (JST, OBS-GPS)

2017/04/16-15:37:30 -0.016760s

Buoyancy: 75kgf (17inch glass floats+Ti sphere), added umbilical rope for a ROV recovery.

4. Acknowledgement

We thank the captain and crew of R/V KAIREI, the KAIKO operation team and a scientific supporting staff of NME. This study is supported by JSPS KAKENHI (26000002).

5. Notice on Using

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

Figures and photos

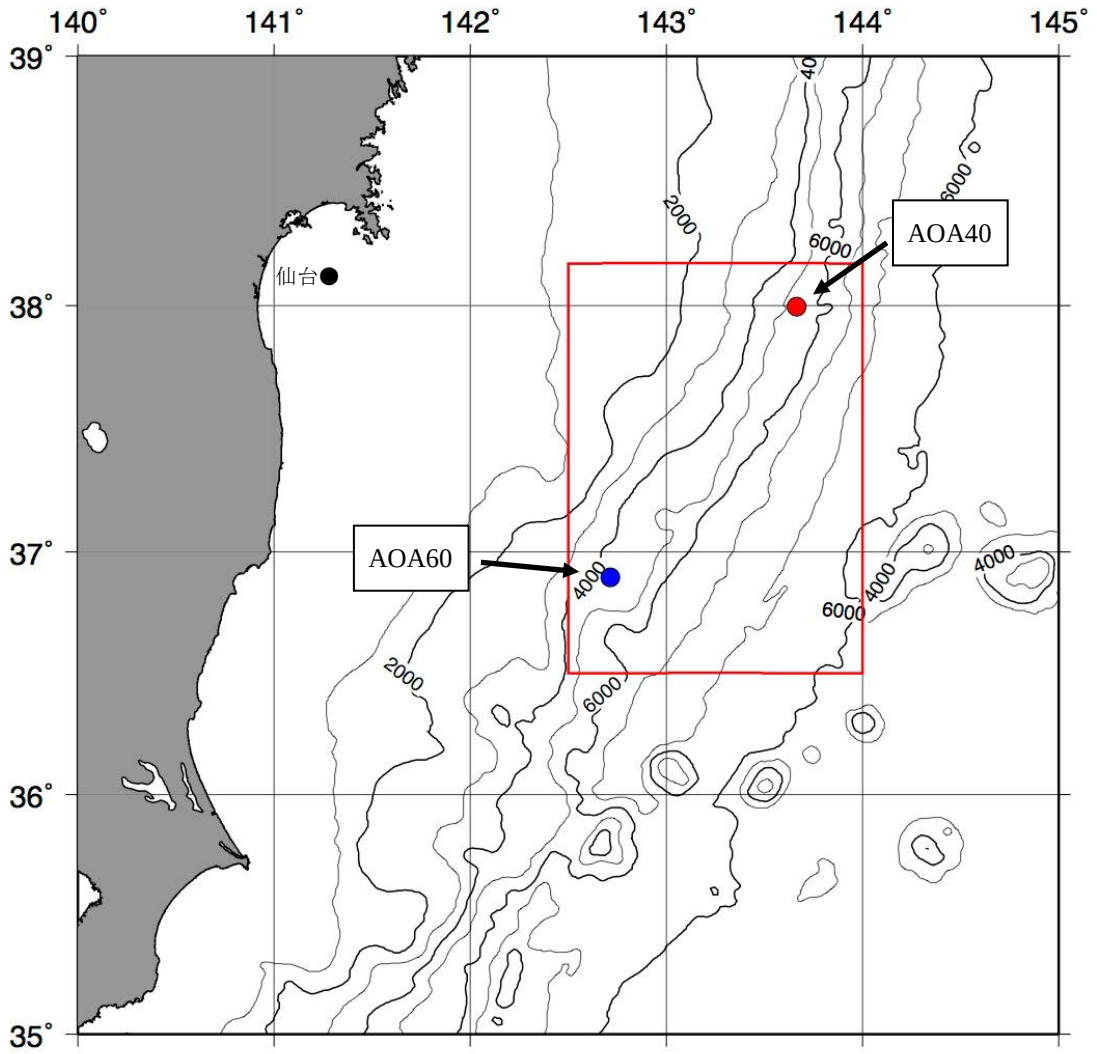

Figure 1. Research area map

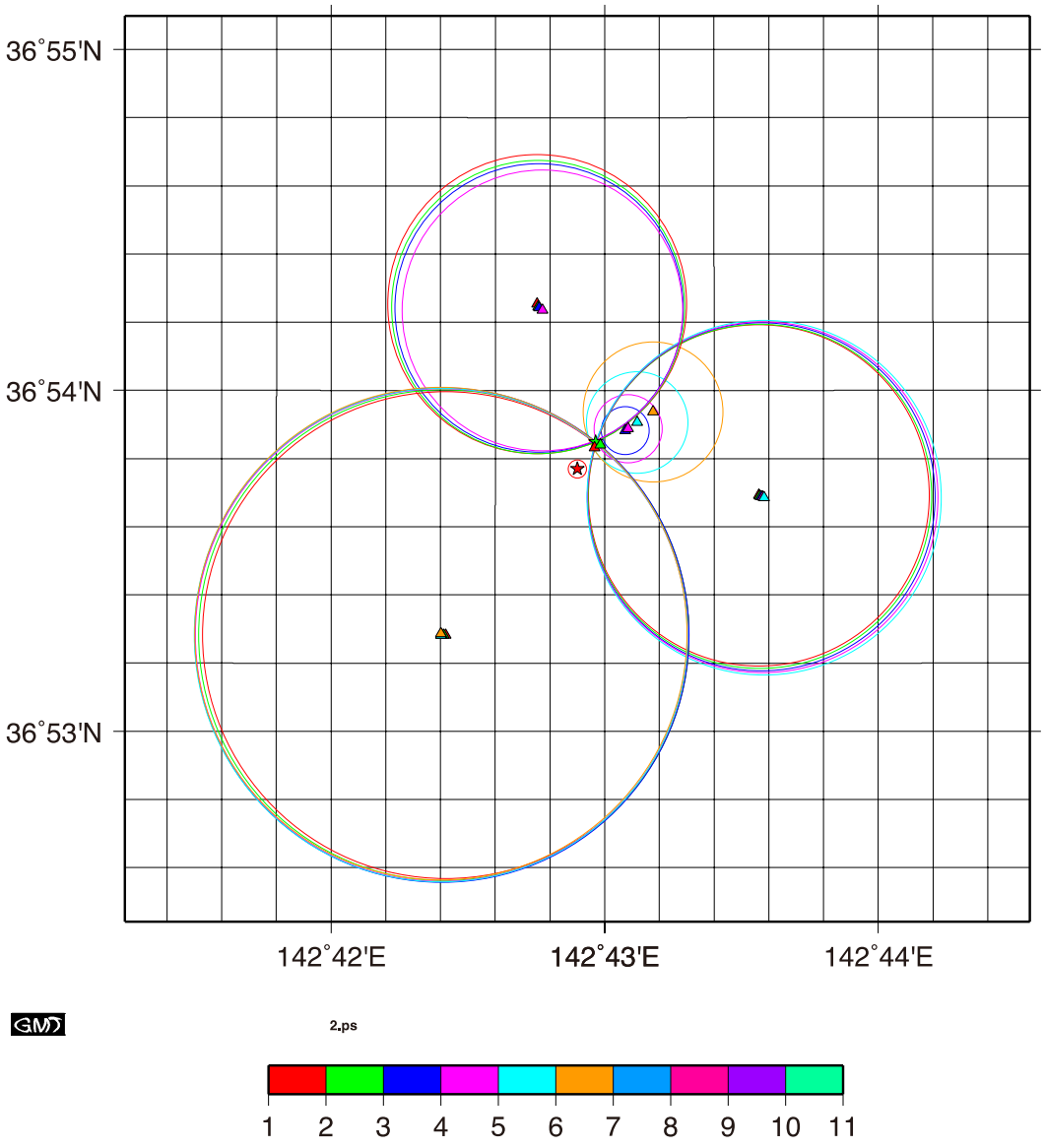

Figure 2. Positioning map of the NX-2G at the AOA60 site

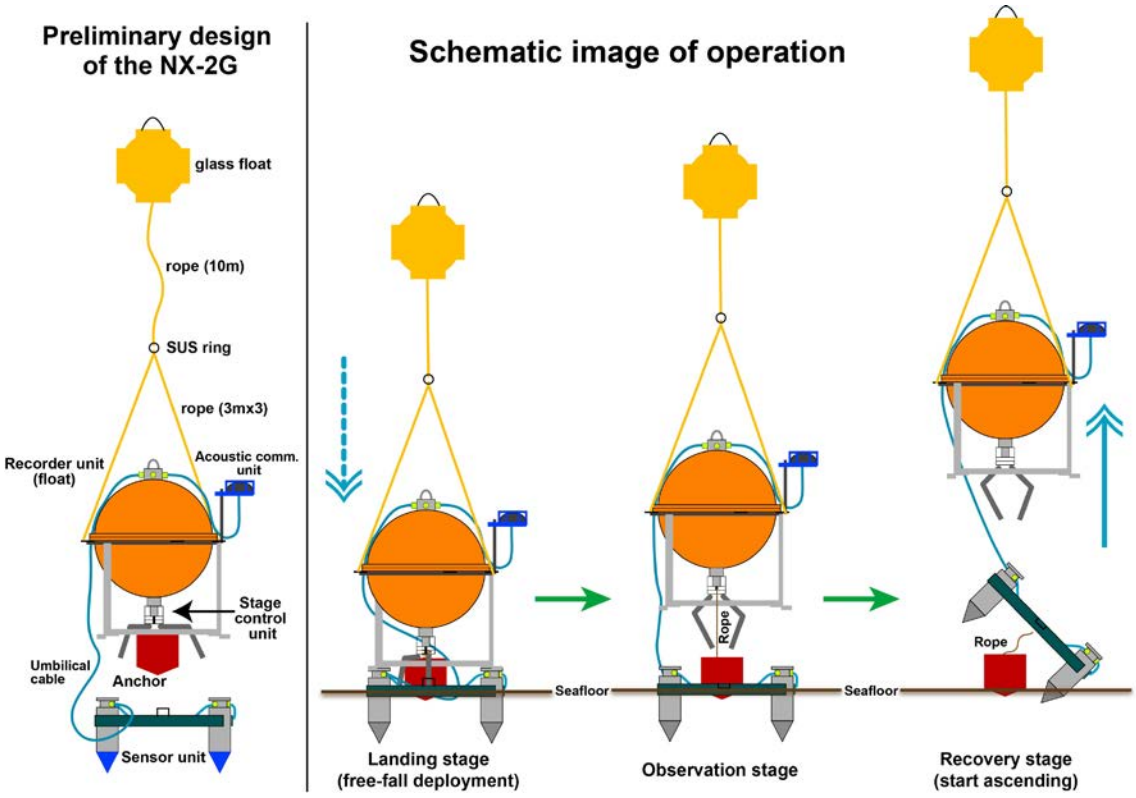

Figure 3. Schematic design and operation of the NX-2G system

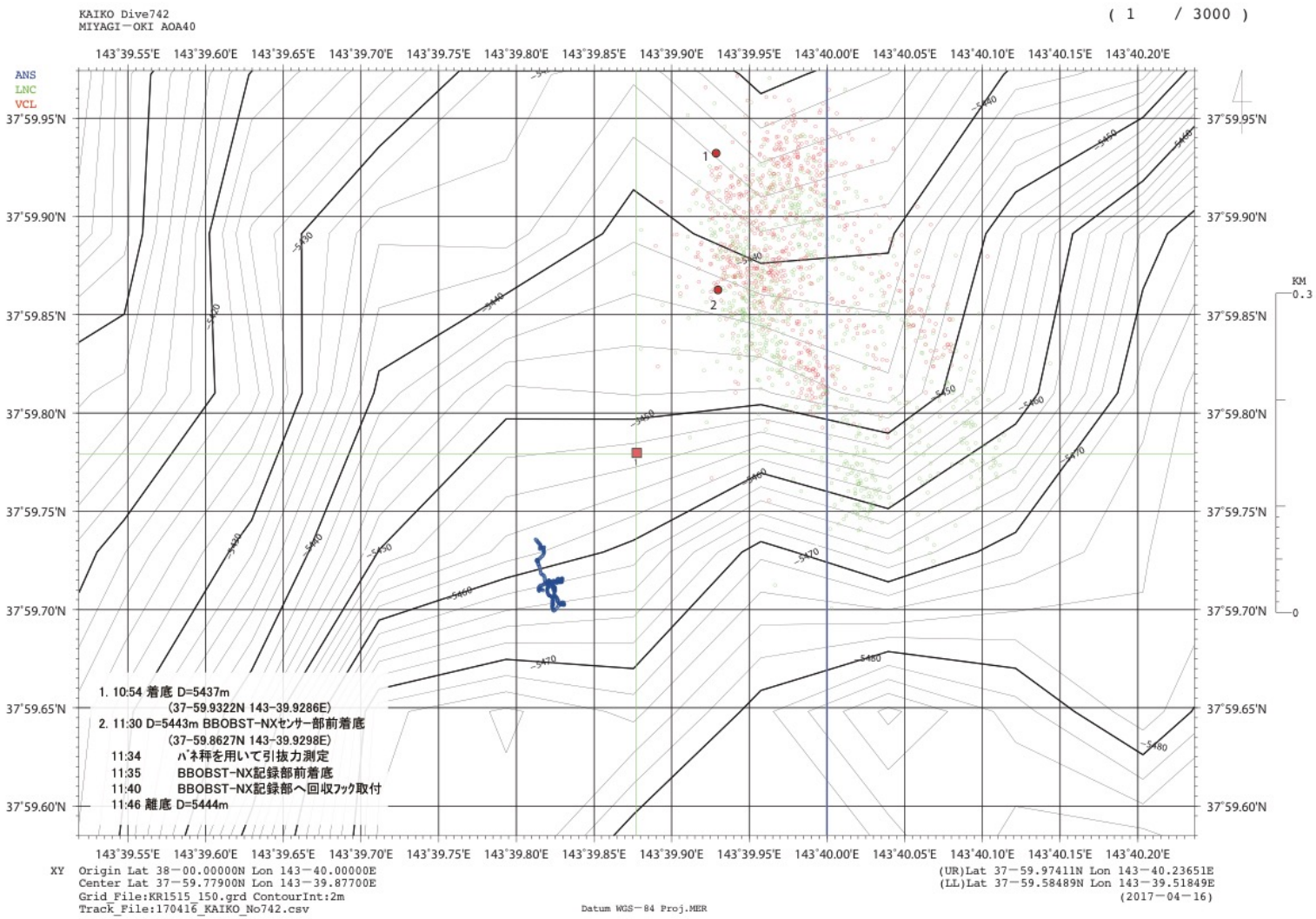

Figure 4. Dive #742 map

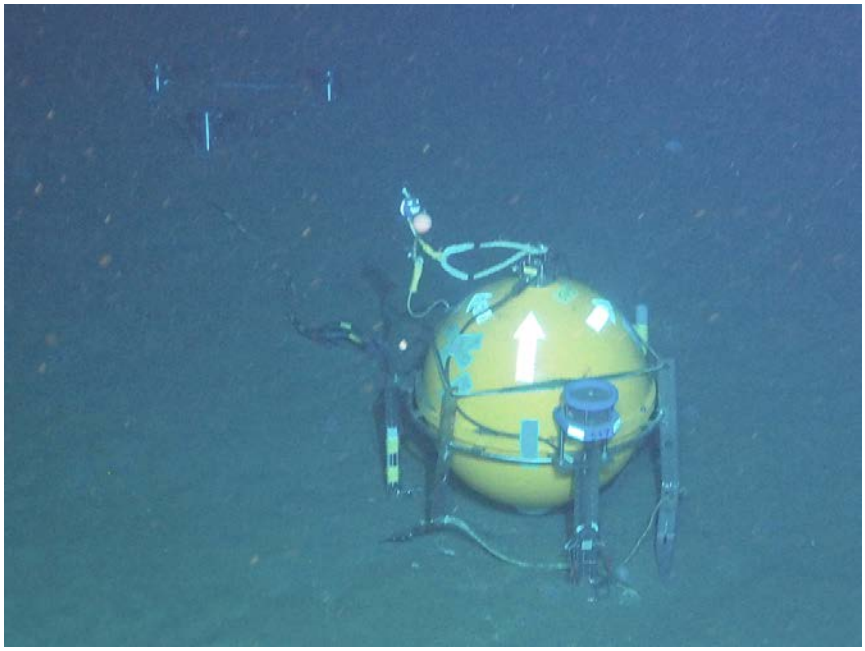

Photo 1. BBOBST-NX at the AOA40 site, on the seafloor

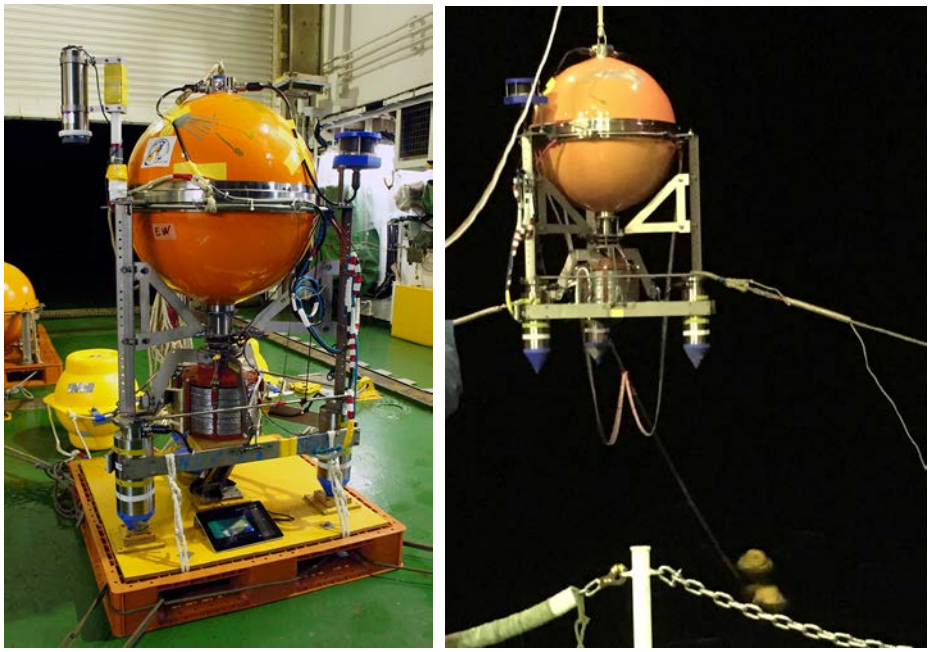

Photo 2. NX-2G, over view and soon before launching