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KAIREI and KAIKO Mk-IV Cruise Report
KR18-13

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

Southern parts of the Japan Trench

Oct. 10 – 13, 2018

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

Contents

Cover photo

4 scenes of the NX-2G selfied by the Deep-Sea CAM.

1. Cruise Information

Cruise ID KR18-13

Name of vessel KAIREI

Title of the cruise

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

Title of project

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

Chief Scientist Shiobara, Hajime [ERI, University of Tokyo]

Representative of Science Party Hino, Ryota [Graduate School of Science, Tohoku University]

Cruise period Oct. 10 ~ 13, 2018

Ports of departure / arrival Yokosuka / Yokosuka

Research area Japan Trench, off Fukushima Prefecture

Research map Refer Fig. 1

2. Researchers, captain, crew, KAIKO team and marine technician

Chief scientist Shiobara, Hajime [ERI, University of Tokyo]

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

Science party

Hajime Shiobara [ERI, University of Tokyo, chief]

Shin'ichi Tanaka [ERI, University of Tokyo, co-chief / support]

R/V KAIREI Crew

Captain	YOSHIYUKI NAKAMURA
Chief Officer	TETSUO SHIRAYAMA
2nd Officer	SYUNSUKE FUJII
3rd Officer	TATSUMI DEGUCHI
Chief Engineer	KAZUHIKO KANEDA
1st Engineer	SHINICHI IKUTA
2st Engineer	AKIRA HANAWA
3rd Engineer	SHOHEI MIYAZAKI
Chief Electronics Operator	TOKINORI NASU
2nd Electronics Operator	RYOSUKE MATSUI
3rd Electronics Operator	MISATO TAKI
Boat Swain	KANAME HIROSAKI
Quarter Master	YASUO KONNO
Quarter Master	SYUICHI YAMAMOTO
Quarter Master	NAO ISHIZUKA
Sailor	KENTA NASU

Sailor	TOSHIYA SAGA
Sailor	TAISEI TANAKA
Sailor	RYO NAKANISHI
No.1 Oiler	JUNJI MORI
Oiler	TOSHINORI MATSUI
Oiler	RYO SATO
Oiler	MAKOTO KOZAKI
Assistant Oiler	FUBUKI HOMMA
Chief Steward	KAZUHIRO HIRAYAMA
Steward	TATSUYA HIRAI
Steward	MASARU SUGIYAMA
Steward	KOKI SHINOHARA
Steward	YUKI SHIRASAKI

KAIKO Mk-Ⅳ Operation Team

Submersible Op. Manager	TOMOE KONDO
1/Submersible Tec. Officer	HOMARE WAKAMATSU
2/Submersible Tec. Officer	SEIJI SHIGETAKE
2/Submersible Tec. Officer	SHOTA IHARA
2/Submersible Tec. Officer	TAKUMA GOTO
2/Submersible Tec. Officer	YUTA YAMAMURO
2/Submersible Tec. Officer	RYO SAIGO
3/Submersible Tec. Officer	NAOKI SATO

Observation Engineer

Marine Technician	KIMIKO SERIZAWA

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 new autonomous type broad-band ocean bottom seismometer (NX-2G) by using the KAIKO Mk-IV (dive #794). The NX-2G was deployed at the AoA60 site off Fukushima prefecture (Fig. 2a) on April 16, 2017, during the KR17-06 cruise. And, we also recovered four long-term ocean bottom seismometers (LTOBSs) around the AoA60 site (Fig. 2b). These OBSs are aimed 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.

3-3 Description of observation instruments

Both of the NX-2G and the LTOBS are originally developed at Earthquake Research Institute, University of Tokyo. The acoustic transponder system is also original one, SI2 type made by KAIYO-DENSHI.

3-3-1 Autonomous BBOBS-NX (NX-2G)

Although the BBOBS-NX, which equips a special design of the CMG-3T (Guralp), using a penetrator sensor unit by gravity 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 to the 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 has been measured in-situ several times at different areas. When we deployed it (Fig. 4), the anchor and the recording unit was connected with a thin rope that has enough length not to disturb the sensor unit extraction, so as to handle it by a ROV after video recording of the transition scene from the observation stage to the recovery stage.

3-3-2 Long-term OBS (LTOBS)

This OBS has a Ti sphere housing of 50cm diameter and equips 1Hz sensor (Lenartz, LE3D-lite), which can be recording more than one year long period. The system is the standard, free-fall deployment and self pop-up recovery type, by using a forced electro-chemical corrosion of two Ti plates.

3-4 Research results

KAIKO Mk-IV dive #794 was conducted on Oct. 11. This dive was intended to recover the NX-2G deployed at the AoA60 site of 4236 m depth. Distance to the NX-2G was continuously monitored just after the vehicle exited below the launcher, which showed the target was located within 100 m horizontal distance at the seafloor by using the acoustic transponder controller for the NX-2G, which was attached to the vehicle. As the sonar of the KAIKO Mk-IV system got the echo from the NX-2G when the distance was 80 m, it was easy to approach the NX-2G system, which has two glass floats at 13 m height from the seafloor. After visual inspection of the NX-2G in the observation stage, we started to monitor the transition from the observation stage to the recovery stage by sending the acoustic command. This transition had started from the disconnection between the anchor and the recording unit, then the buoyancy of two glass floats and the recording unit started to ascend. Next, the rope (and cable) between the sensor unit and the recording unit pulled one vertex (one component case) of the sensor unit caused tilt of it to make easy retrieval of the sensor unit from the sediment (Fig. 5). This time, all process of this transition went immediately with about 75 kgf buoyancy. After this in-situ observation, video recording, the NX-2G was recovered by the KAIKO MK-IV. The deep-sea video camera (DSCAM) attached on the NX-2G to selfy the landing and the first transition was also safely recovered with the video data. Unfortunately, one component (N/S) of the sensor had trouble in mass position control, but the recording of two others (U/D and E/W) was going well until Sep. 30, 2018. The internal clock accuracy was also good enough for 100 Hz sampling.

The recovery of 4 LTOBSs was performed from the early morning of Oct. 12. As we had already checked that the response from the AoA64 was not recognized by using the ship bottom transducer on Oct. 11, the recovery was started from the AoA63 in counterclockwise. 3 LTOBSs were released and recovered as expected. The response from the last one, AoA64, could not be heard even with the transducer deployed from the rear shipside. So, we tried to send release command twice with 30 minutes time spacing. After possible time to release and ascend, the radio beacon signal was received and the LTOBS was found nearby the ship, and it was safely recovered (Fig. 6). By the inspection of the transponder system on the deck, the acoustic transmission level became very low. Later, more inspection at the laboratory in ERI, the acoustic transponder system looked work if the transducer is put upside down, but the isolation test with 1000V for the transducer showed that the transducer at the upside position (connector at down), same as at the seafloor, had no isolation. So, it seems that small amount of seawater contamination exists within the oil inside of the transducer, which could work in low-voltage receiving signal but not in high-voltage transmission signal. The seismic data of 4 LTOIBSs were recorded as expected with enough time accuracy.

3-5 Cruise Log

Date & Time	Description	Weather / Wind / Sea Condition
2018/10/10 Wed.	Noon Position: 34-50.5N, 139-52.0E (YOKOSUKA-SHINKO port)	bc / North-3 / 3
08:00	Scientist party onboard a vessel.	
09:00	Sail out, proceeding to research area from YOKOSUKA SHINKO.	
	Let go all shore lines & left YOKOSUKA SHINKO for ONAHAMA Off.	
10:00	Briefing about ship's life and safety.	
16:40	Konpira ceremony	
2018/10/11 Thu.	Noon Position: 36-53.8N, 142-42.9E (OFF FUKUSHIMA JAPAN TRENCH)	o / ESE-5 / 4
02:00	Arrived at research area	
04:35	Released XBT(36-50.7400N, 142-43.0306E)	
05:10-05:39	MBES Survey	
07:31	Hoisted up KAIKO	
07:41	Launched and Started KK794 operation	
10:37	Landed on the sea floor (D=4,213m)	
11:47	Left the sea bottom (D=4,210m)	
14:04	KAIKO floated, hoisted up	
14:25	Recovered KAIKO	
15:26	Recovered BBOBS NX-2G(AoA60)	
2018/10/12 Fri.	Noon Position: 36-54.0N, 142-43.0E (OFF FUKUSHIMA JAPAN TRENCH)	r / North-6 / 5
06:52	Recovered LTOBS(AoA63)	
08:22	Recovered LTOBS(AoA62)	
10:50	Recovered LTOBS(AoA61)	
13:41	Recovered LTOBS(AoA64)	
14:00	Left research area for YOKOSUKA	
2018/10/13 Sat.		
11:00	Arrived at JAMSTEC, Completed voyage KR18-13	

3-6 Dive information

3-6-1 Dive Number, date and aim

794 Oct. 11, 2018. Recovery of the NX-2G at the AoA60 site

3-6-2 Payloads

Remote commander for the acoustic communication with the NX-2G

3-6-3 Dive map

Refer Fig. 7.

3-7 Research Information

3-7-1 Descriptions of the recovered NX-2G

site: AoA60

SI2 transponder code: 902 (2 step mechanical type)

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

Recovery: 2018/10/11-10:43 (send release command), -11:47 (left seafloor by vehicle)

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, 360 s, about 1000 V/m/s), Tilt (Pitch: 1.1°, Roll: 1.5° w/o offset), Azimuth: 240°N
pitch and roll in the raw log file: 2.2° and 0.9°
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
2018/10/11-16:34:00 -5.4369703s
Buoyancy: 75 kgf (two 17inch glass floats + Ti sphere), added umbilical rope for a ROV recovery.

Note1: H1(N/S) mass position was always high level. After 2017/07/31, H1 signal was NG.
Note2: The DSCAM was attached to selfy the landing and the first transition.
Note3: The MACR, MEMS acceleration and gyro logger was installed inside of the recording unit.

3-7-2 Descriptions of recovered four LTOBSs
Site: AoA61, 62, 63, 64
SI2 transponder code: 705, 403, 688, 640, respectively.
Deployment: 2017/10/26
Recovery: 2018/10/12
Relocated positions:

AoA61	36° 54.1574' N	142° 43.2901' E	4230m
AoA62	36° 53.7804' N	142° 43.3035' E	4231m
AoA63	36° 53.8565' N	142° 42.7978' E	4232m
AoA64	36° 54.2764' N	142° 42.8332' E	4234m

Recording period
start: 2017/10/30-00:00:00 (timer) stop: 2018/10/12 (manual, before releasing)

4. Acknowledgements

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

Figures and photos

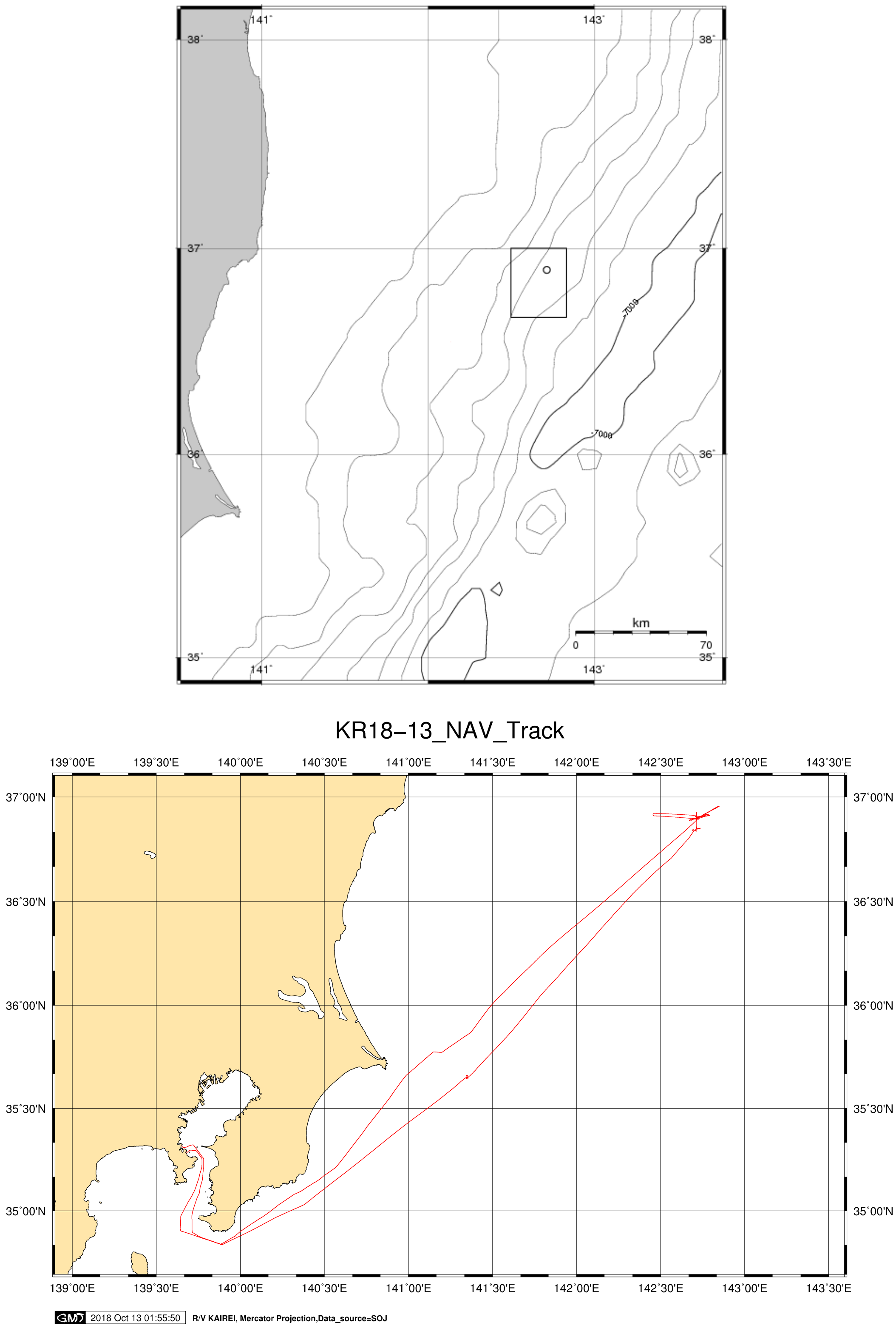

Fig. 1. Map of survey area and the ship track. Small circle shows the AoA60's position.

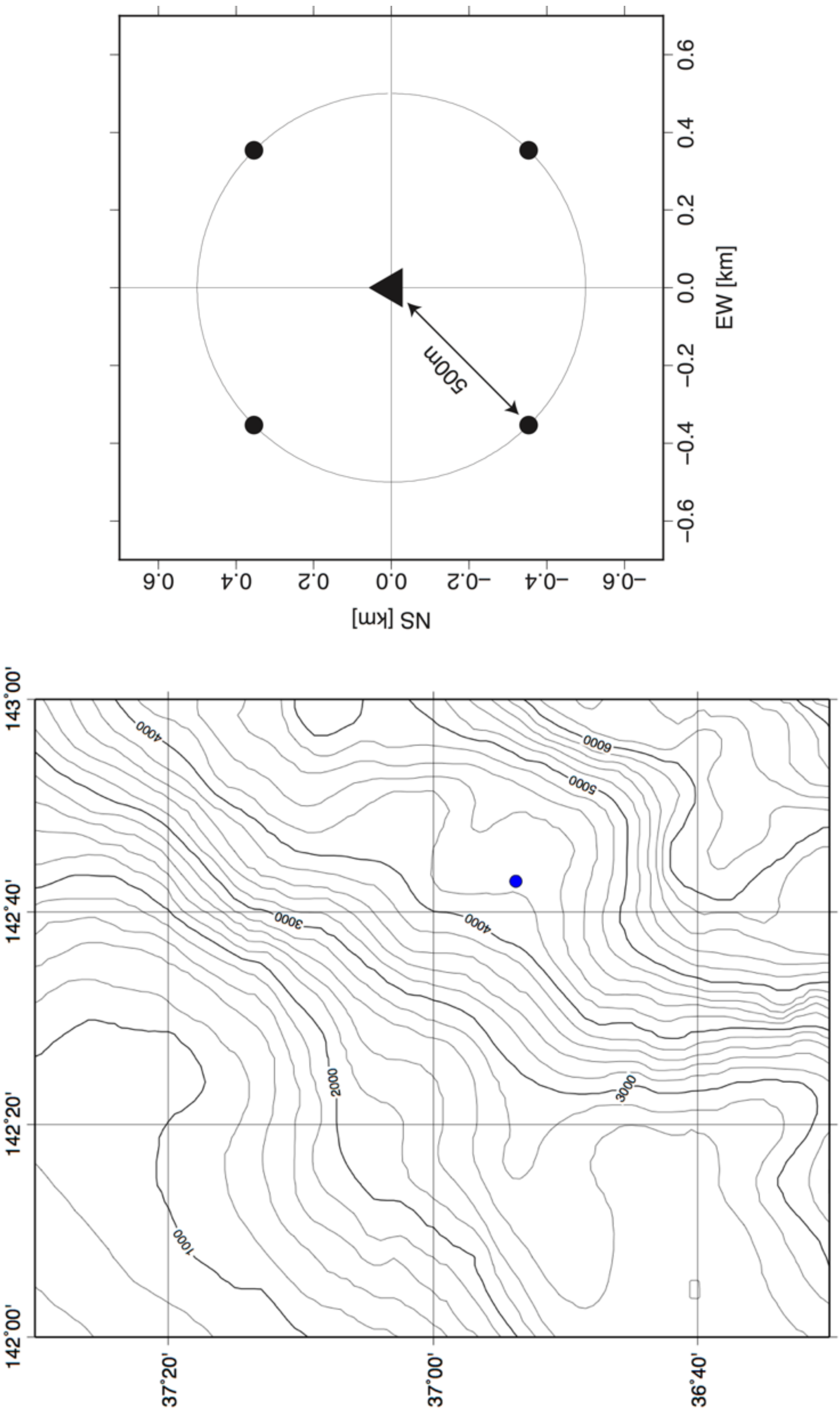

Fig. 2. Site map with topography of the dive position AoA60 (blue dot) and four LTOBSs relative locations. From the NE position based on the AoA60 (central triangle) in clockwise, AoA61, AoA62 (SE), AoA63 (SW), and AoA64 (NW), respectively.

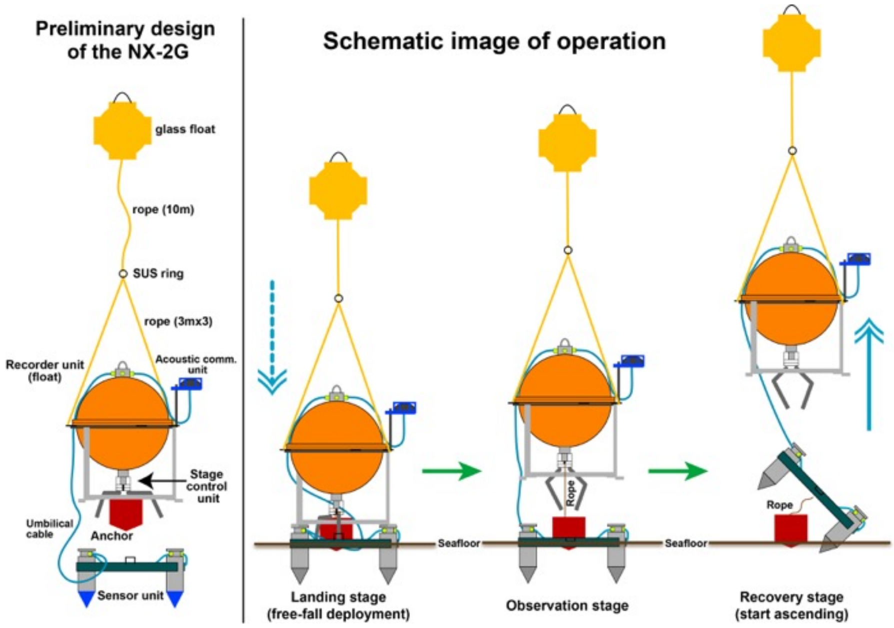

Fig 3. Schematic design and operation of the NX-2G system.

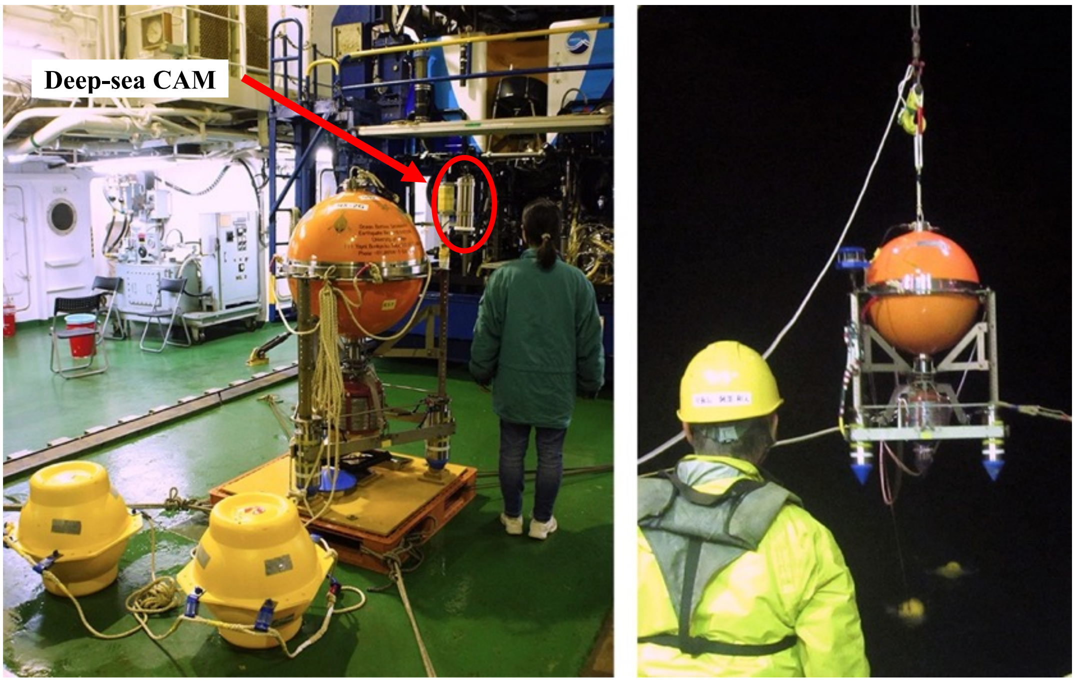

Fig. 4. The NX-2G system deployed in the KR17-06 cruise.

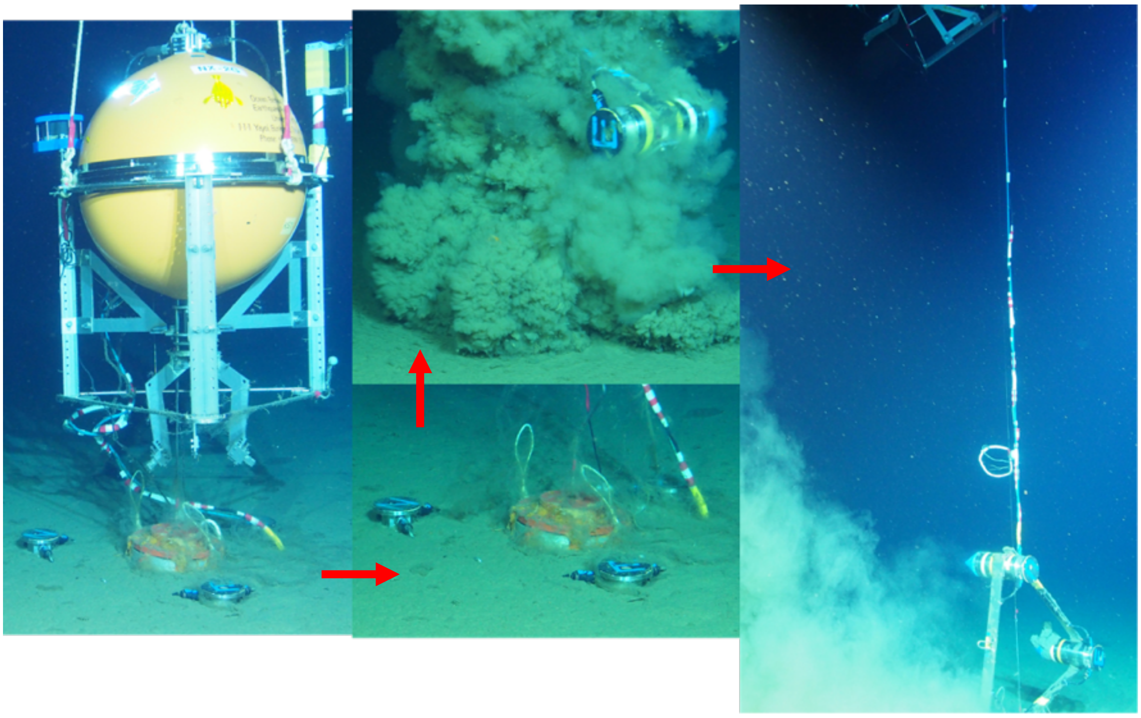

Fig. 5. The transition from the observation stage (left) to the recovery stage (right), observed in the KAIKO MK-IV #794 dive.

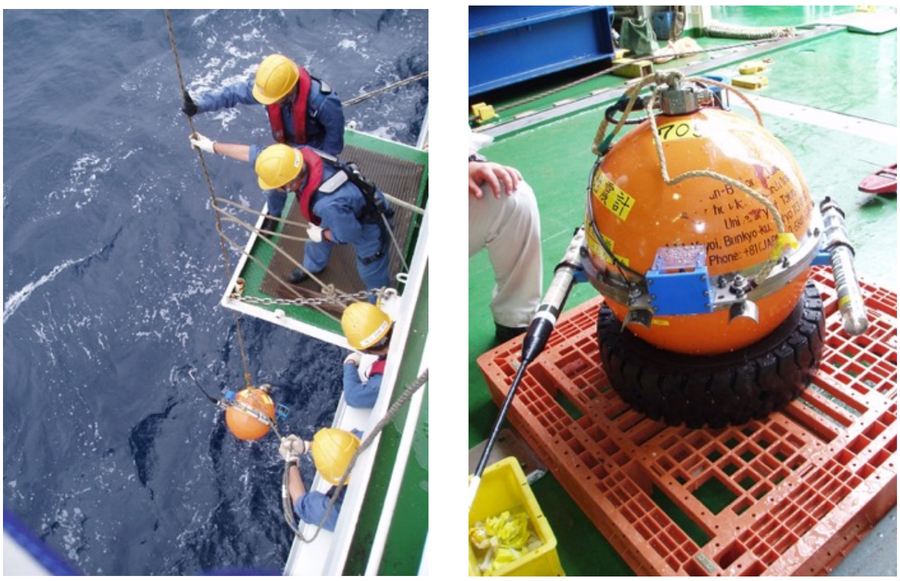

Fig. 6. LTOBSs recovered.

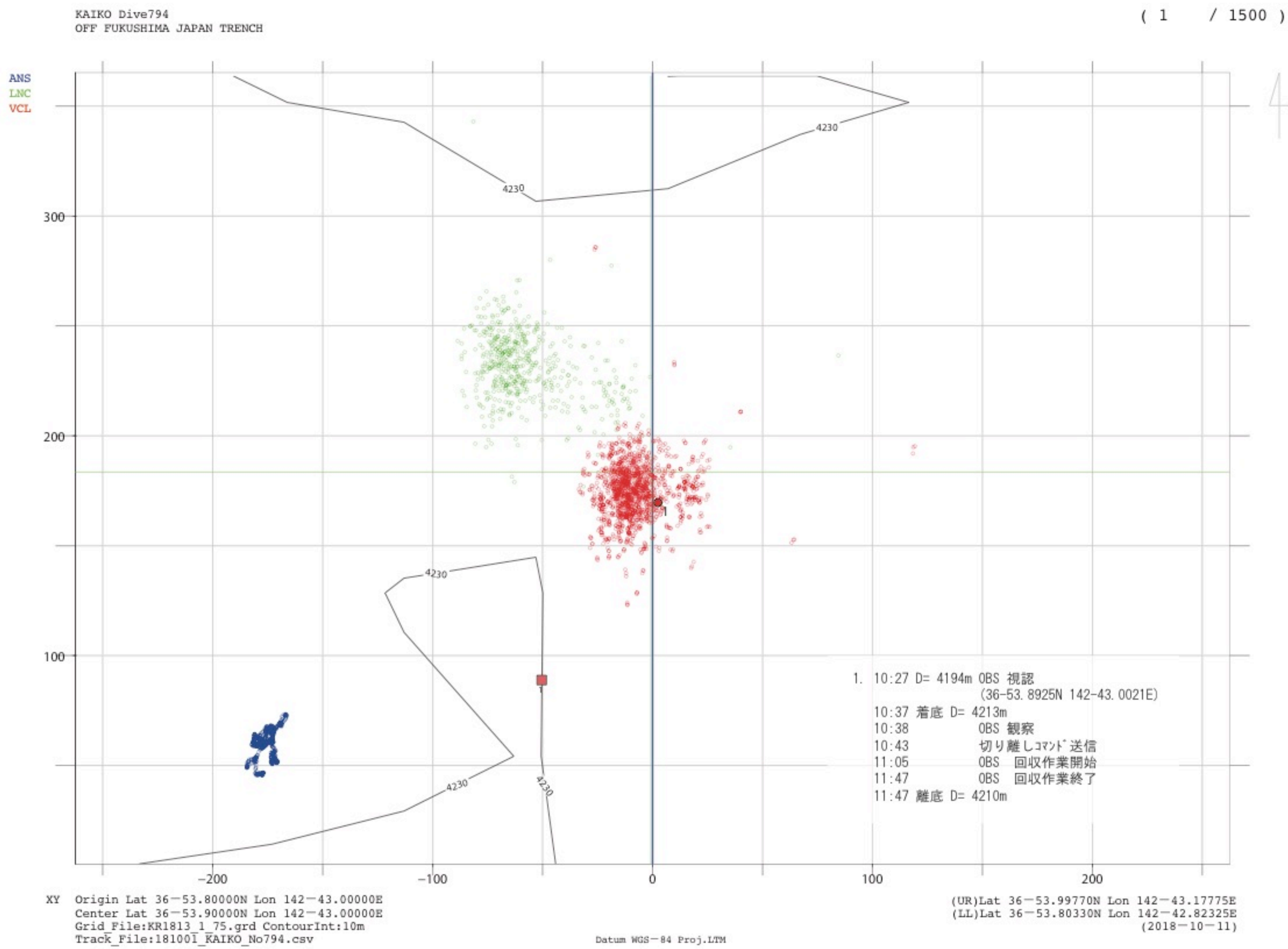

Fig. 7. The navigation map of KAIKO Mk-IV #794 dive.