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R/V *KAIMEI* Cruise Report

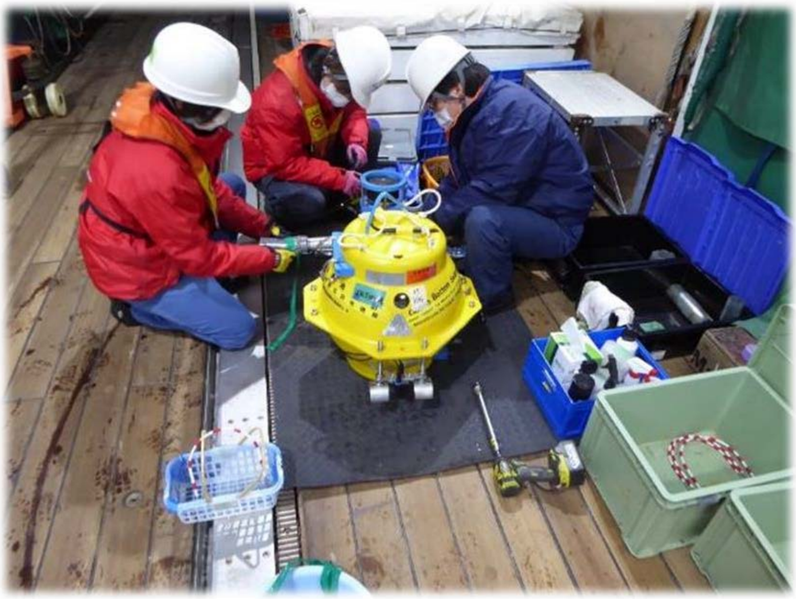
KM22-07

Wide-area 2-D seismic survey of earthquake source faults in and around the Kuril and Japan Trenches area

May. 26 - Jun. 17, 2022

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

Contents:



1. Cruise Information:

(1) **Cruise ID, Ship name:** KM22-07, R/V *KAIMEI*

(2) **Title of the cruise:** 2022 FY "Wide-area 2-D seismic survey of earthquake source faults in and around the Kuril-Japan Trenches area"

(3) **Proposal title:**
High precision wide-area survey of earthquake source faults: seismic survey and crustal activity observation

(4) **Cruise period, Port call:** 05/26/2022–06/17/2022, Yokosuka Headquarters to Yokosuka Headquarters

(5) **Research Area:** Off the Southeastern Hokkaido to off the Ibaraki Prefecture, Northwestern Pacific Ocean

(6) **Research Map:** Fig. 1

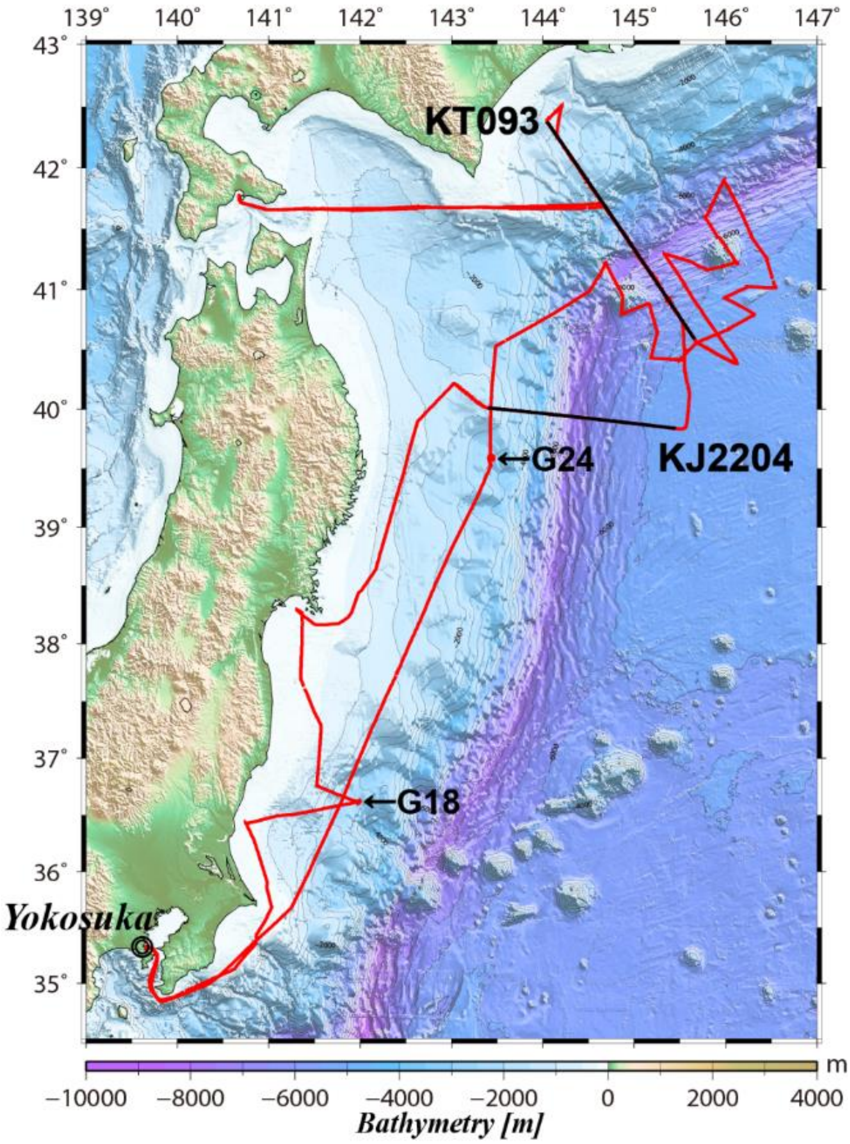


Fig. 1 Map of ship track during the KM22-07 cruise.

2. Researchers:

(1) Chief Scientists [Affiliation]:

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(2) Representative of Science Party [Affiliation]:

Seiichi MIURA [IMG/JAMSTEC]

(3) KM22-07 Shipboard Science Party:

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Ryo MIURA [IMG/JAMSTEC]: Vice-chief Scientist
Yue SUN [University of Tokyo]: Graduate student
Yuki OHWATARI [Nippon Marine Enterprises, Ltd. (NME)]: Chief marine technician
Masayuki TOIZUMI [NME]: Marine technician
Keita SUZUKI [NME]: Marine technician
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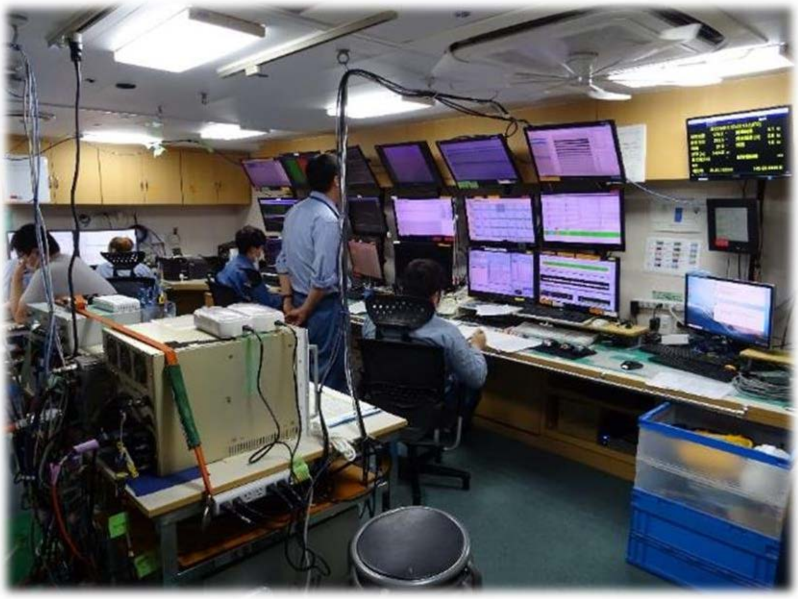
Taiki KAWANO [NME]: Marine technician



3. Overview Of Observations:

(1) Objective:

This survey's study areas are the Kuril Trench and the northern parts of the Japan Trench; there is a high tendency for large-magnitude earthquakes to occur in the subduction zones and outerrise areas of these regions (e.g., Earthquake Research Committee, 2019). In the past, such major earthquakes as the 1968 Tokachi–Oki Earthquake (M_J7.9), the 1994 Sanriku Earthquake (M_J7.6), and the 2003 Tokachi–Oki Earthquake (M_J8.0) have occurred around these survey areas. Recently, seismic activity has increased off the east coast of Aomori Prefecture (Uehira et al., 2021). In addition, the Seafloor Observation Network for Earthquakes and Tsunamis along the Japan Trench (S-net) has been deployed around the Japan and Kuril Trenches since the late 2010s (National Research Institute for Earth Science and Disaster Resilience, 2019), and new knowledge such as research on low-frequency tremor activity (Nishikawa et al., 2019; Tanaka et al., 2019) has been obtained. Moreover, source fault mapping and tsunami simulations have been performed on the basis of seismic and bathymetric surveys and seismic observation data around the outer-rise region of the Japan Trench (Baba et al., 2020). However, there is still a lack of crustal structure data for real-time tsunami predictions and earthquake cycle simulations in these trenches. This survey will be critical for determining structural changes from the Kuril Trench to the Japan Trench and gathering basic data on the possibility of large earthquakes occurring at this junction.

In the 2000s, JAMSTEC conducted the seismic surveys in the vicinity of these survey areas using R/V *KAIREI* and *KAIYO*. For example, based on ocean bottom seismograph (OBS) survey conducted using R/V *KAIYO*, Ito et al. (2004) investigated the geometry of the plate boundary off the eastern Aomori Prefecture, which includes the coseismic rupture zone of the 1994 Sanriku–Oki earthquake. Moreover, the results of the seismic surveys of the KR09-06 and KY09-03 cruises showed a markedly different seismic velocity structure in the Japan and Kuril Trenches, reflecting differences in the outerrise seismic activity that occurred near the two trenches (Fujie et al., 2019). Following the 2011 Tohoku–Oki earthquake, the R/V *YOKOSUKA* (YK16-17, YK18-12) conducted high-resolution seismic surveys across the bottom of the trench using a portable multichannel seismic reflection (MCS) system, and the seismic survey by the R/Vs *KAIREI* and *KAIMEI* also covered the area from southeast Hokkaido to the east of the Aomori Prefecture to investigate the crustal structure imaging of the plate boundary fault and outerrise faults in the subduction zone since 2019 (KR19-07, KM20-E02, and KM21-04 cruises).

In May–June 2022, a seismic survey was conducted from southeast Hokkaido to Iwate Prefecture. Additionally, OBSs for earthquake observation, deployed around the outer slopes of the Kuril Trench off the southeastern Hokkaido during the YK22-07 cruise in April 2022, were recovered. Additionally, we observed seafloor crustal movements at two sites to elucidate the interplate coupling and stress accumulation process around the Japan Trench.

(2) List of observational instruments:

1) MCS survey (Figs. 2–4):

MCS surveys were conducted along the line KJ22204, with a total length of approximately 176 km.

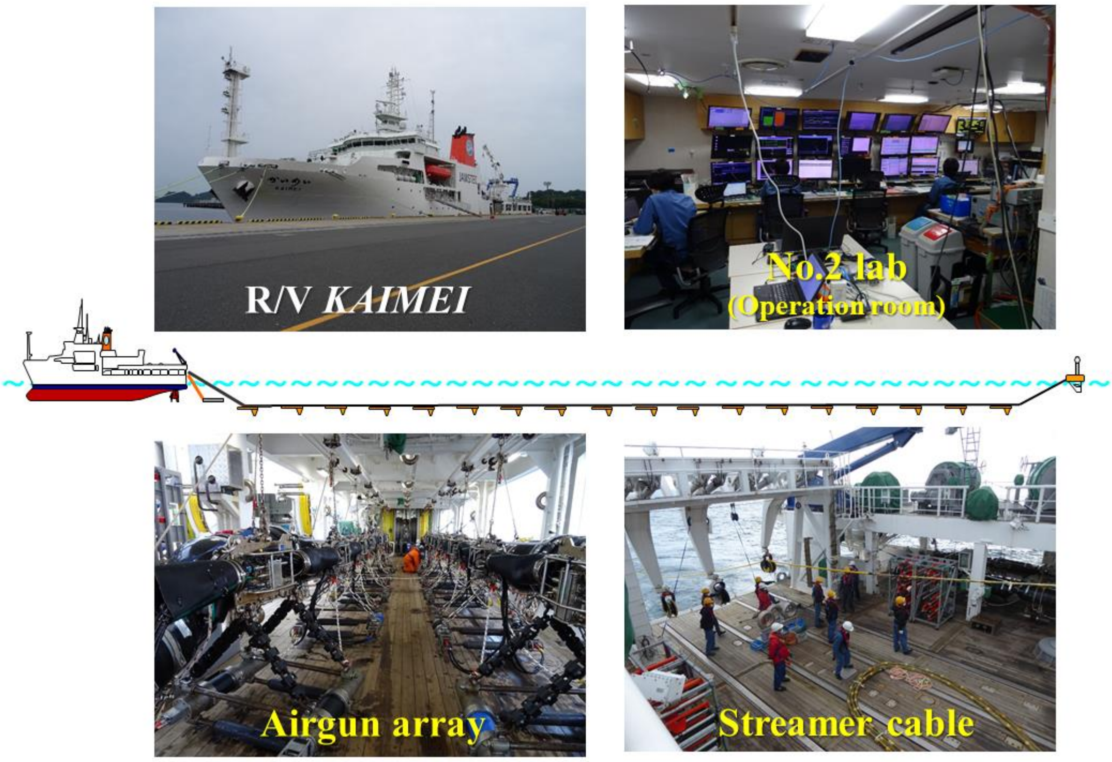


Fig. 2 Seismic system on R/V *KAIMEI*.

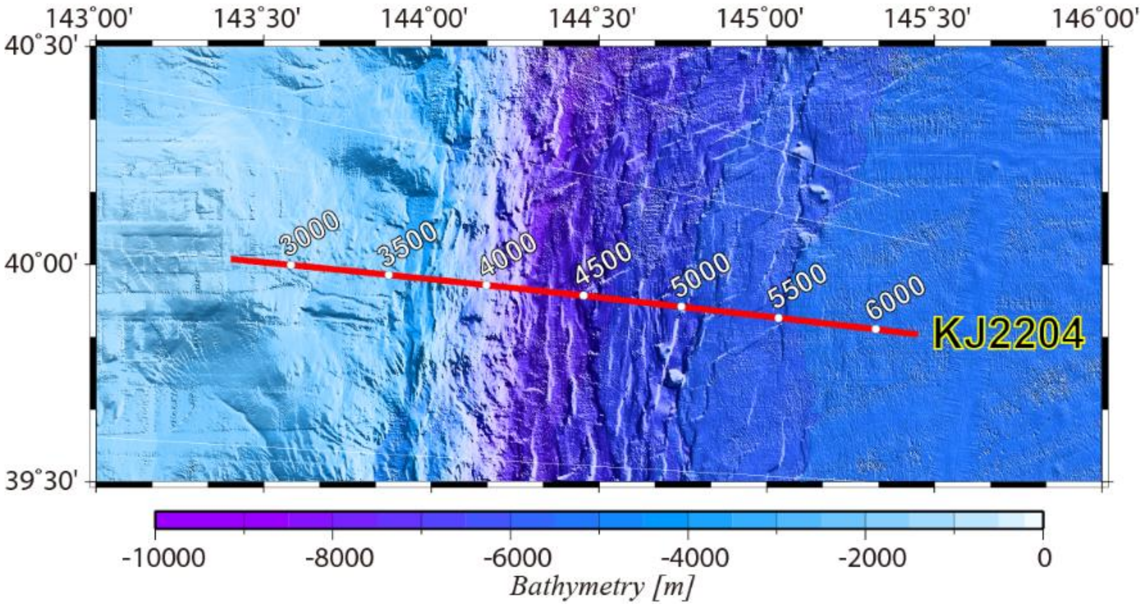


Fig. 3 Location map showing the MCS lines (solid red line) of this cruise. The white numbers indicate the shot point number.

a) Source:

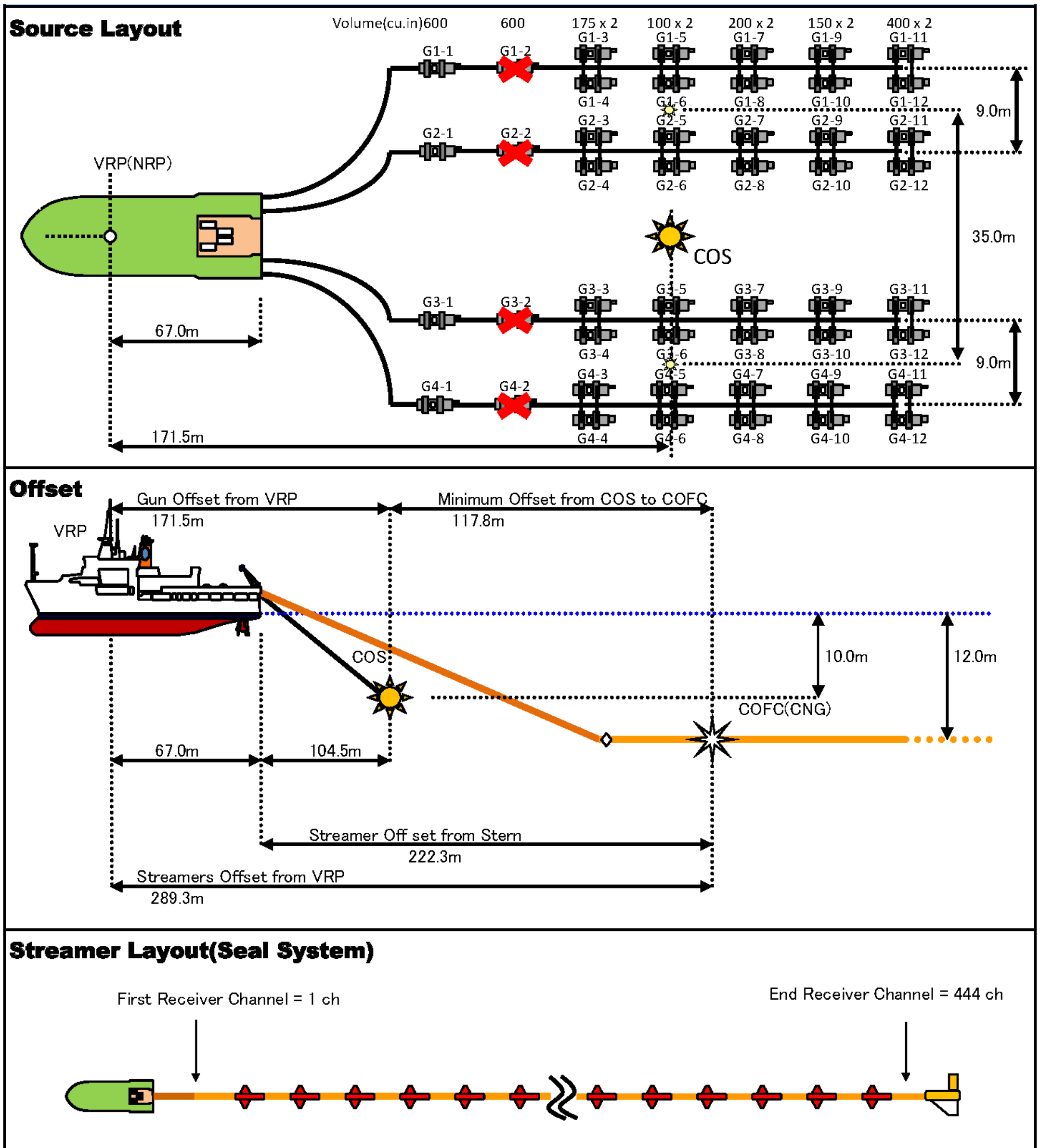
To obtain superior-quality MCS data, we shot an air gun array with a spacing of 50 m. The tuned air gun array had a maximum total volume of 10,600 cubic inches (approximately 87 L) and consisted of 44 air guns (Bolt Long Life Air Gun). The standard air pressure was 2,000 psi (approximately 14 MPa). During the experiment, the air gun array depth was maintained at 10 m below the sea surface. More information about the towing geometry is shown in Fig. 4.

b) Receiver:

During the air gun shooting, we towed a hydrophone streamer cable with a group interval of 12.5 m (Sentinel Digital Streamer System, Sercel Inc.). Signals from eight sensors in the same group (channel) were stacked before A/D conversion. The towing depth of the streamer cable was maintained at 12 m below the sea surface using depth controllers called Bird (ION DigiCOURSE streamer depth controllers).

c) Recording and navigation systems

A Sercel Seal System, constructed by Sercel Inc., was used in this survey, which collected seismic data on a hard disk in the SEG-D 8058 Rev.1 format. The system delay was set to 200 ms, the sampling rate was 2 ms, and the recording length was 16 s. A differential global positioning system was used to determine the accurate positions. We adopted Fugro's StarFix_G2 as the primary positioning system and backup. We used ORCA (ION) as navigation software for seismic data acquisition. Shot times and points were set on the ORCA, and a trigger signal was sent to the recording system and the gun controller (SeaMap GunLink2500). The navigation parameters are as follows: the survey datum was WGS84, the map projection was UTM, and the UTM zone parameter was 55 N.



Bird																					
No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	No.11	No.12	No.13	No.14	No.15	No.16	No.17	No.18	No.19	No.20	No.21	–
–	ch	ch	ch	ch	ch	ch	ch	ch	ch	ch	ch	ch	ch	ch	ch	ch	ch	ch	ch	ch	–
HESA	001 – 012	013 – 024	037 – 048	061 – 072	085 – 096	097 – 108	121 – 132	145 – 156	169 – 180	193 – 204	217 – 228	241 – 252	265 – 276	289 – 300	313 – 324	337 – 348	361 – 372	385 – 396	421 – 432	TES	–

VRP : Vessel Reference Point
COS : Center of Source
COFC : Center of First Receiver Channel
WB : Water Break hydrophone

Fig. 4 Vessel towing geometry during this seismic survey. The top figure shows the source (air gun system) layout, the middle figure represents the source–receiver depth and position and navigation offsets, and the bottom figure shows the streamer cable configuration during the MCS survey.

d) Onboard processing of MCS data:

Raw MCS data from the study areas were processed onboard for quality control. Onboard data processing was performed in the conventional processing sequence, which included trace header edit, common midpoint (CMP) binning with an interval of 6.25 m, bandpass filter, datum correction, amplitude compensation, predictive deconvolution, velocity analysis, normal moveout correction, multiple suppression, mute, CMP stack, and time migration (Fig. 5).

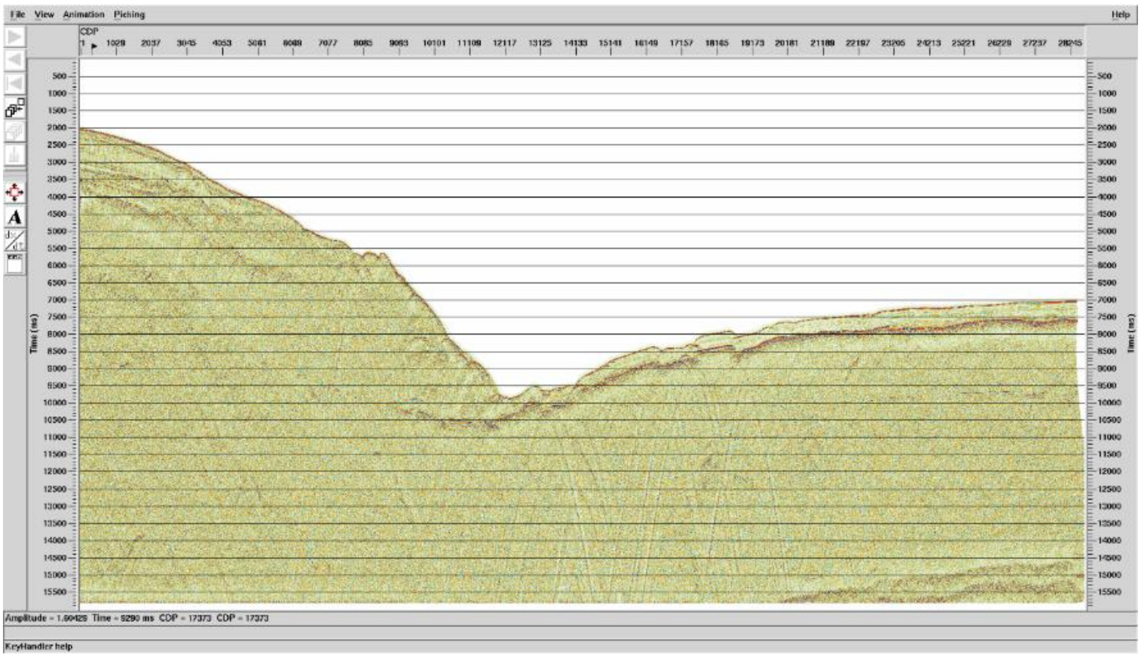


Fig. 5 Example of MCS imaging with onboard processing on the KJ2204 line.

2) Seismic survey using OBSs

The seismic survey using OBSs was conducted along the line KT093 (Fig. 6). The air gun array in this survey was placed in almost the same configuration as that in the MCS survey (Fig. 3), and we shot an air gun array with a spacing of 200 m.

78 OBSs (Sites 1–78) for the seismic survey were deployed on the YK22-07 cruise. Two types of OBSs were used depending on the depth of the water in which they were deployed. Type "K" OBSs (Shinohara et al., 1993; Kanazawa and Shiobara., 1994) were used for depths shallower than 6000 m (Tables 1 and 5), and Type "U" OBSs (Asakawa et al., 2012) were used for depths deeper than 6000 m (Tables 2 and 5). OBSs were retrieved during this cruise. Fig. 7 shows examples of record sections for OBSs (Sites 30 and 60).

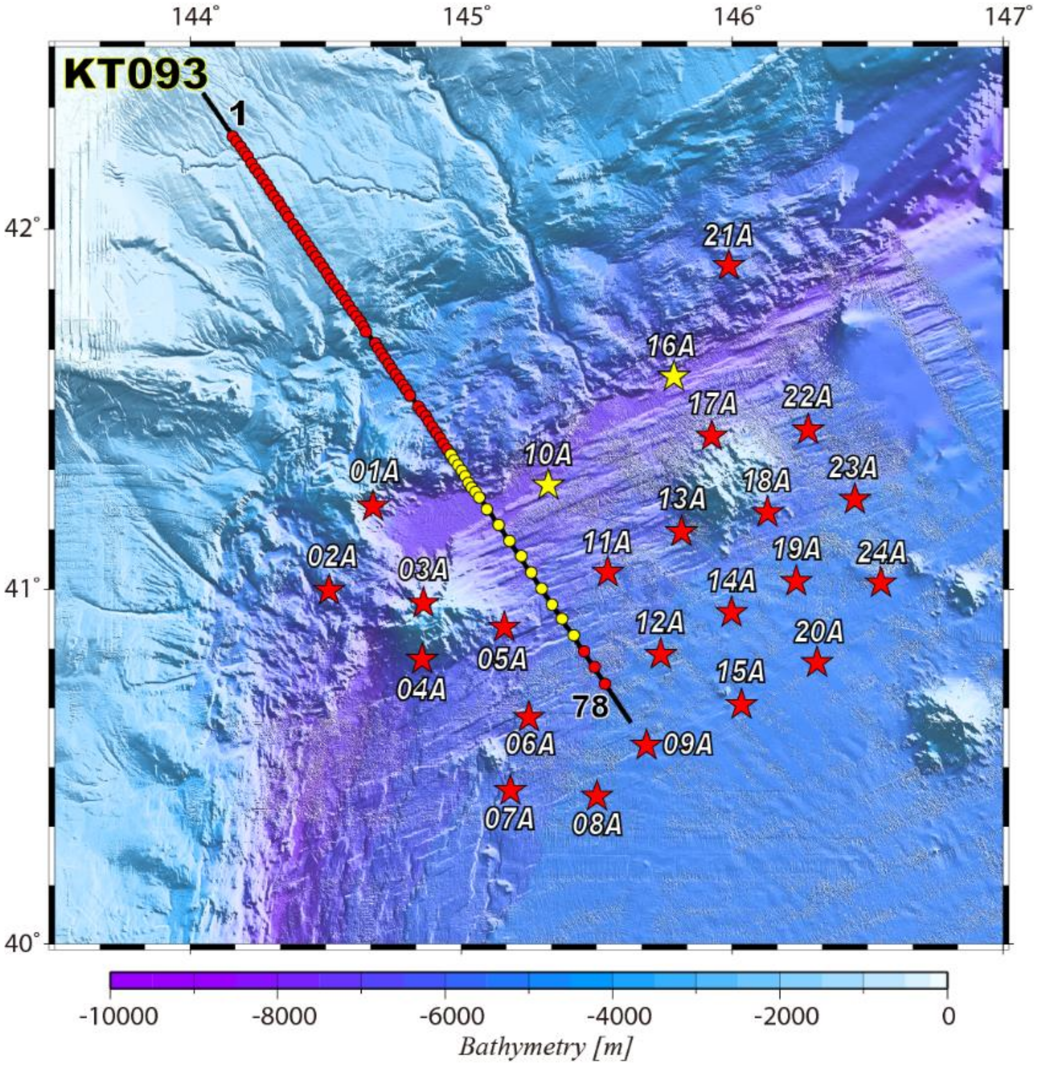


Fig. 6 Location maps of OBS sites. The black line represents the line KT093, and circles represent the positions of OBS sites for seismic survey (red: Type K; yellow: Type U). Stars represent OBSs for earthquake observation (red: Type K; yellow: Type U).

Type	POBS-150, Katsujima Co., LTD.
Maximum Depth	6000 m
Dimension (w/ anchor)	120 * 100 * 52 cm
Weight (w/ anchor)	101 kg in air, 46 kg in water (Site1–57,75–78, JKT01A–09A, 11A–15A, 17A–24A)
Sensor	Three-component Geophone [One vertical and two horizontal components, Natural frequency: 4.5Hz, Sensitivity:0.8V/inch/s (OPEN)] & Hydrophone
Recorder	SPM2, Nippon Marine Enterprises, Ltd.
Recording System	Sampling continuously (Timer control is possible for start time)
Sampling Rate	24 bit, 250Hz
Power	Lithium-Ion Rechargeable Battery
Acoustic Communication & Release System	Electric corrosion method
Attached Parts	Weight, Flash light, Radio beacon
Pressure Resistant Container	17 inch glass sphere

Table 1 Specifications of OBS of Type K.

Type	UD (ultra-deep) - OBS [made by JAMSTEC/Kyocera/NME (Site 67–74, JKT10A, JKT16A), made by NME (Site 58–66)]
Maximum Depth	11000 m
Dimension (w/ anchor)	120 * 100 * 65 cm
Weight (w/ anchor)	104 kg in air, 47 kg in water (Site67–74, JKT10A, JKT16A), 106 kg in air, 46 kg in water (Site58–66)
Sensor	Three-component Geophone [One vertical and two horizontal components, Natural frequency: 4.5Hz, Sensitivity:0.8V/inch/s (OPEN)] & Hydrophone
Recorder	SPM2, Nippon Marine Enterprises, Ltd.
Recording System	Sampling continuously (Timer control is possible for start time)
Sampling Rate	24 bit, 250Hz
Power	Lithium-Ion Rechargeable Battery
Acoustic Communication & Release System	Electric corrosion method
Attached Parts	Weight, Flash light, Radio beacon
Pressure Resistant Container	445 mm ceramic sphere

Table 2 Specifications of OBS of Type U.

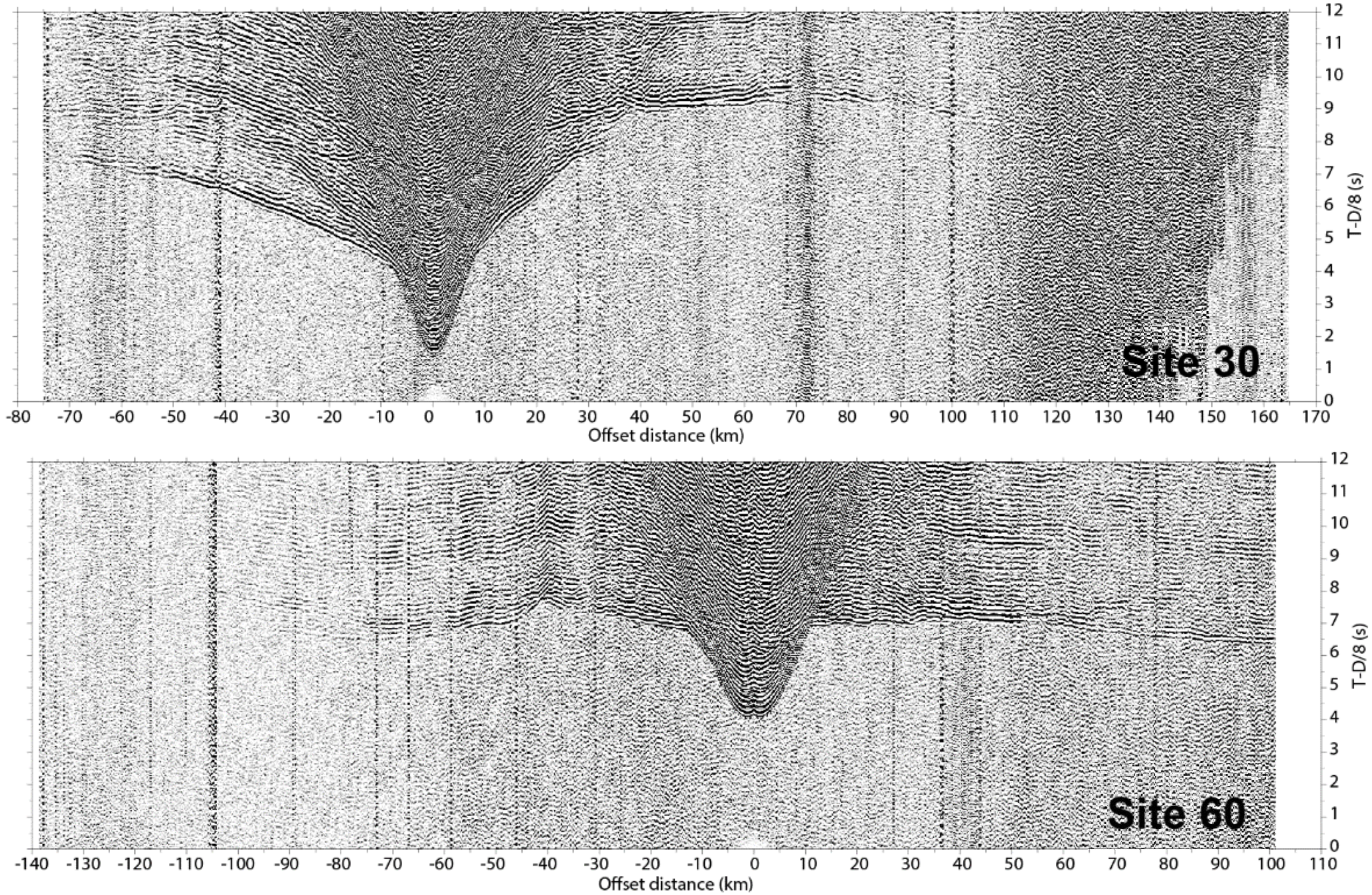


Fig. 7 Examples of record sections for OBSs on the vertical component (Site 30 [upper] and 60 [lower]).

3) Recovery of OBSs for earthquake observation

24 OBSs (Sites JKT01A–JKT24A) for earthquake observation, which were deployed around the outer slopes of the Kuril Trench off southeastern Hokkaido during the YK22-07 cruise in April 2022, were recovered (Table 5). Two types of OBSs, Type "K" and Type "U," were used depending on the depth of the water in which they were deployed as with the seismic survey along the line KT093 (Fig. 5; Tables 1 and 2).

4) Observation of seafloor crustal movements

We conducted positioning observations at the submarine crustal deformation observation stations located around the Japan Trench using a crustal deformation sensor (ship's bottom transducer) and a GPS antenna mounted on the R/V *KAIMEI*. The observations were conducted at the central fixed point, and moving observations (approximately 4.0 knots) were performed on the circumference with a diameter equal to the water depth below the observation point. One XCTD observation was performed at each observation point. The observation points considered during this cruise were G24 (off the Iwate Prefecture) and G18 (off the Ibaraki Prefecture) (Fig 7).

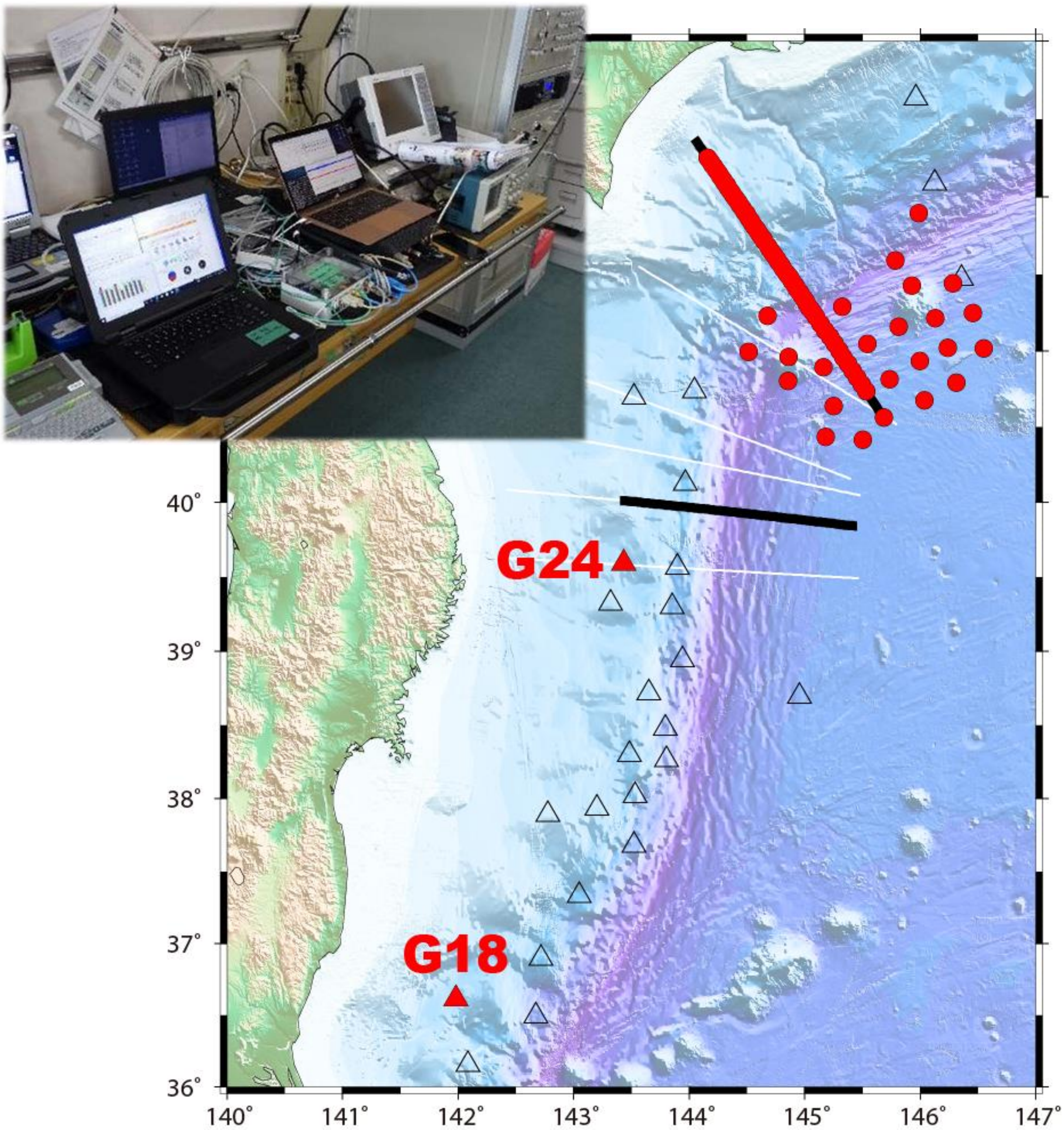


Fig. 7 Location map of seafloor crustal movement observation points (red squares). The photo on the top left is a seafloor crustal movement observation system installed in Laboratory No. 1 during this cruise.

5) Bathymetric, magnetic, and XCTD/XBT surveys

Bathymetric and magnetic data were continuously recorded during the survey. The bathymetric survey on R/V *KAIMEI* used a multi-narrow beam echo sounder (EM122 [Deep water type], Kongsberg) (Fig. 8). The magnetic survey used a three-component magnetometer (SFG-2015, Tiera Technica Corporation). In addition, XCTD surveys were conducted when the MCS system was not towed and seafloor crustal movement observations were performed.

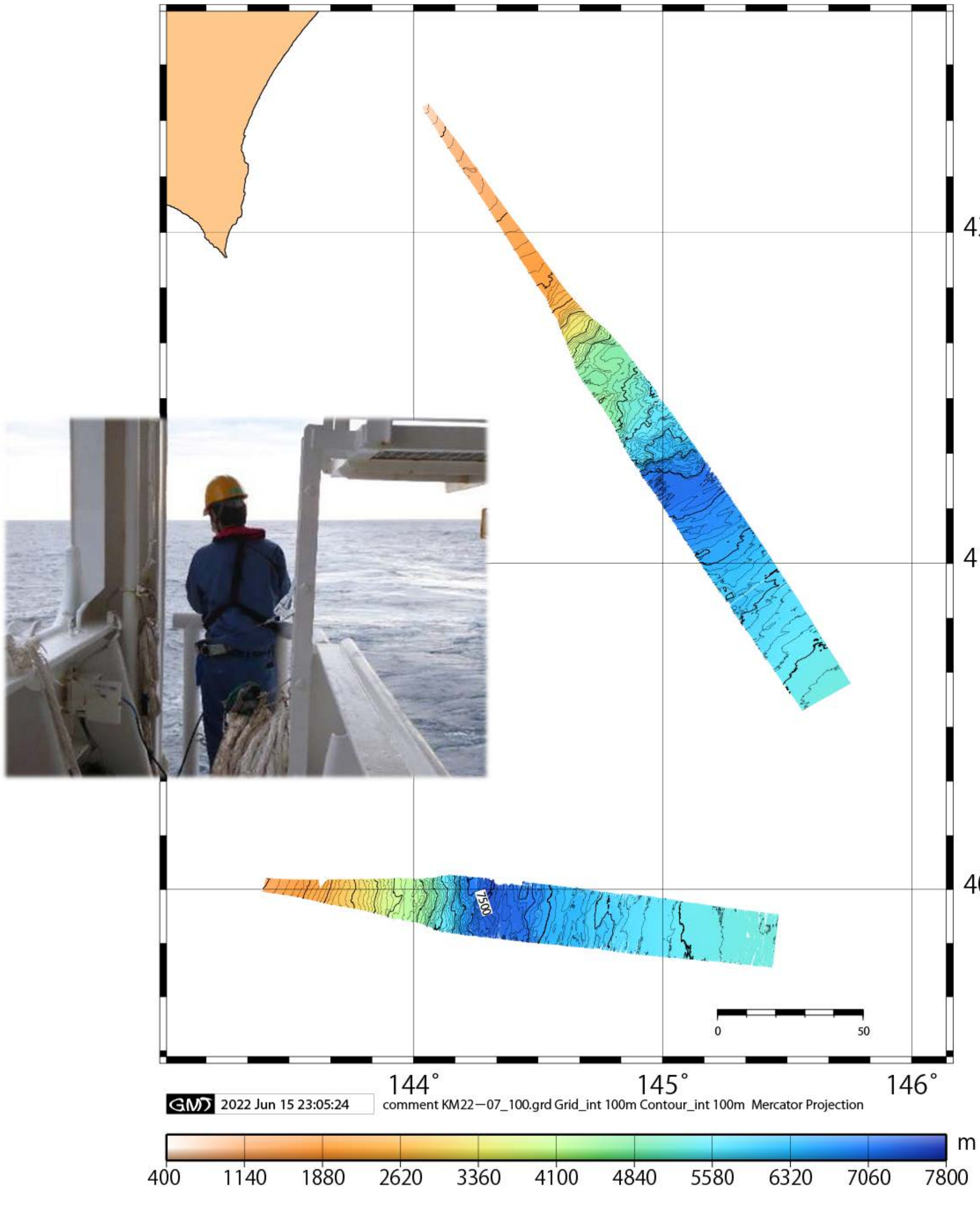


Fig. 8 Map of the result of the bathymetric survey during this cruise. The photo on the middle left is a scene of the XCTD observation at the stern.

(3) **Cruise log:** Table 3

Date		Remarks
5/26/2022	Thu	Departure from Yokosuka port (JAMSTEC wharf). Wait on weather off Yokosuka.
5/27/2022	Fri	Transit to the survey area.
5/28/2022	Sat	Transit to the survey area. Seafloor geodetic observation (G24).
5/29/2022	Sun	Seafloor geodetic observation (G24). OBS retrieval (JKT02A, 01A, 03A).
5/30/2022	Mon	OBS retrieval (JKT04A, 05A, 06A, 07A, 08A, 09A, 15A, 20A).
5/31/2022	Tue	OBS retrieval (JKT14A, 19A, 24A, 23A, 22A, 21A, 16A).
6/1/2022	Wed	OBS retrieval (JKT17A, 18A, 13A, 10A, 11A, 12A).
6/2/2022	Thu	Airgun system deployment. Airgun shooting (KT093 [SE to NW], 200 m shot interval).
6/3/2022	Fri	Airgun shooting (KT093 [SE to NW], 200 m shot interval). Airgun system retrieval.
6/4/2022	Sat	OBS retrieval (Site1-26).
6/5/2022	Sun	OBS retrieval (Site27-37). Transit to the waiting area.
6/6/2022	Mon	Transit to the waiting area. ADCP survey through the Eastern Tsugaru Strait. Wait on weather in Hakodate Bay.
6/7/2022	Tue	Wait on weather in Hakodate Bay. Transit to the survey area. ADCP survey through the Eastern Tsugaru Strait.
6/8/2022	Wed	Transit to the survey area. OBS retrieval (Site38-51).
6/9/2022	Thu	OBS retrieval (Site52-67).
6/10/2022	Fri	OBS retrieval (Site68-77).
6/11/2022	Sat	OBS retrieval (Site78). MCS system deployment, MCS survey (KJ2204 [E to W], 50 m shot interval).
6/12/2022	Sun	MCS survey (KJ2204). MCS system retrieval. Transit to the waiting area.
6/13/2022	Mon	Wait on weather in Ishinomaki Bay.
6/14/2022	Tue	Transit to the survey area. Seafloor geodetic observation (G18).
6/15/2022	Wed	Seafloor geodetic observation (G18). Transit to Yokosuka port.
6/16/2022	Thu	Transit to Yokosuka port.
6/17/2022	Fri	Arrival at Yokosuka port (JAMSTEC wharf). End of KM22-07 cruise.

Table 3 Cruise log of KM22-07.

(5) Seismic line list: Table 4

LINE NAME	DATE (UTC)	TIME (UTC)	F.S.P. / F.G.S.P. / L.G.S.P. / L.S.P.	VESSEL POSITION Lat.	VESSEL POSITION Lon.	Depth (m)	LENGTH FGSP - LGSP (km)	DIRECTION (°)
KT093 (OBS)	06/02/2022	02:56:00	2200	40_35.41110'N	145_39.45270'E	5315	239.8	327.3
	06/02/2022	02:56:00	2200	40_35.41110'N	145_39.45270'E	5315		
	06/03/2022	06:25:54	1001	42_22.60806'N	144_02.70354'E	755		
	06/03/2022	06:25:54	1001	42_22.60806'N	144_02.70354'E	755		
KJ2204 (MCS)	06/11/2022	06:17:02	6216	39_50.40474'N	145_26.93310'E	5296	176.2	277.9
	06/11/2022	06:17:02	6216	39_50.40474'N	145_26.93310'E	5296		
	06/12/2022	04:00:25	2693	40_00.79680'N	143_24.03372'E	1490		
	06/12/2022	04:00:25	2693	40_00.79680'N	143_24.03372'E	1490		

Table 4 List of seismic survey lines.

(6) OBS position list: Table 5

Site	Lat.		Lon.		Depth (m)	Type	Site	Lat.		Lon.		Depth (m)	Type
1	42	15.315	144	9.457	1119	K	31	41	48.184	144	34.381	2362	K
2	42	14.438	144	10.312	1150	K	32	41	47.308	144	35.194	2417	K
3	42	13.550	144	11.161	1184	K	33	41	46.467	144	35.965	2516	K
4	42	12.646	144	12.011	1189	K	34	41	45.572	144	36.814	2752	K
5	42	11.919	144	12.825	1234	K	35	41	44.702	144	37.642	3100	K
6	42	10.862	144	13.579	1280	K	36	41	43.808	144	38.426	3215	K
7	42	9.938	144	14.468	1225	K	37	41	43.009	144	38.963	3303	K
8	42	9.118	144	15.312	1258	K	38	41	41.120	144	41.034	3737	K
9	42	8.222	144	16.116	1286	K	39	41	40.246	144	41.652	4038	K
10	42	7.323	144	16.934	1320	K	40	41	39.361	144	42.403	4428	K
11	42	6.401	144	17.728	1345	K	41	41	38.555	144	43.137	4633	K
12	42	5.516	144	18.536	1369	K	42	41	37.639	144	43.955	4706	K
13	42	4.662	144	19.492	1412	K	43	41	36.765	144	44.714	4746	K
14	42	3.739	144	20.080	1447	K	44	41	35.927	144	45.526	4749	K
15	42	2.853	144	21.023	1497	K	45	41	35.071	144	46.327	4697	K
16	42	1.948	144	21.811	1532	K	46	41	34.155	144	47.137	4755	K
17	42	0.710	144	22.966	1575	K	47	41	33.321	144	47.939	4870	K
18	41	59.837	144	23.789	1611	K	48	41	32.427	144	48.700	4928	K
19	41	58.936	144	24.608	1654	K	49	41	30.557	144	50.485	4980	K
20	41	58.058	144	25.412	1676	K	50	41	29.730	144	51.243	4983	K
21	41	57.149	144	26.216	1729	K	51	41	28.943	144	52.196	5204	K
22	41	56.279	144	27.046	1782	K	52	41	28.045	144	52.874	5214	K
23	41	55.384	144	27.871	1828	K	53	41	27.134	144	53.711	5292	K
24	41	54.461	144	28.692	1858	K	54	41	26.214	144	54.522	5447	K
25	41	53.589	144	29.518	1881	K	55	41	25.313	144	55.329	5499	K
26	41	52.704	144	30.320	1928	K	56	41	24.365	144	56.065	5540	K
27	41	51.776	144	31.121	1976	K	57	41	23.459	144	56.909	5645	K
28	41	50.886	144	31.949	1994	K	58	41	22.551	144	57.711	5937	U
29	41	49.993	144	32.761	2065	K	59	41	21.639	144	58.529	6060	U
30	41	49.101	144	33.608	2181	K	60	41	20.755	144	59.350	6276	U

Table 5 List of OBS positions. The coordinate values were estimated from the super short base line (SSBL) positioning system during YK22-07 cruise.

Site	Lat.		Lon.		Depth (m)	Type	Site	Lat.		Lon.		Depth (m)	Type
61	41	19.865	145	0.131	6178	U	JKT01A	41	13.905	144	40.507	5731	K
62	41	18.949	145	0.870	6489	U	JKT02A	40	59.810	144	30.777	5662	K
63	41	17.819	145	1.658	6975	U	JKT03A	40	57.645	144	51.724	4523	K
64	41	17.063	145	2.302	6886	U	JKT04A	40	48.204	144	51.390	5748	K
65	41	16.306	145	3.190	7011	U	JKT05A	40	53.589	145	9.619	5923	K
66	41	15.411	145	4.054	7186	U	JKT06A	40	38.418	145	14.981	5795	K
67	41	13.440	145	5.734	7180	U	JKT07A	40	26.043	145	10.943	5746	K
68	41	10.790	145	8.263	7094	U	JKT08A	40	25.081	145	30.022	5380	K
69	41	8.130	145	10.694	6874	U	JKT09A	40	33.730	145	41.066	5277	K
70	41	5.552	145	13.324	6720	U	JKT10A	41	17.417	145	19.337	7052	U
71	41	2.817	145	15.574	6533	U	JKT11A	41	2.832	145	32.466	5935	K
72	41	0.140	145	17.864	6356	U	JKT12A	40	48.975	145	44.190	5411	K
73	40	57.420	145	20.082	6142	U	JKT13A	41	9.636	145	48.810	5832	K
74	40	55.024	145	22.314	6099	U	JKT14A	40	56.057	145	59.892	5317	K
75	40	52.254	145	24.898	5925	K	JKT15A	40	40.583	146	2.039	5223	K
76	40	49.533	145	27.208	5787	K	JKT16A	41	35.497	145	47.083	7286	U
77	40	46.910	145	29.538	5653	K	JKT17A	41	25.639	145	55.491	5917	K
78	40	44.116	145	31.802	5557	K	JKT18A	41	12.888	146	7.841	5476	K
							JKT19A	41	1.304	146	14.217	5355	K
							JKT20A	40	47.681	146	18.773	5212	K
							JKT21A	41	53.966	145	59.291	5827	K
							JKT22A	41	26.672	146	16.848	5723	K
							JKT23A	41	15.078	146	27.225	5464	K
							JKT24A	41	1.092	146	32.926	5293	K

Table 5 (Continued) List of OBS positions. The coordinate values were estimated from the SSBL positioning system during YK22-07 cruise.

4. Notice on using:

This cruise report is a preliminary documentation as of the end of cruise.

This report is not necessarily corrected even if there is any inaccurate description (i.e. taxonomic classifications). This report is subject to be revised without notice. Some data on this report may be raw or unprocessed. If you are going to use or refer the data on this report, it is recommended to ask the Chief Scientist for latest status.

Users of information on this report are requested to submit Publication Report to JAMSTEC.

http://www.godac.jamstec.go.jp/darwin/explain/1/e#report

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