



“KAIYO” Cruise Report

KY13-15

Experiments of underwater acoustic technology,

Suruga-Bay, North part of Nankai Trough and

Sagami-Bay

11/Oct./2013 – 23/Oct./2013

Japan Agency for Marine-Earth Science and Technology

(JAMSTEC)

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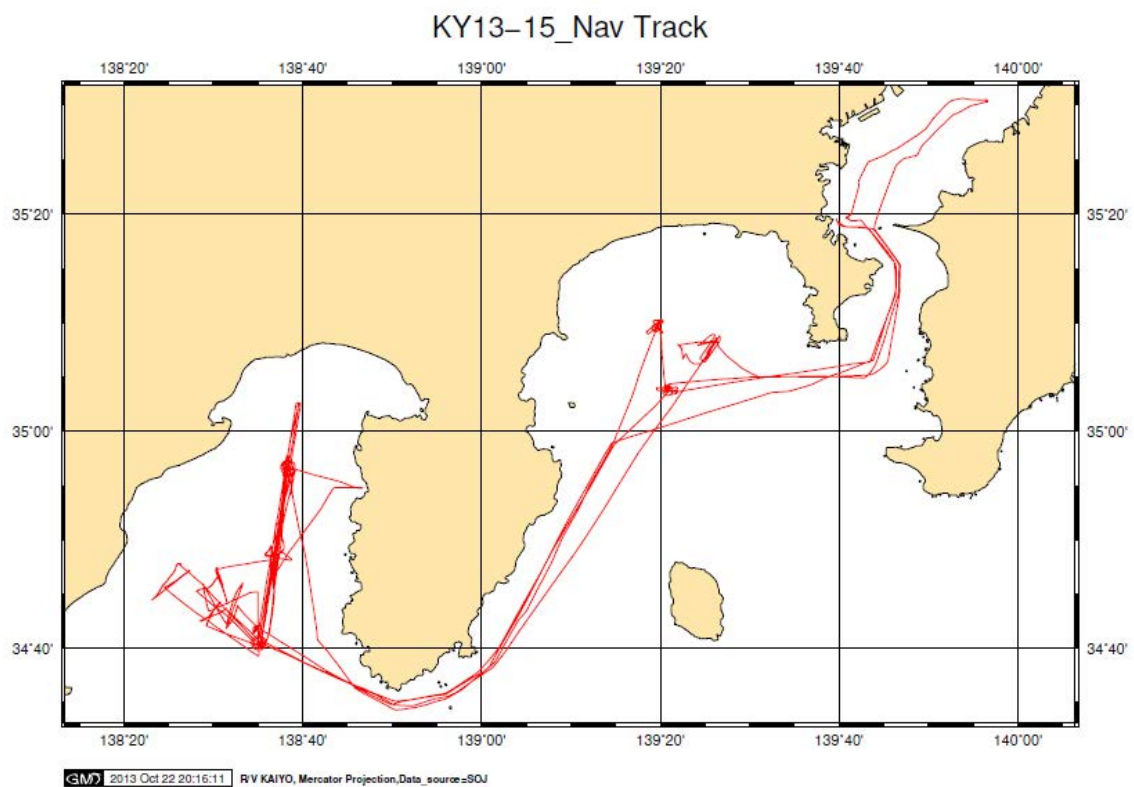
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1. Cruise Information

- Cruise ID: KY13-15
- Name of vessel R/V KAIYO
- Title of the cruise Experiments of underwater acoustic technology
- Title of proposal
 - R&D for navigation of AUV by ISSBL with acoustic data transmission.
 - Experimental research for acoustic communication by phase conjugate wave, source tracking by inverse analysis and deep sea seismic.
- Cruise period 11/Oct./2013 – 23/Oct./2013
- Ports of call Yokosuka (Sumitomo Heavy Industry)
- Research area Suruga-Bay, North part of Nankai Trough and Sagami-Bay
- Research Map



2. Researchers

- Chief scientist [Affiliation] Hiroshi OCHI [JAMSTEC]
- Representative of the science party [Affiliation] Yoshitaka WATANABE [JAMSTEC]
Takuya SHIMURA [JAMSTEC]
- Science party [Affiliation, assignment etc.]
Hiroshi OCHI, Takuya SHIMURA, Yoshitaka WATANABE, Mitsuyasu DEGUCHI, Yukihiro KIDA and Takami MORI [JAMSTEC]
Keisuke MATSUMOTO, Tomoyuki TAKAMORI, Hiroki USHIROMURA [Marine Works Japan. LTD]

3. Purpose

Our group is researching and developing precise navigation system using inverse super short baseline (ISSBL), and long-range acoustic communication using time-reversal wave. In this cruise, our purposes are

1. To obtain data of propagated acoustic wave for ISSBL.
2. To obtain data of propagated acoustic wave for long-range acoustic communication in single / multi user.
3. To obtain data of propagated acoustic wave for source tracking.

And to get XBT and sound speed profile data are also the purposes of this cruise.

4. Experiment

4.1 ISSBL (Inverse Super Short Base-Line)

In our group, ISSBL for navigation of autonomous underwater vehicle (AUV) has been researched in these years as one of the solution to measure precise positioning. In this cruise, experiment of ISSBL was carried out. Acoustic signal for ISSBL was transmitted from surface ship to moored receiver (Fig.1).

A photo of a moored receiver as shown in Fig.2. Four hydrophones are mounted at vertices of top side square for receiving acoustic signal. Received signals are saved to SD card, which is inside of the pressure canister, after signal conditioning and digitizing. Obtained data is analyzing now.

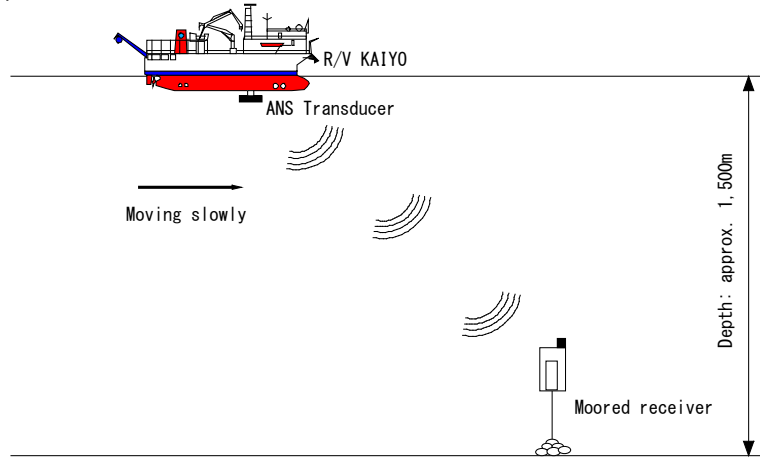


Fig.1 Configuration of experiment.

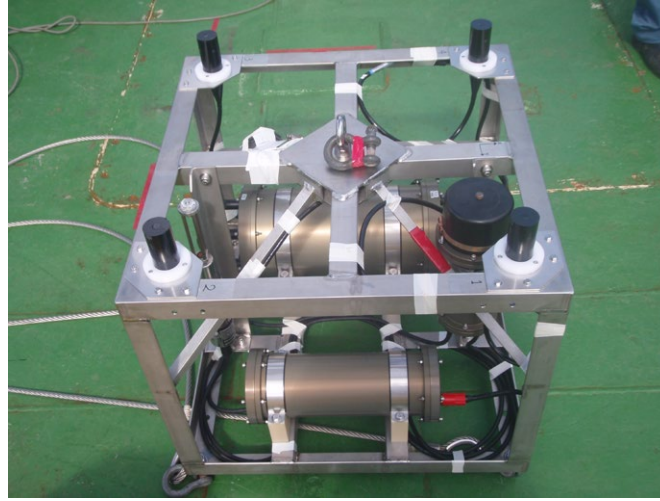


Fig.2 A moored receiver.

4.2 Multi-user communication by time reversal

In our group, time-reversal communication has been researched in these years. The inter-symbol interference (ISI) due to rich multipath environment inherent in the ocean acoustic propagation is the major problem for underwater acoustic communication. Spatial and temporal focusing of time reversal removes such ISI by collecting multipath signals. In other words, time reversal can turn multipath signals as obstacles into a benefit. Moreover, time reversal can be applied to multiuser communication. Additionally, time reversal is an attractive solution to achieve multiuser communication. By its spatial focusing, signals from sources at different positions can be separated each other by the same processing in the single user case without sacrificing throughput, and more complex multipath arrivals give better crosstalk cancellation.

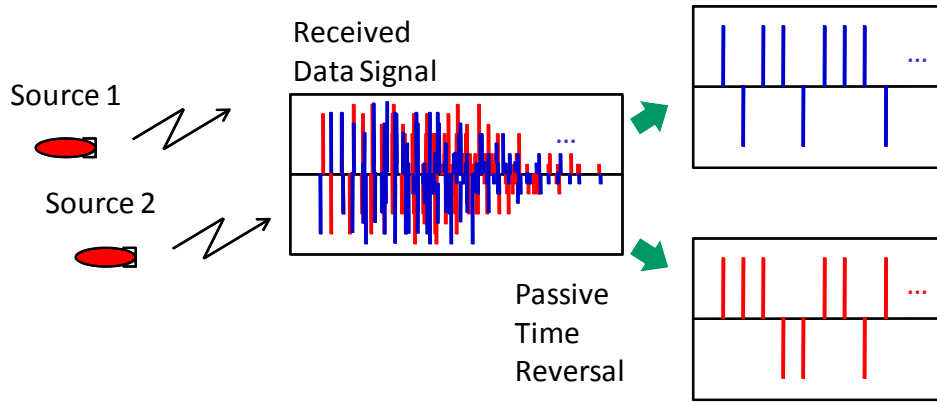


Fig.3 Schematic of multi-user communication by time reversal.

The experiment described in this cruise was carried out in Suruga-bay, as illustrated in Fig. 3. A 20-channels vertical receiver array with element spacing ~ 6 m was moored, at the depth of around 1,000 m. And the low-frequency source, whose source levels were 197 dB re $1 \mu\text{Pa}$, were used with the bandwidth from 450 to 550 Hz. The source was suspended at the range of 45 km from research vessel, whose depth was changed to 200 to 1,400 m at the step of 100 m. The measured signals from various positions were synthesized to create signals "multi-user", and the synthesized signals are processed by time reversal.

The figure 4 shows one of demodulated results, in which the signals from 700 and 800 m depth. This shows that time reversal can separate the signals from two positions well and error-free demodulation achieve.

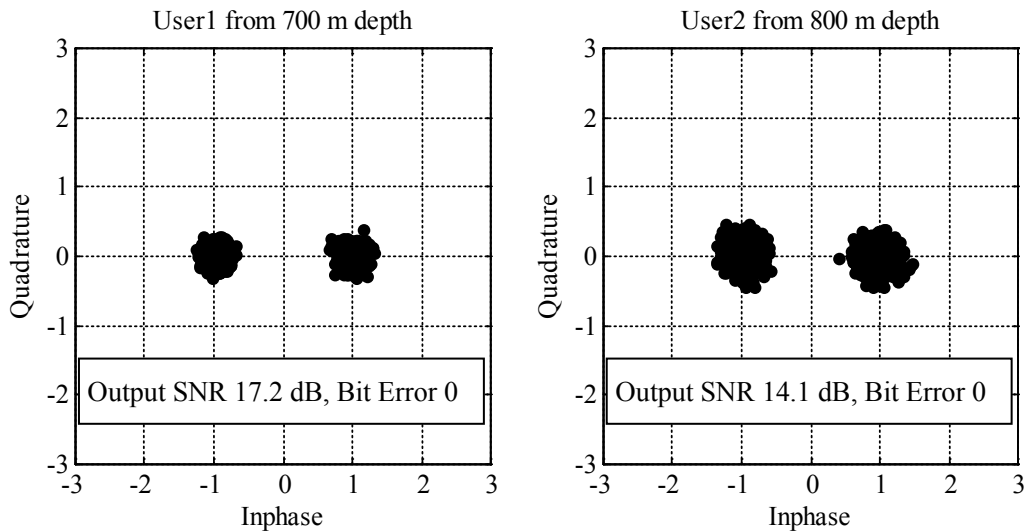


Fig.4 An example of results of time-reversal multi-user communication.

4.3 Source tracking

In this cruise, we have tried to obtain data for source tracking, and it was carried out. Obtained signals were transmitted from drifting low frequency (500 Hz) source, and were received moored hydrophone array. Example of correlated data in each element of hydrophone array is shown in Fig.5. That experiments were executed 4 times in different horizontal range, 10, 20, 30 and 40 km.

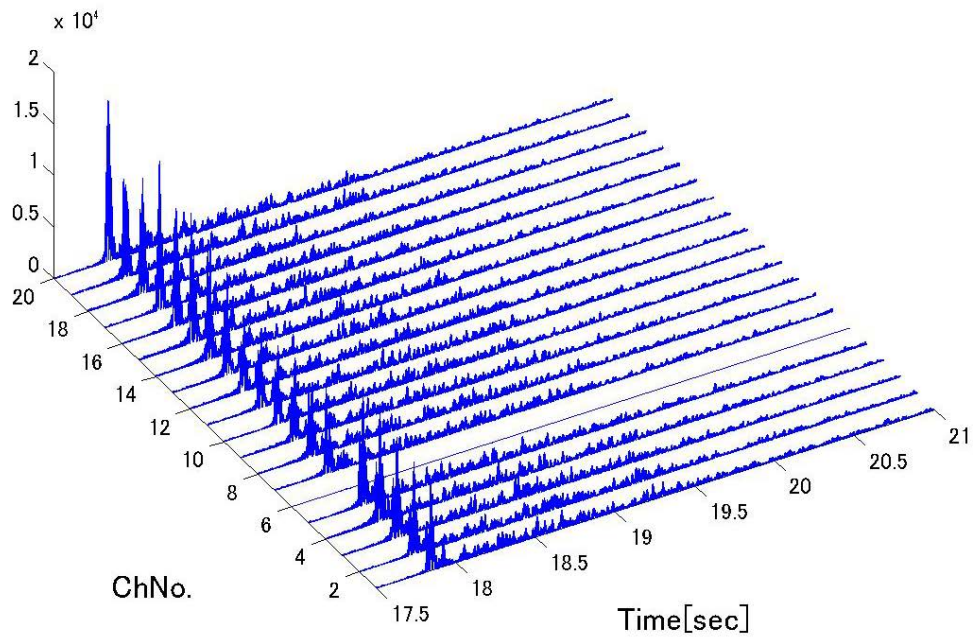


Fig.5 Example of correlated received signal. (Ch 1 through 20, except Ch 6)

4.4. Research Information

● Cruise log

Date	Time [JST]		
2013/10/11	08:30	Leave the port	Yokosuka
	16:53	XBT	Suruga-Bay
	17:40 – 18:10	Multi beam echo sounder	
2013/10/12	07:00 – 08:40	Experiment of ISSBL part 1	
	09:10 – 12:15	Test of Glass Balls part1	
	13:10 – 15:50	Experiment of ISSBL part 2	
	16:10 – 16:30	Multi beam echo sounder	
2013/10/13	07:06 – 09:22	Moor an hydrophone array at point 0	
	10:03	XBT	
	10:19 – 13:05	Experiment of source tracking at 10 km away from point 0.	
	13:48	XBT	
	14:28 – 16:43	Experiment of source tracking at 20 km away from point 0.	
	16:46 – 17:47	Multi beam echo sounder	
	18:13 – 18:57	Calibration of hydrophone array.	
	19:08 – 22:22	Multi beam echo sounder	
2013/10/14	06:00	XBT	
	06:30 – 08:44	Experiment of source tracking at 30 km away from point 0.	
	09:13	XBT	
	09:52 – 12:13	Experiment of source tracking at 40 km away from point 0.	
	14:25 – 16:14	Recover the hydrophone array at point 0.	
	16:30 – 21:00	Move to Sagami-Bay	
	21:22	XBT	Sagami-Bay
	21:47 – 22:31	Multi beam echo sounder	
2013/10/15	07:34 – 10:40	Experiment of ISSBL part 3	Tokyo-Bay
	11:00	Leave the test area. Move to Tokyo Bay	
	15:00	Refuge drifting at Keiyo Berth	
2013/10/16	All day	Refuge drifting at Keiyo Berth	
2013/10/17	06:30	Arrive at the test area.	Sagami-Bay

2013/10/17	06:33	XBT	Sagami-Bay
	07:59-10:31	Test of Glass Balls	
	10:53-17:00	Experiment of ISSBL	
	17:15-21:30	Move to next test area.	
	21:33	XBT (Moored point)	Suruga-Bay
2013/10/18	07:06 – 09:24	Moor an hydrophone array at point 0	
	09:30-10:07	Calibration of hydrophone array.	
	11:53	XBT (30 km from point 0)	
	12:56-14:45	Moor an transducer at 30 km from point 0	
	15:03-15:46	Monitor transmitted acoustic signal.	
	15:55-16:48	Calibration of transducer.	
	19:05	XBT (midpoint of Tx and Rx)	
	22:01	XBT (midpoint of Tx and Rx)	
2013/10/19	00:55	XBT (midpoint of Tx and Rx)	
	04:00	XBT (midpoint of Tx and Rx)	
	07:19-17:00	Experiment of multiuser communication	
	19:01	XBT (midpoint of Tx and Rx)	
2013/10/20	01:23	XBT (midpoint of Tx and Rx)	
	04:01	XBT (midpoint of Tx and Rx)	
	08:24-09:33	Recover the transducer.	
	10:30	Arrive at Toi port.	
	12:10	Leave Toi port	
	13:40-16:55	Test of Glass Balls	
2013/10/21	06:24-08:06	Recover the hydrophone array.	
	08:10	Shift to the next test area.	
	09:47	Arrive at the next test area, and XBT.	
	09:58-16:15	Experiment of ISSBL	
	16:15	Move to Sagami Bay	
	22:54	Arrive at Sagami Bay, and XBT.	
2013/10/22	06:32-11:40	Experiment of ISSBL	Sagami-Bay
	12:58-14:53	Test of Glass Balls	
	15:00	Finish all experiment, move to Yokosuka	
2013/10/23	09:00	Arrive at Yokosuka	Yokosuka

● Deployment and recovery information

Moored number	Moored date	Moored point		Depth	Recovery date
		Latitude	Longitude		
#01Com	2013/10/13	34-40.4620N	138-35.0803E	2,086m	2013/10/14
#02Nav	2013/10/17	35-03.7764N	139-20.8029E	1,413m	2013/10/17
#03Com	2013/10/18	34-40.4951N	138-35.0759E	2,135m	2013/10/21
#04Com	2013/10/18	34-56.7085N	138-38.3763E	1,444m	2013/10/20
#05Nav	2013/10/21	34-56.7557N	138-38.3306E	1,488m	2013/10/21
#06Nav	2013/10/22	35-09.5252N	139-19.5024E	1,018m	2013/10/22

● XBT

Cast number	Cast date [JST]	Cast time [JST]	Cast point	
			Latitude	Longitude
306	2013/10/11	16:53	34-41.9417N	138-34.8094E
307	2013/10/13	10:03	34-45.7810N	138-36.2719E
309	2013/10/13	13:48	34-50.5279N	138-37.2515E
310	2013/10/14	06:00	34-56.6325N	138-38.3971E
311	2013/10/14	09:13	35-01.3091N	138-39.3296E
312	2013/10/14	21:22	35-07.5579N	139-25.6644E
313	2013/10/17	06:33	35-03.8203N	139-20.7773E
314	2013/10/17	21:33	34-40.2057N	138-35.9906E
315	2013/10/18	11:54	34-56.3139N	138-38.2142E
318	2013/10/18	19:05	34-48.7770N	138-36.6106E
319	2013/10/18	22:01	34-48.4830N	138-36.5979E
320	2013/10/19	00:55	34-48.4604N	138-36.6503E
321	2013/10/19	04:00	34-48.4815N	138-36.6584E
322	2013/10/19	19:01	34-48.3650N	138-36.9633E
323	2013/10/19	22:00	34-48.5127N	138-36.7143E
324	2013/10/20	01:23	34-48.6009N	138-36.7284E
325	2013/10/20	04:01	34-48.5126N	138-36.7094E
326	2013/10/21	09:48	34-55.9177N	138-38.2071E
327	2013/10/21	22:54	35-09.5937N	139-19.5734E

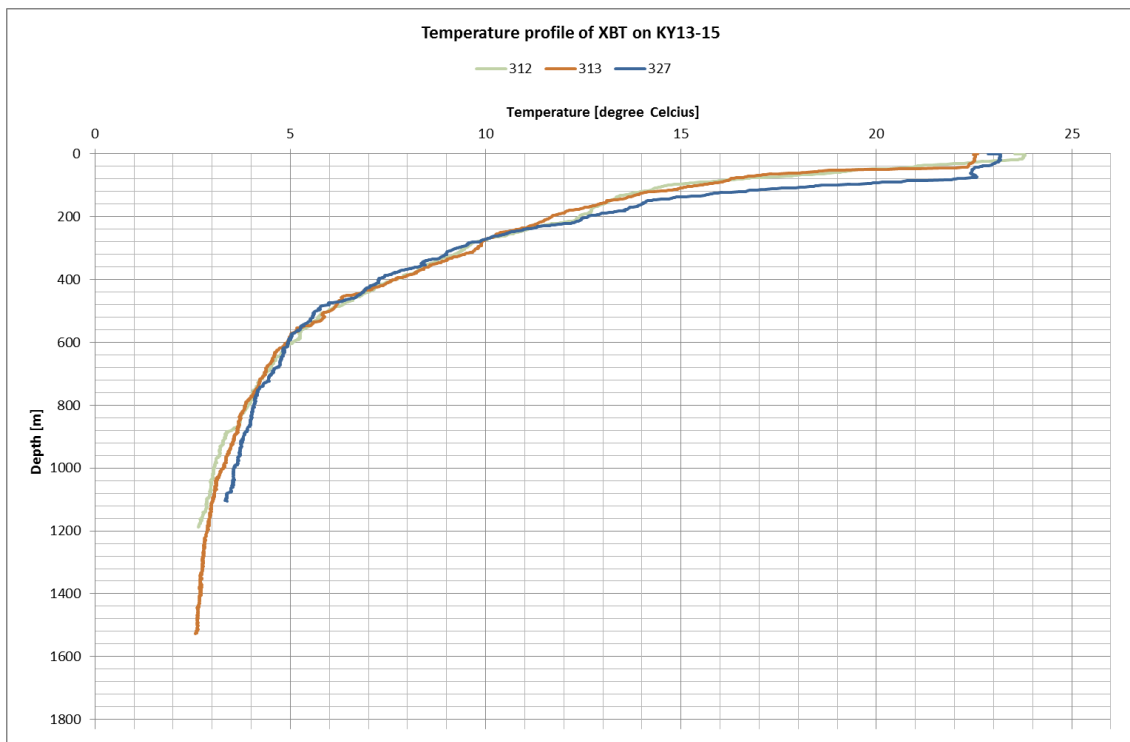


Fig.6 Temperature profiles for ISSBL at Sagami-Bay.

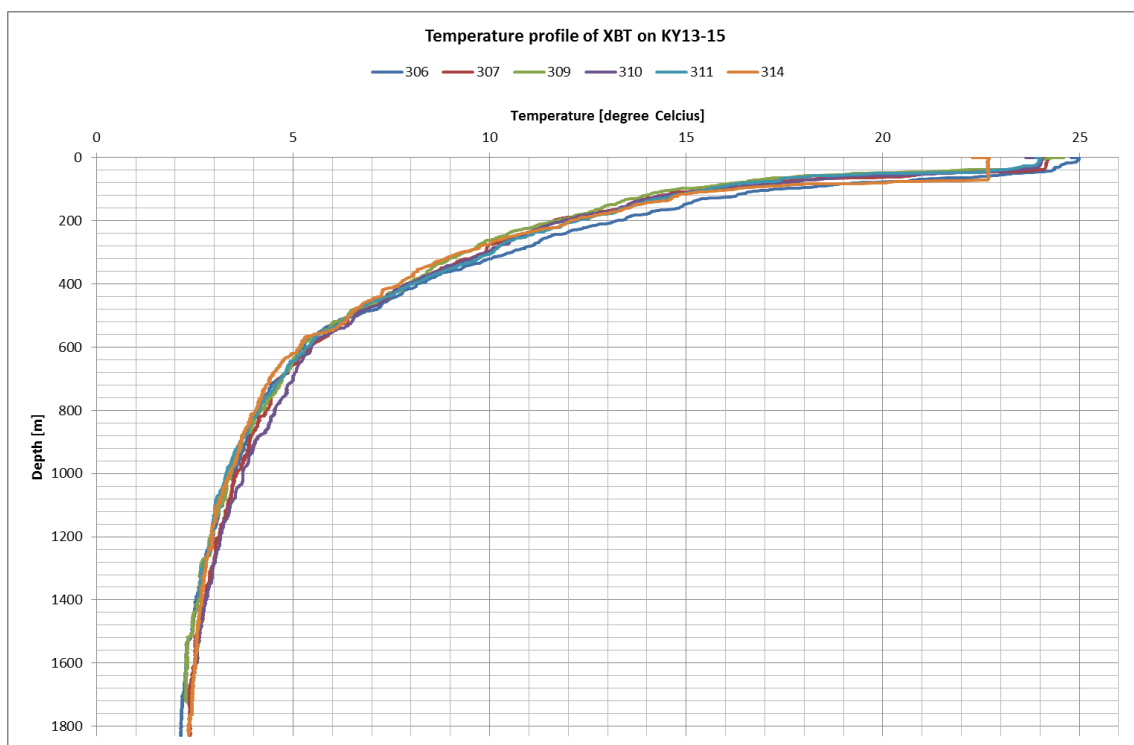


Fig.7 Temperature profiles on the line of source tracking.

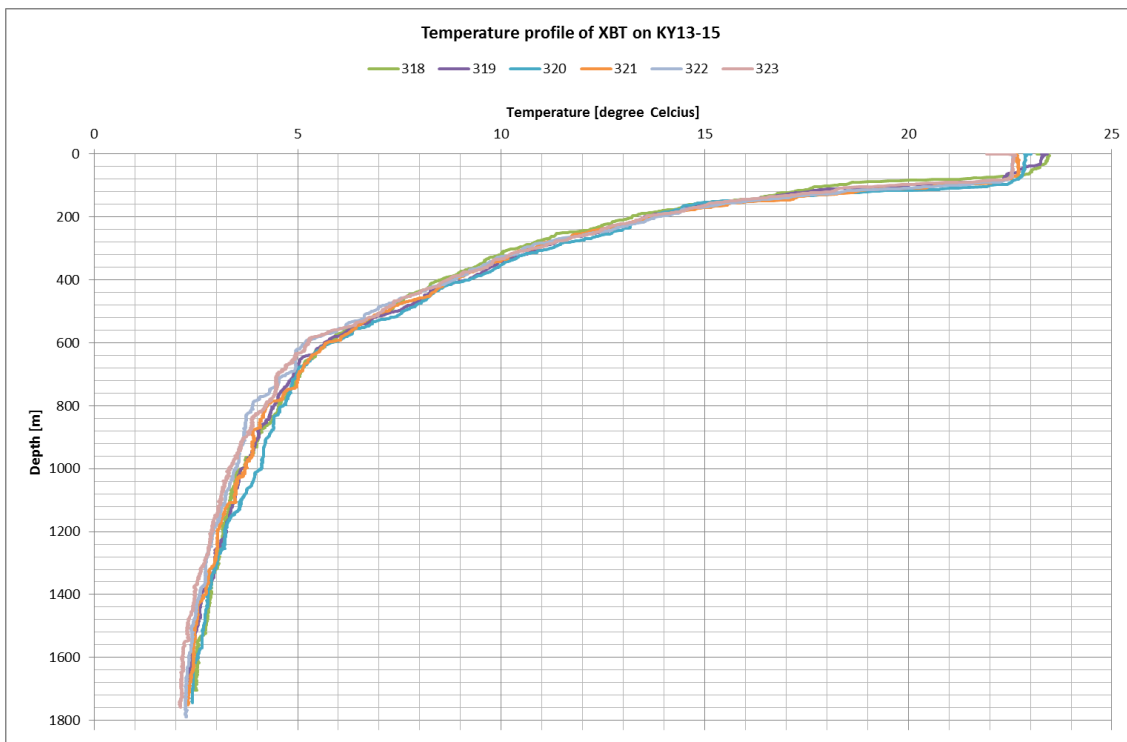


Fig.8 Temperature profiles at the midpoint of Tx and Rx mooring systems.

5. Notice on Using

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

This report may not be corrected even if changes on contents (i.e. taxonomic classifications) may be found after its publication. This report may also be changed without notice. Data on this cruise report may be raw or unprocessed. If you are going to use or refer to the data written on this report, please ask the Chief Scientist for latest information.

Users of data or results on this cruise report are requested to submit their results to the Data Management Group of JAMSTEC.