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"NATSUSHIMA" Cruise Report

NT15-19

Ocean Experiments of AUV Navigation Using ISSBL Method and Control and Observation Technology of A Working AUV

Sagami Bay, Suruga Bay, Omuro-dashi

Oct. 29, 2015 - Nov. 05, 2015

Japan Agency for Marine-Earth Science and Technology

(JAMSTEC)

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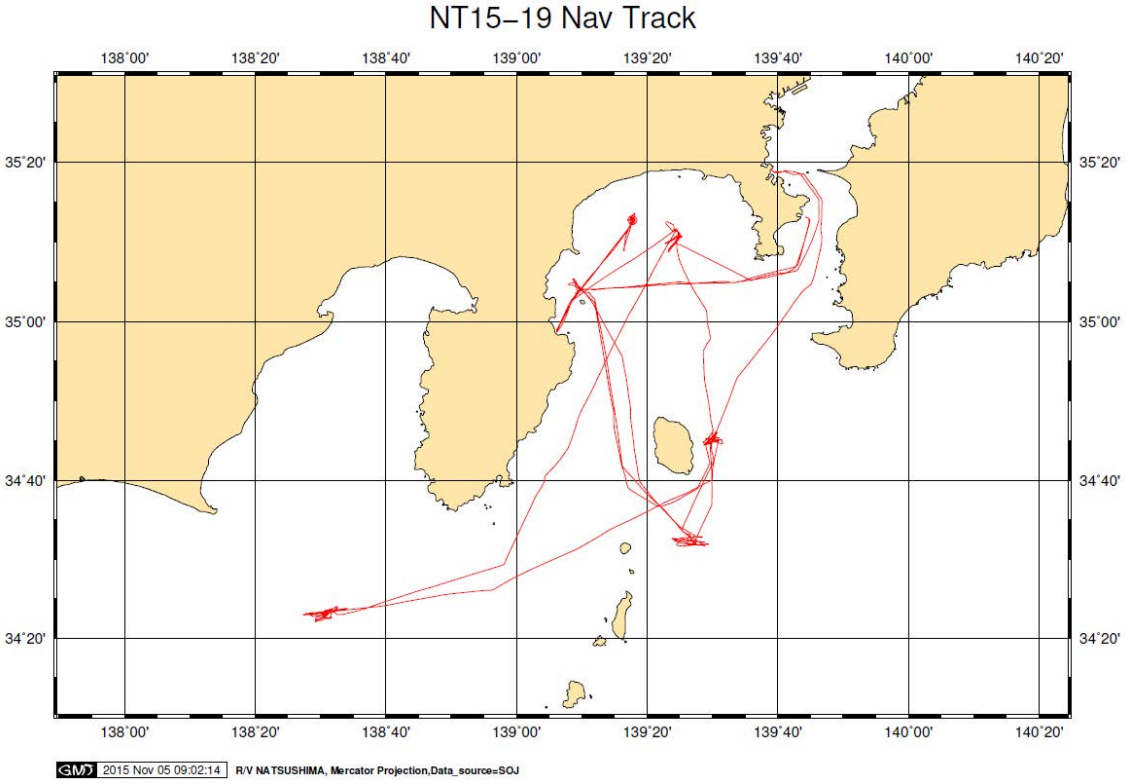
1. Cruise Information

- Cruise ID: NT15-19
- Name of vessel: R/V NATSUSHIMA
- Title of the cruise: Ocean Experiments of AUV Navigation Using ISSBL Method and Control and Observation Technology of A Working AUV
- Title of proposal: Ocean Experiments of AUV Navigation Using ISSBL Method and Control and Observation Technology of A Working AUV
- Cruise period: Oct. 29. 2015 – Nov. 05. 2015
- Ports of departure / arrival: JAMSTEC Headquarter, Yokosuka
- Research area: Sagami Bay, Suruga Bay, Omuro-dashi
- Research Map



2. Researchers

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3. Experiments

● Purpose

Purpose of this cruise is to conduct ocean experiments of elemental technologies for autonomous underwater vehicle (AUV) in order to substantiate and evaluate the proposed elemental technologies. The elemental technologies tested in this cruise are navigation using inverse super short baseline (ISSBL), autonomous control of a working AUV, and observation using 3D laser scanner.

● Summary

In this cruise, working AUV “OTOHIME” was used as a platform of experimental devices. “OTOHIME” was communicated with thin optical fiber from the mother ship and controlled during experiments. Experiments of ISSBL navigation were performed in two ways, in which the experimental device was equipped on “OTOHIME” and on a mooring system. Three dives of “OTOHIME” were performed in Sagami Bay and Omuro-dashi. First two dives were for experiments of observation with 3D laser scanner and autonomous control of AUV in areas of which water depth was up to 434 m in Sagami Bay and 182 m in Omuro hole. Especially in experiment in Omuro hole, things like thermal plume were observed by 3D laser scanner. Another dive of “OTOHIME” was performed for experiment of ISSBL navigation at the north side of Sagami Knoll, and water depth in the diving area was up to 820 m. Furthermore, two experiments of ISSBL navigation with mooring system were carried out in order to evaluate degrees of error depending on water depth. One was conducted at point of 1,000 m depth in north area of Sagami Bay, and another was at point 2,800 m depth, just out of Suruga Bay Southward.

● Experimental platform and devices

-Working AUV “OTOHIME” (as an experimental platform)

“OTOHIME” is a working AUV developed in JAMSTEC. It has two thrusters with tilt control and vertical and horizontal wings as actuators to control the body motion. It can cruise at up to about 1.2 kt, hover to keep a position, and land on the sea bottom on the skid. In this cruise “OTOHIME” was used as a platform of Experiments.

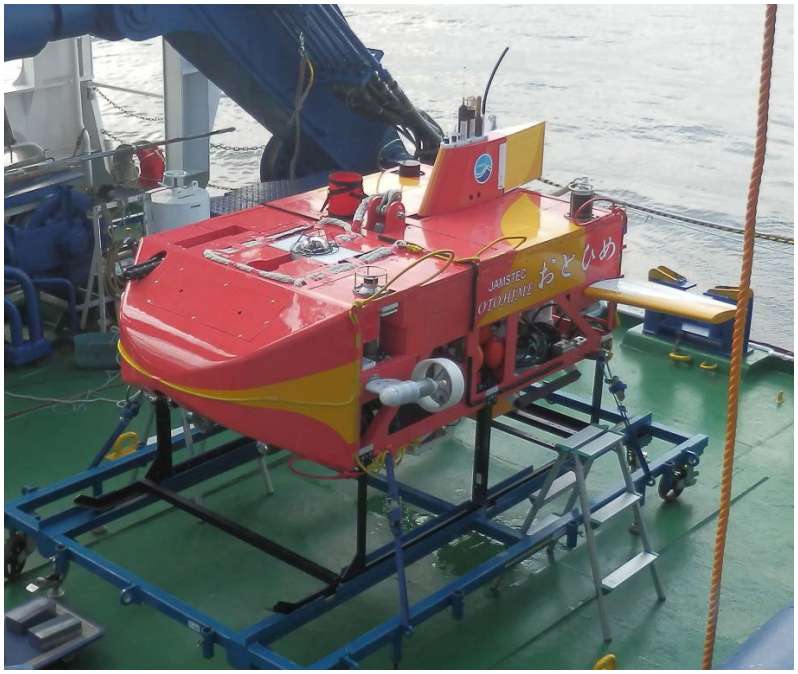

Fig. 1 Working AUV “OTOHIME” on working deck of R/V NATSUSHIMA.

Table 1. General specifications of “OTOHIME”.

Item	Specification
Length	2.6 m
Weight	900 kg
Depth rating	3,000 m
Cruise speed	0 (hovering) – 1.2 kt
Turning radius	0 (turning around)
Endurance	8 hours
Operation mode	AUV mode UROV mode (with thin optical fiber cable)
Actuators	Two 400W tilt thrusters Vertical and horizontal wings
Communication devices	Acoustic communication, optical fiber, wireless LAN
Navigation devices	Inertial navigation system, Doppler velocity log, CTD sensor (depth), Acoustic transponder (for SSBL)
Observation devices	CTD sensor, CO2 sensor, stereo snapshot camera, side scan sonar, high definition camera, 3D laser scanner

-3D laser scanner

3D laser scanner observes precisely the seafloor topography using a laser system, which sweeps a laser two-dimensionally and measures distance to the sea bottom. It was equipped on "OTOHIME" to a downward direction as shown in Fig. 2. "OTOHIME" cruised at 10 - 20 meters height from the sea bottom during experiments of the 3D laser scanner.

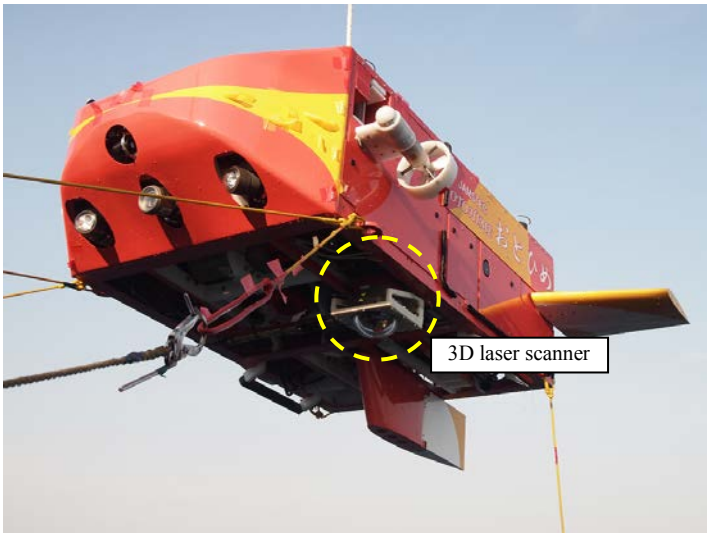

Fig. 2 3D laser scanner equipped on "OTOHIME".

-Experimental device of ISSBL navigation

In this method, ISSBL system measures direction of arrival (DOA) of acoustic signal from mother ship by receiving the signal with a receiver array which size was 0.8 x 0.8 m and consists of four hydrophones, and calculates relative position of itself from the mother ship with the DOA and depth. Information of ship's position is included in the signal and absolute position of the ISSBL system can be obtained with the relative position and the transmitted ship's position. Experiments of ISSBL navigation were performed by two ways, on mooring system and on "OTOHIME".

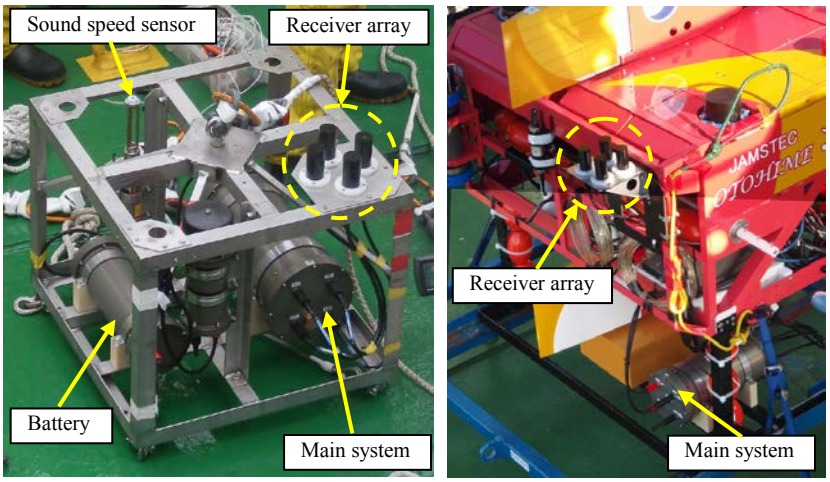

Fig. 3 Experimental device of ISSBL navigation for mooring system (left) and on "OTOHIME" (right).

-Configuration of mooring system for experiment of ISSBL navigation

A mooring system was used for evaluation accuracy of the ISSBL navigation system by positioning of a fixed position under valuable relationship between the moored point and the ship. The experimental device was set at about 35 m height from the sea bottom as shown as Fig. 4.

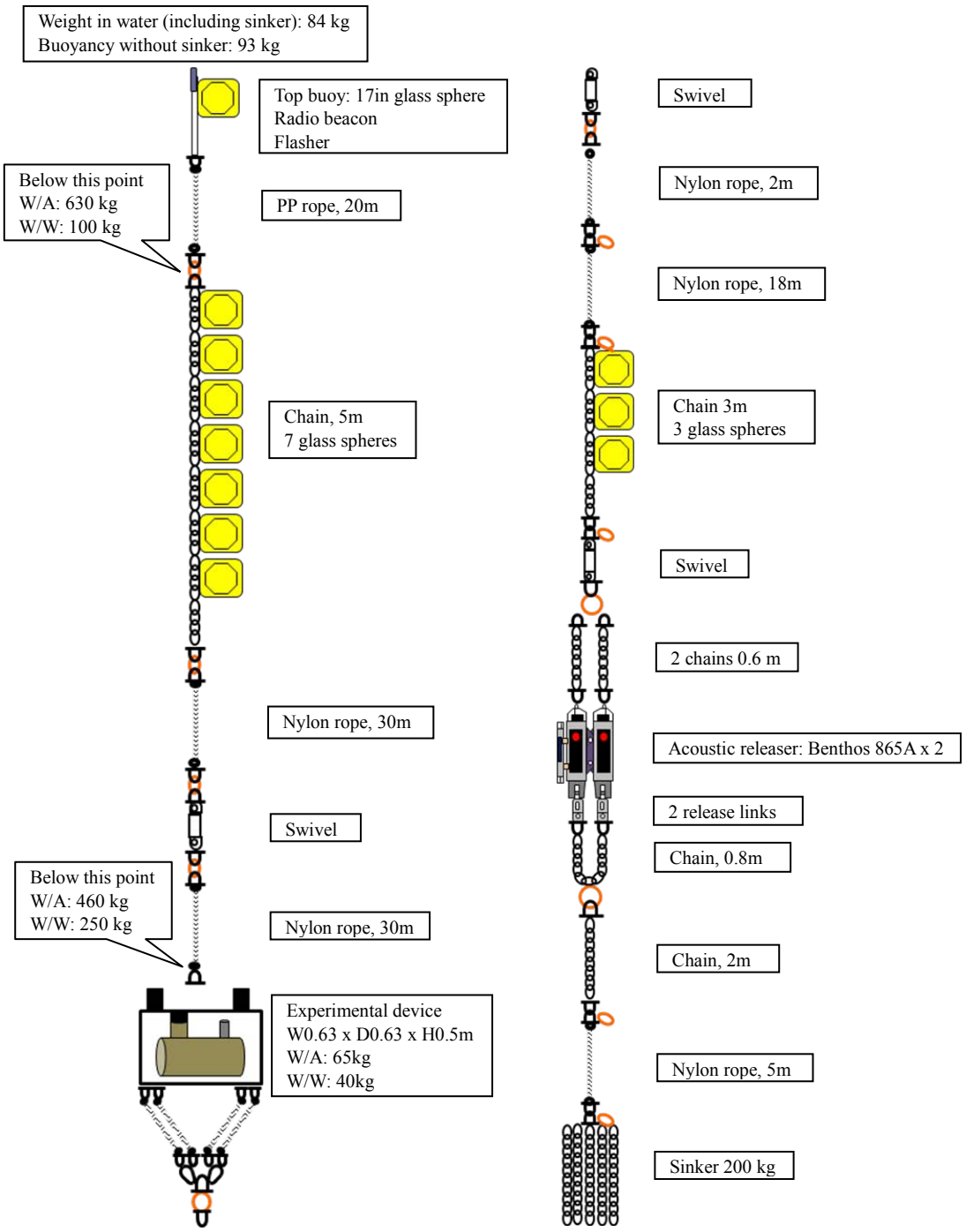

Fig. 4 Configuration of mooring system for experiment of ISSBL navigation.

●Experiments

-Experiments of autonomous control of working AUV and 3D laser scanner

Experiments of two elemental technologies, which are autonomous control of working AUV and precise sea floor observation with 3D laser scanner, were simultaneously carried out. Dive #14 and #15 of "OTOHIME" were conducted for these two elemental technologies. Dive #14 was conducted in west side area of Sagami Bay. The maximum depth of the vehicle was 434 meters and the vehicle cruised about 1.4 kilo-meters during three hours. In experiment of autonomous control the vehicle was operated with AUV mode even connected to the mother ship with thin optical fiber cable. Autonomous control was hard to achieve because the current was strong. Dive #15 was conducted in Omuro hole. The vehicle descended out of Omuro hole at first and cruise into the hole. In this dive the vehicle was successfully controlled autonomously and cruise across the bottom of the hole with keeping the height about 15 meters. As a result of experiment of the 3D laser scanner something like thermal plume were observed in the hole.

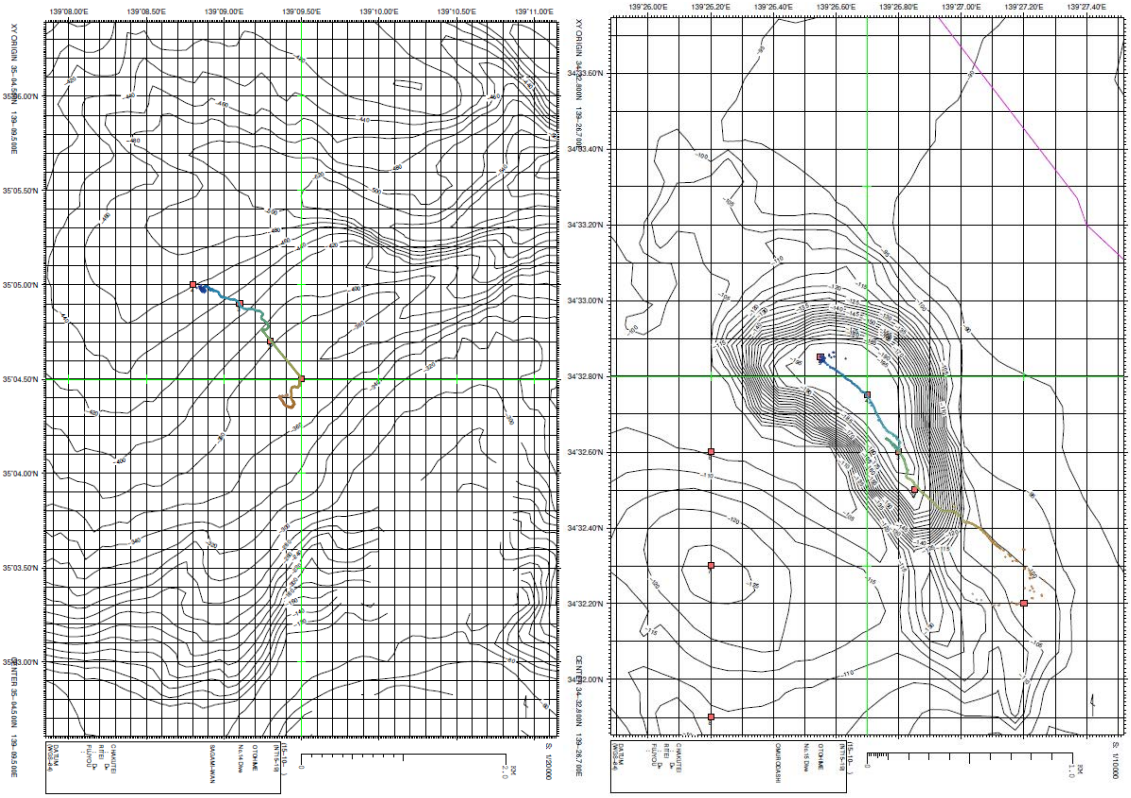

Fig. 5 Dive tracks of "OTOHIME" dive #14 (left) and #15 (right) measured by acoustic navigation system (ANS) on R/V "NATSUSHIMA".

-Experiments of ISSBL navigation

Dive #16 of “OTOHIME” was conducted for an experiment of ISSBL navigation technology. The vehicle at first descended at North-East edge of Sagami Knoll and cruised toward deeper area. The vehicle cruised about 3 kilo-meters long and finally reached at 820 meters depth. During this cruise acoustic signal for the experiment was intermittently transmitted from the mother ship and received signal by the receiver array on the vehicle was acquired. On the other hand, two experiments using the mooring system were performed at about 1,000 meters depth and 2,800 meters depth. The result of the experiment at 1,000 meters depth will be compared with result of previous experiment with lager array. The experiment at deeper site was carried out to evaluate at targeted maximum operation depth which is 3,000 meters. R/V “NATSUSHIMA” cruised various pattern of cruise track to evaluation of the accuracy. The position of the mooring points were calibrated by SSBL calibration function of the ANS on R/V “NATSUSHIMA”.

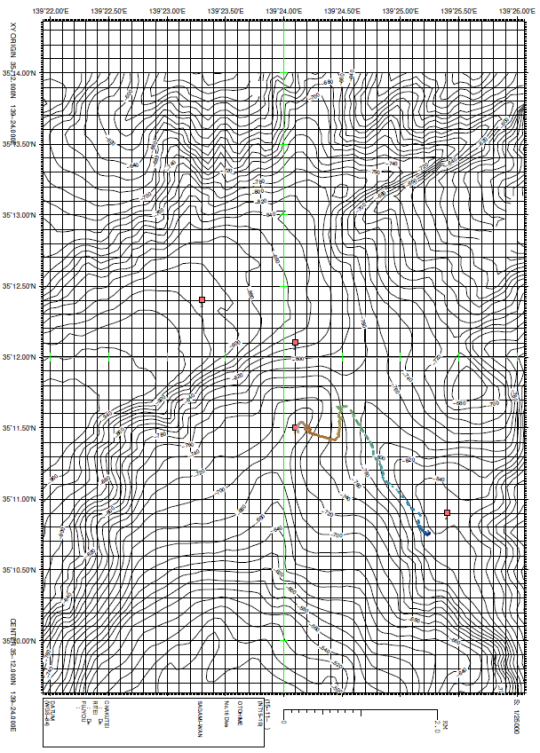

Fig. 6 Dive track of “OTOHIME” dive #16 by ANS on R/V “NATSUSHIMA”.

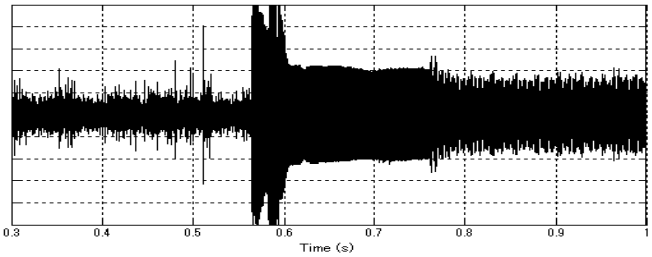

Fig. 7 Example of received signal in experiment at 2,800 meters depth.

-List of experiments

Table 2. List of experiments.

Date	Experiment No.	Point	Depth (m max.)	Time Dive start - ascend to surface	Purpose
10/30	Dive #14	35-04.4N, 139-09.4E	434	11:38 - 14:06	Autonomous control of working AUV Observation with 3D laser scanner
10/31	Dive #15	34-32.3N, 139-27.2E	186	11:06 - 12:52	Autonomous control of working AUV Observation with 3D laser scanner
11/02	Mooring #1	35-12.725N, 139-17.758E	984	-	ISSBL navigation, precision evaluation
11/03	Dive #16	35-11.5N, 139-24.1E	824	10:27 - 14:22	ISSBL navigation, on-platform validation
11/04	Mooring #2	34-23.010N, 138-31.026E	2,811	-	ISSBL navigation, precision evaluation

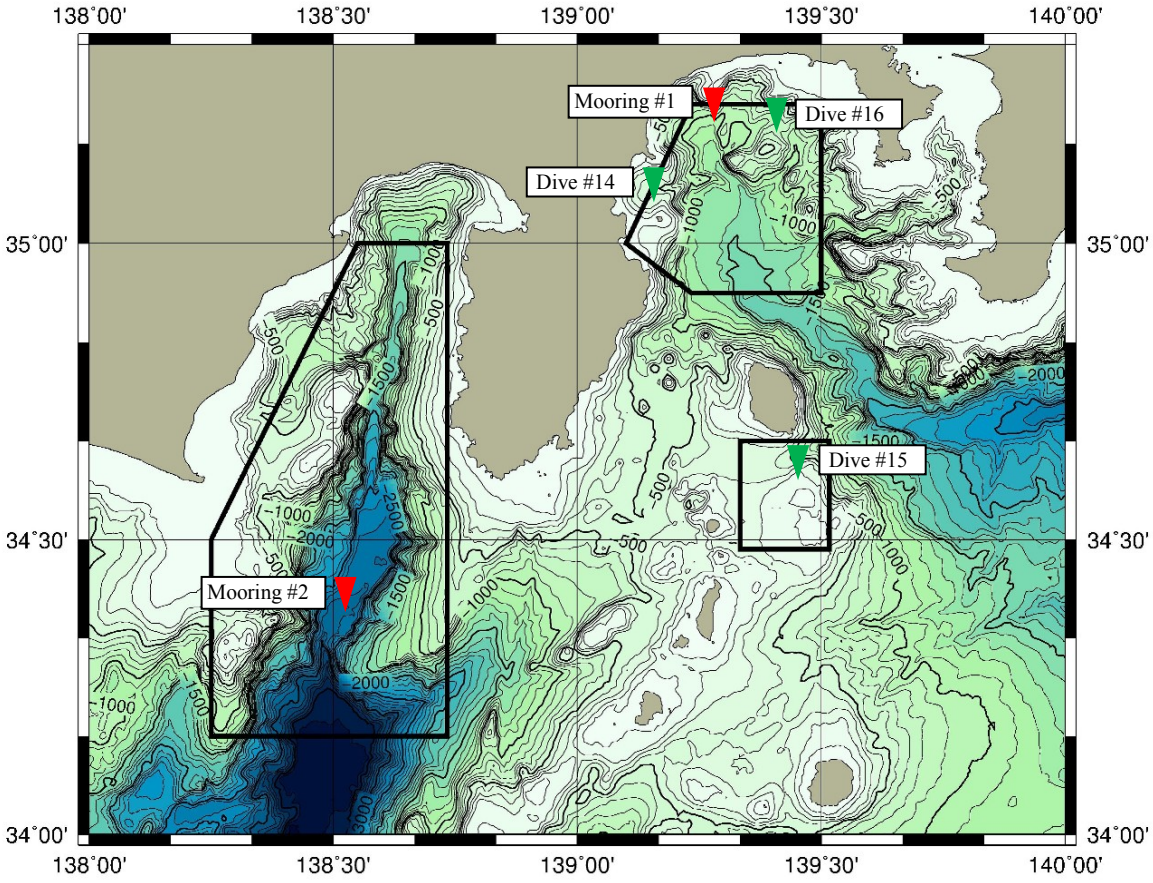

Fig. 8 Experimental sites.

4. Notice on Using

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

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.