1. Cruise Information

Cruise number: KY10-05

Cruise ship: “KAIYO”

Title of the cruise: Research on underwater acoustic technology

Chief scientist: Hiroshi Ochi (JAMSTEC)

Representative of science party: Takuya Shimura (JAMSTEC)

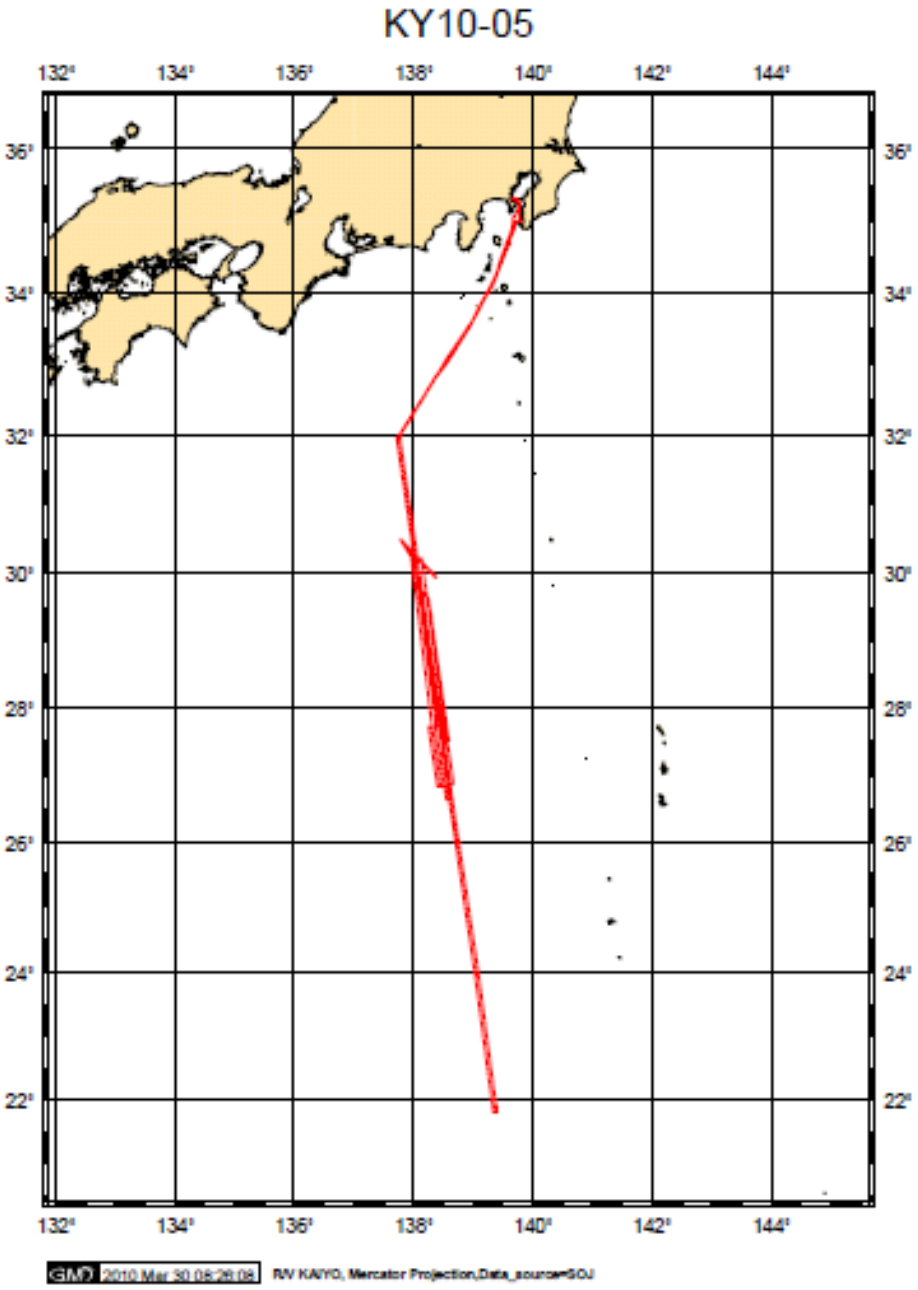
Yoshitaka Watanabe (JAMSTEC)

Cruise period: 12/March/2010 – 30/March/2010

Port call: JAMSTEC (Yokosuka)

Research area: Izu, Ogasawara

Research map:



2. Purpose

Researches on “long range acoustic communication using time reversal wave” and “long range acoustic positioning” have been investigating in our group for applying AUV, which cruises on long distance. Our purposes of this cruise were: 1. to obtain propagated data of time reversal wave over 300 km, 2. to obtain propagated data for acoustic positioning up to 100 km. And also obtain data of CTD and sound speed profile for analysis of sound field.

3. Outline of experiments

3-1. Experiments for “long range underwater acoustic communication by time reversal wave”.

In the ocean, many multipath waves cause inter-symbol interferences (ISI) that make it difficult to achieve communication as known well. Time reversal (TR) has a possibility to solve this problem. Because TR converge and utilize multipath signals so that ISI are removed.

In this cruise, experiments for passive time-reversal (PTR) communication, that is, single-input-multiple-output (SIMO) time-reversal communication, were executed. The experiment line is shown in Fig. 2. The center frequency and bandwidth of the source was 500 ± 50 Hz and the source level was 186 dB. The receiver array was composed of 20 receiver systems. The intervals between the receivers were 6.0 m approximately. Then, the array length was 114 m approximately. The source and the receiver array were moored at the ranges of 500, 600, 700 and 900 km on the red line as shown in Fig. 1. The source and receivers were installed at the depth of 1,000 m approximately.

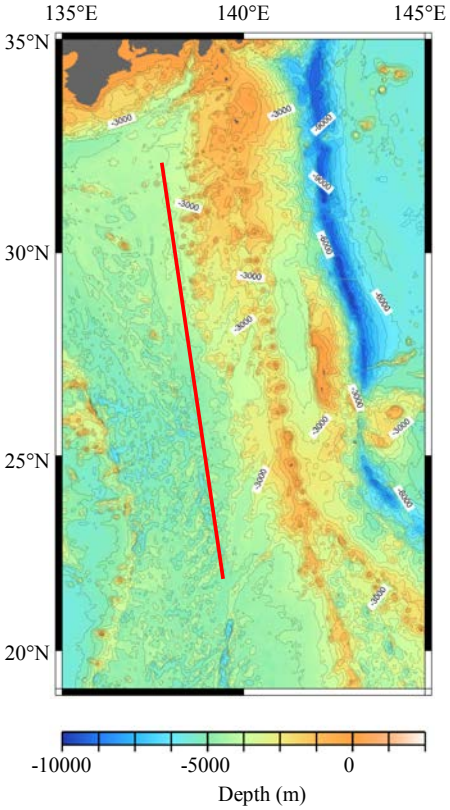


Fig. 1 The bathymetry of the experiment site.

Some of results are shown here as a flash report.

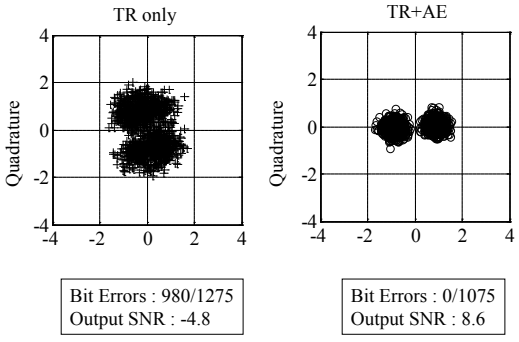


Fig. 2 Demodulation results at the range of 700 km.

In the measurement of 700-km-range, M-sequence signals were transmitted as a probe signal. The data rate was 100 bps. The probe signal was processed with the fourth root raised-cosine filter and the data signal was processed with the root raised-cosine filter. The received probe signal was correlated with the original M-sequence signal, and correlated with the received data signal as PTR process.

One of the demodulated results is shown in Fig. 3. In this figure, “TR only” indicates using only time-reversal, and “TR+AE” indicates the proposed method of combining time-reversal and adaptive equalization (AE). In this result, the demodulated symbols are rotated in the case of TR due to the ship drifting similarly as in the previous experiments. Such phase rotation is compensated well in the case of TR+AE. Thus, it is performed that communication at the range of 700 km is accomplished.

In the measurements of 900-km-range, the same probe and data signals were transmitted. However, it was impossible to realize demodulations. Thus, the technique of combining spread spectrum (SS) additionally was introduced. Such results will be summarized and published in future.

3-2. Experiments for “long range acoustic positioning system”.

In this cruise, experiments were conducted to acquire data to consider long range acoustic positioning for cruising AUV. Positioning method is considered as that AUV receives acoustic signal from acoustic reference, measures propagation time and arrival direction of the acoustic signal, and compute its own position. The AUV is equipped with receiver array on the body side, and the array is horizontally long. The depth can be measured by a depth sensor which is typically on the AUV. The horizontal position, latitude and longitude, should be estimated by the received acoustic signal.

Fig.3 shows experimental configuration. The transmitter device were equipped with a transducer, and moored on sea bottom. The depth of transmitter device was set at about 1,100m depth which is near the axis of sound fixing and ranging channel (SOFAR). The receiver device were equipped with 8 hydrophones, which were allocated as planer array, suspended from the ship. The size of the receiver array is 0.7 m for vertical and 4.9 m for horizontal. Acoustic signals transmitted by the transmitter device were received by the receiver device and recorded as digital signal data for post-processing and consideration. Frequency band of the transmitted signal was 1 kHz +/-100 Hz, and was coded by a pseudo noise (PN) code. The 8-th and 9-the M-sequence codes were used as PN codes, and the pulse width of the acoustic signal were 1.275s and 2.555s. The acoustic pulses were not single but with multiple pulses transmitted at regular intervals. The received pulses are synthesized at post-processing.

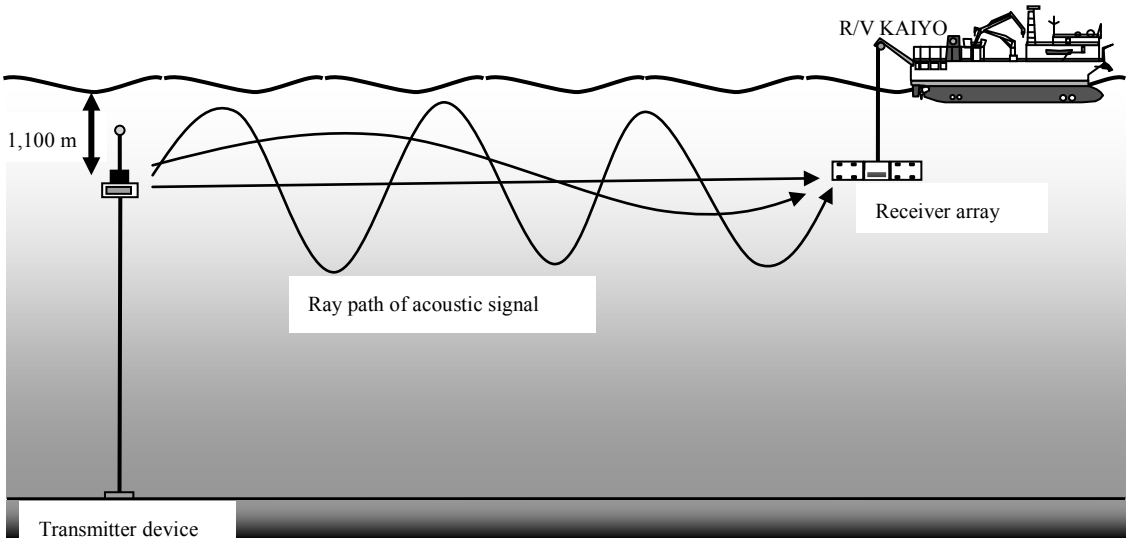


Fig.3 Experimental configuration.

Fig. 4 shows event points in the cruise. The yellow plots show the points where the sound speed profile was measured. The green plot show the position where the transmitter device was moored, and the red plots show the position where the receiver device was suspended from the ship.

The experiments were conducted three times. In experiments, the ship with the receiver device drifted at 0.5 knot in order to obtain signal data of multiple pulses with moving receiver array. In one of the two experiments of 100 km range, the track of the receiver was south-to-north, which is along the line between the transmitter and the receiver. And another experiment of 100 km range, the track of the receiver was west-to-east, which is across the line between transmitter and receiver.

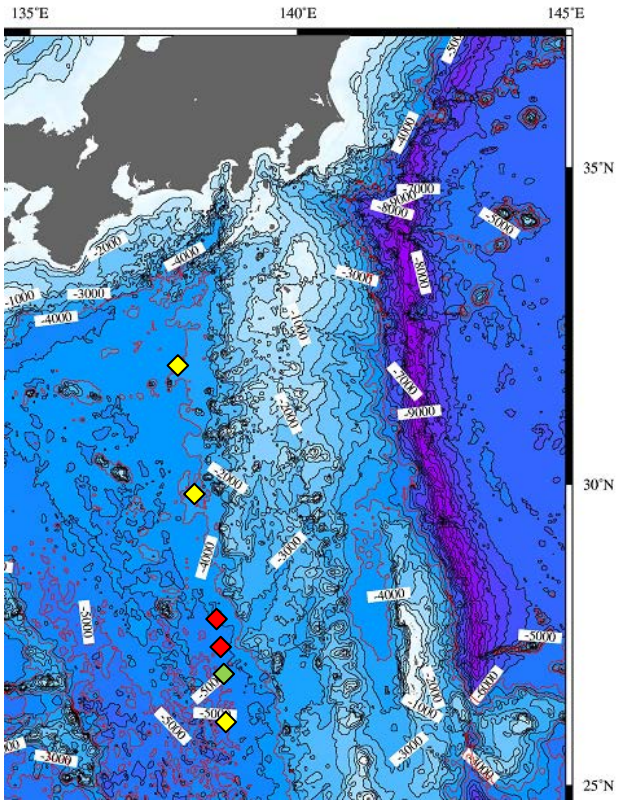


Fig. 4 Position where some events were conducted.