Measuring the Flow Through the Kerama Gap

Mark Wimbush & Jae-Hun Park
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882-1197
Phone: 401-874-6515 & 401-874-6514
Fax: 401-875-6728
E-mail: mwimbush@gso.uri.edu & jpark@gso.uri.edu

Award No. : N00014-09-1-0391

BACKGROUND

The principal flows in and out of the East China Sea are through gaps in this Ryukyu Ridge. Since ~20 Sv of Kuroshio mean flow enters and exits through two of them, those two are especially well known: the East Taiwan Channel (sill depth 775 m) at the ridge's southwestern end, and the Tokara Strait (sill depth 690 m) near its northeastern end [Choi et al., 2002]. But the deepest channel connecting the ECS to the surrounding ocean is near the mid-point of the ridge. This is the Kerama Gap, about 50 km wide with sill depth 1050 m [Choi et al., 2002]—see Figure 1.

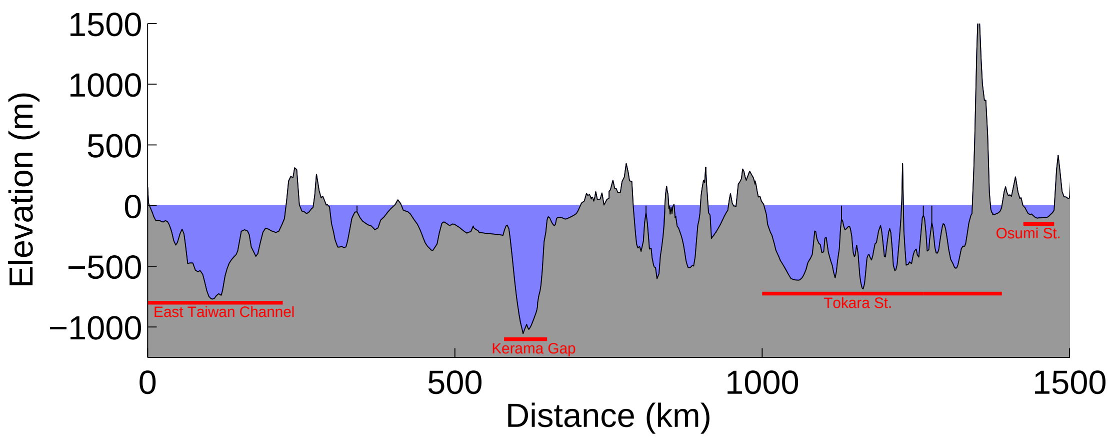

Figure 1. The Ryukyu ridgeline, from Taiwan (on the left) to Kyushu, Japan (on the right). The island of Okinawa is at Distance = 700-800 km, just to the right (i.e., northeast) of the Kerama Gap.

Little is reliably known about the flow through the Kerama Gap. Mean-flow estimates from measurements and models range from 0.9 Sv out of the East China Sea to 7.2 Sv into it. Knowledge of the flow variability is even more uncertain, but there is evidence of transport variations with magnitude a few Sverdrups, caused by impingement of Philippine Sea eddies from the east, at intervals of a few months [Andres et al., 2008a].

Our main purpose in this project is to make a reliable determination of the varying flow through the Kerama Gap.

LONG-TERM GOAL

To measure and understand the time-varying structure and transport of flow between the Pacific Ocean and the East China Sea through the Kerama Gap, on scales from a few hours to more than a year.

OBJECTIVES

On time scales ranging from two days to two years, our main objectives are to test the following three hypotheses:

1) increase in transport through the Kerama Gap is associated with (a) an increase in ECS-Kuroshio transport across the PN-line, north of Okinawa, and (b) a decrease in Ryukyu Current transport east of Okinawa about two months earlier;

2) the arrival of anticyclonic (cyclonic) eddies at the eastern side of the Kerama Gap is associated with an increase (decrease) of transport through the Gap;

3) variations in wind stress over the local region cause variation in the flow through the Kerama Gap.

APPROACH

Our plan was to deploy an array of four Current- and Pressure-sensor-equipped Inverted Echo Sounders (CPIESs), with approximately 15 km spacing, across the Kerama Gap, while our Japanese colleague, Dr. Hirohiko Nakamura, would deploy 3 current-meter moorings mid-way between each adjacent pair of CPIES instruments. Figure 2 is a diagram of the Kerama Gap in cross-section showing the planned CPIES and current-meter moorings.

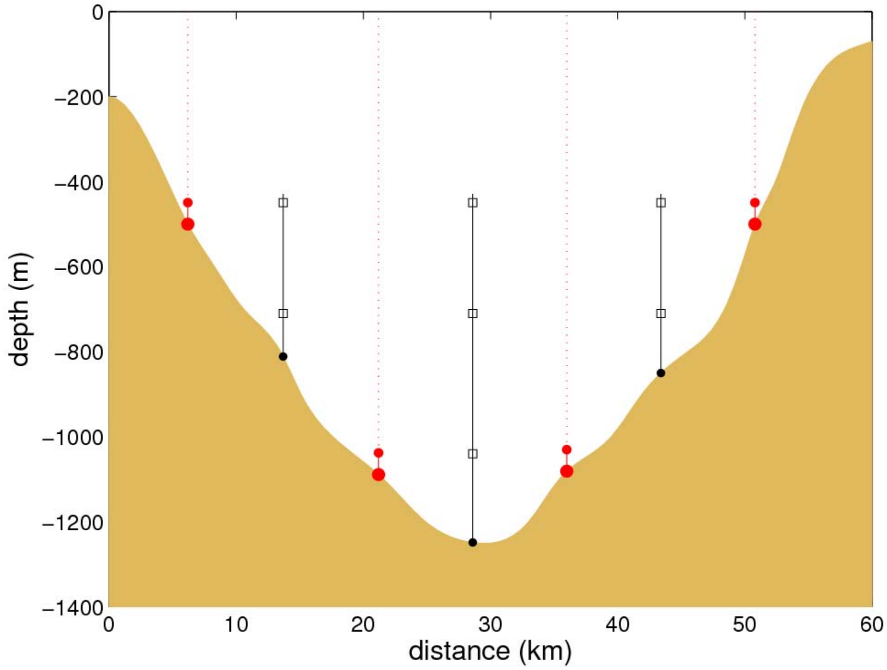

Figure 2. Proposed Kerama Gap array. Four CPIESs are shown as solid red dots (smaller upper dot represents the position of the current sensor 50 m above the sea floor). Seven CMs on three moorings are shown as open squares. Note: this section across the Kerama Gap is slightly northwest of the sill, hence the maximum depth at the section is greater than the sill depth (1050 m).

WORK COMPLETED

In early 2009, we built one new CPIES instrument and shipped it to Japan along with four existing CPIESs. The extra CPIES was intended as a spare, in case one of our CPIESs failed to operate successfully. In June, three of us from the University of Rhode Island joined Dr. Nakamura and his team on the Training Vessel Kagoshima-maru for the deployment cruise. Since all five of our CPIES instruments worked perfectly, we deployed the fifth CPIES (originally taken as a spare) at the center of the Gap about 10 km northwest of the main array line. Dr. Nakamura successfully deployed his three current-meter moorings as planned. Figure 3 shows the actual deployment locations of the CPIES and current-meter moorings.

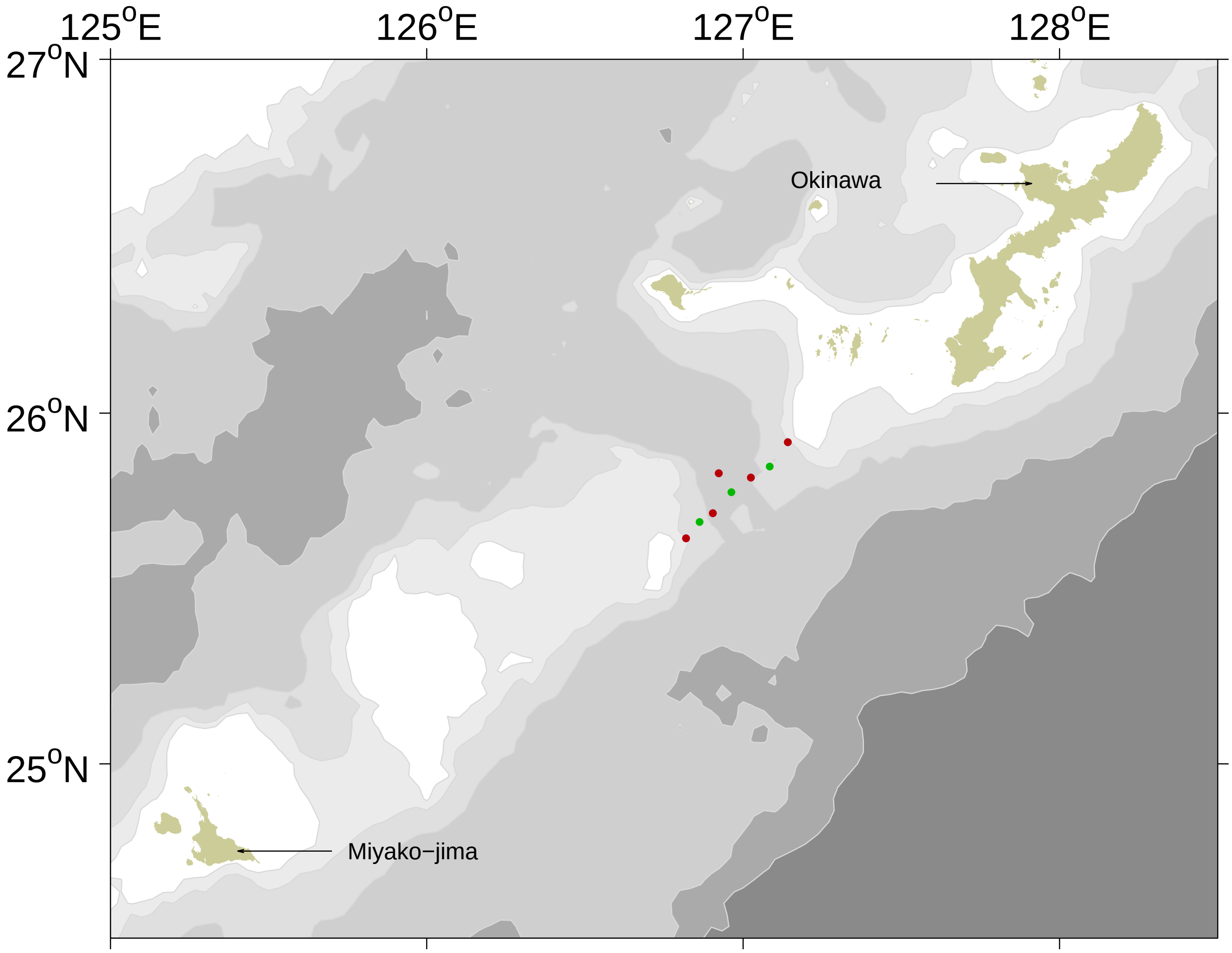

Figure 3. The Kerama Gap array, as deployed in June 2009, consists of five CPIES instruments (red dots) and three current-meter moorings (green dots). The array is along a line across the Kerama Gap, except that one CPIES instrument near the center of the Gap is about 10 km northwest of this line. Depth contours are at 200, 500, 1000, 2000 and 3000 m.

RESULTS

We will not have any results to report until after June 2010, when our next cruise on the T/V Kagoshima-maru is planned. At that time CPIES data will be telemetered to the ship and the current-meter moorings will be replaced. We will take with us a spare CPIES instrument in case one of our currently deployed CPIESs is no longer operating correctly. In June 2010 the entire array of instruments will be recovered and we will then analyze the full data set.

IMPACT/APPLICATIONS

Because flows through the Kerama Gap add to or subtract from the measured Kuroshio flow in the East China Sea north of Okinawa [Andres et al., 2008a], the results from this study should lead to advances in our understanding of western-boundary-current dynamics.

Recently it has been shown that Kuroshio transport in the East China Sea is correlated with the Pacific Decadal Oscillation (PDO) index [Andres et al., 2009]. If, through this two-year measurement of the Kerama Gap transport, we are able to find a suitable long-term proxy (e.g., sea-level differences measured with tide gauges or satellite altimeters), we will determine whether there is a similar PDO-related transport in flow through the Kerama Gap.

RELATED PROJECTS

The University of Rhode Island was supported by ONR to deploy an array of IESs in the Okinawa Trough near the PN-line in a project titled, "Variability of the Kuroshio in the East China Sea, and its Relationship to the Ryukyu Current." These instruments recorded the main part of the Kuroshio transport in the ECS. The array was deployed in December 2002 and recovered in November 2004, thus providing spatiotemporal structure of the Kuroshio for a two-year time period. The results of this study are to be found in Andres et al. (2008a,b) and Andres et al. (2009).

REFERENCES

Andres, J-H. Park, M. Wimbush, X-H. Zhu, K-I. Chang and H. Ichikawa, 2008a. "A study of the Ryukyu Current - Kuroshio system based on the integrated use of satellite altimetry and in situ data." J. Oceanogr., 64, 937-950.

Andres, M., M. Wimbush, J-H. Park, K-I. Chang, B-H. Lim, and D.R. Watts, H. Ichikawa, W. J. Teague, 2008b. "Observations of Kuroshio flow variations in the East China Sea." J. Geophys. Res., 113, C05013,

Andres, M., J.-H. Park, M.Wimbush, X-H. Zhu, H. Nakamura, K.Kim, and, K-I. Chang, 2009 "Manifestation of the Pacific Decadal Oscillation in the Kuroshio." Geophys. Res. Lett., doi:10.1029/2009GL039216.

Choi, B.H., K.O. Kim, and H.M. Eum (2002): Digital bathymetric and topographic data for neighboring seas of Korea, J. Korean Soc. Coastal and Ocean Engrs., 14(1), 41-50 (in Korean).