Kuroshio Variability on the Shelf of the East China Sea

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LONG-TERM GOALS

To characterize and understand the dynamics of the time varying structure and transport of the Kuroshio in the East China Sea (ECS) in conjunction with the ONR-supported project, "Variability of the Kuroshio in the East China Sea, and its Relationship to the Ryukyu Current."

OBJECTIVES

Through the ONR-supported project, an array of eleven IESs (inverted echo sounders) has been in operation since December 2002 in the ECS to measure the Kuroshio for a two-year time period, i.e., until the end of 2004. The IES array was deployed in the Okinawa Trough at depths deeper than 500m. The Kuroshio, however, extends to the outer continental shelf (see Figures 1,2). This NICOP project aims

(1) to observe the part of the Kuroshio over the outer continental shelf of the ECS for one year to quantify its entire transport along with IES data simultaneously obtained in the Okinawa Trough, and

(2) to determine the relationship between the Kuroshio axis (from the IES data) and its transport over the shelf in order to estimate its transport for the two-year period of IES deployment.

APPROACH

We will deploy two acoustic Doppler current profilers (ADCPs) in the ECS near the IES array. The ADCPs will be bottom moored at depths shallower than 300m housed in a trawl-resistant bottom mount (TRBM) and a subsurface foam buoy to measure the time-varying full-depth currents for one year, spanning all seasons of the year, during the two-year IES array deployment time.

KORDI has two TRBM-ADCP packages originally supported by another NICOP project, "Korean Coastal Currents," under a collaboration between Dr. Henry Perkins at NRL and K.-I. Chang at KORDI. The TRBM has a barnacle shape (Perkins et al., 2000) and has been proven to be efficient for measuring full-depth current profiles in active fishing areas for relatively long times, from 1 month off the west coast of Korea to 6 months in the Korea/Tsushima Strait (Teague et al., 2002). The field work will consist of four cruises to minimize the loss of instruments in this region with enormous fishing activity: initial deployment, 2 turnarounds, and final recovery. Currently, the TRBM-ADCP can only be used in areas shallower than 150m due to the limited length of the recovery line. To measure the Kuroshio in the 150~500m depth range, one ADCP will be housed in a subsurface buoy and bottom moored at around 250~300m.

The ADCPs will record current speed and direction profiles at 4 or 8m vertical intervals. They will also record bottom temperature. The data from the ADCPs will be routinely analyzed to determine mean currents and current fluctuations that will be further examined along with the IES data after completion of the IES observations.

KORDI will also support this international project by providing some funds (KORDI's in-house project, contract number PE84100) and by reducing the ship-time charge for KORDI's *R/V Onnuri*. Two of the four cruises will use KORDI's vessel for initial deployment and final recovery; the other two will use Japanese vessel(s) for mooring turnarounds.

WORK COMPLETED

Under KORDI's support, we first tested the performance of TRBM-ADCP packages before the deployment in the ECS. The field testing was planned to check the performance of recently updated acoustic releases (CARTs) and one new version of the TRBM as well as older types of instruments. During the field testing, special attention was given to the TRBM's pop-up and ballast release mechanisms and the performance of the acoustic releases (see RESULTS section).

The ADCP deployment sites belong to the Japanese Exclusive Economic Zone (EEZ); written consent from the Japanese government is therefore required for a foreign vessel (KORDI's *R/V Onnuri*) to enter the EEZ for the deployment of instruments. We submitted an application for consent to conduct an initial deployment of instruments in areas under the national jurisdiction of Japan, and received formal consent.

After field testing, the two ADCPs were refurbished and prepared for deployment. The initial deployment using *R/V Onnuri* will be carried out between September 29 and October 2 (2003) at two locations: K1 (approximately 28.42°N, 126.86°E, ~250m) with the subsurface buoy, and K2 (approximately 28.54°N, 126.68°E, ~150m) with the TRBM. CTD casts will be performed at the deployment sites prior to the deployment with additional CTD stations along the PN line after the deployment, if time permits.

RESULTS

To test performance of TRBMs and acoustic releases, a short cruise was made between May 19 and May 22 (2003) off the east coast of Korea, in which two TRBM-ADCPs were deployed at 30m and

120m depths and successfully recovered three days after the deployment. A minor ballast-release problem in one of the TRBMs was found and fixed. One CART acoustic release did not work properly in water, although it works in air. This CART will not be used in the field deployment.

Recovery and redeployment of the ADCPs are planned for November 2003 using a Japanese vessel, so the initial data recorded by the ADCPs will be available if they are successfully recovered.

IMPACT/APPLICATIONS

The results from this study should lead to advances in our understanding of western-boundary-current (WBC) dynamics, in particular the dynamics associated with spatiotemporal variability of meanders and bifurcations. This knowledge should be applicable to the Kuroshio at other latitudes, and also to other WBCs.

The NICOP project will also contribute to understanding penetration of the Kuroshio onto the continental shelf and the generation mechanism of its branch, the Tsushima Current. The directly observed Kuroshio transport in the ECS will also provide an opportunity, for the first time, to compare the Kuroshio transport in the ECS with the transport of the East/Japan Sea throughflow, the latter is being monitored by both submarine cable (Lyu et al., 2003) and ship-of-opportunity (Takikawa et al., 2003).

TRANSITIONS

Until the first recovery of the ADCPs no data are available; so others are not yet able to make use of our work on this project.

RELATED PROJECTS

The University of Rhode Island is 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 will record the main part of the Kuroshio transport in the ECS. The array was deployed in December 2002 and will be finally recovered in December 2004, thus providing spatiotemporal structure of the Kuroshio for a two-year time period.

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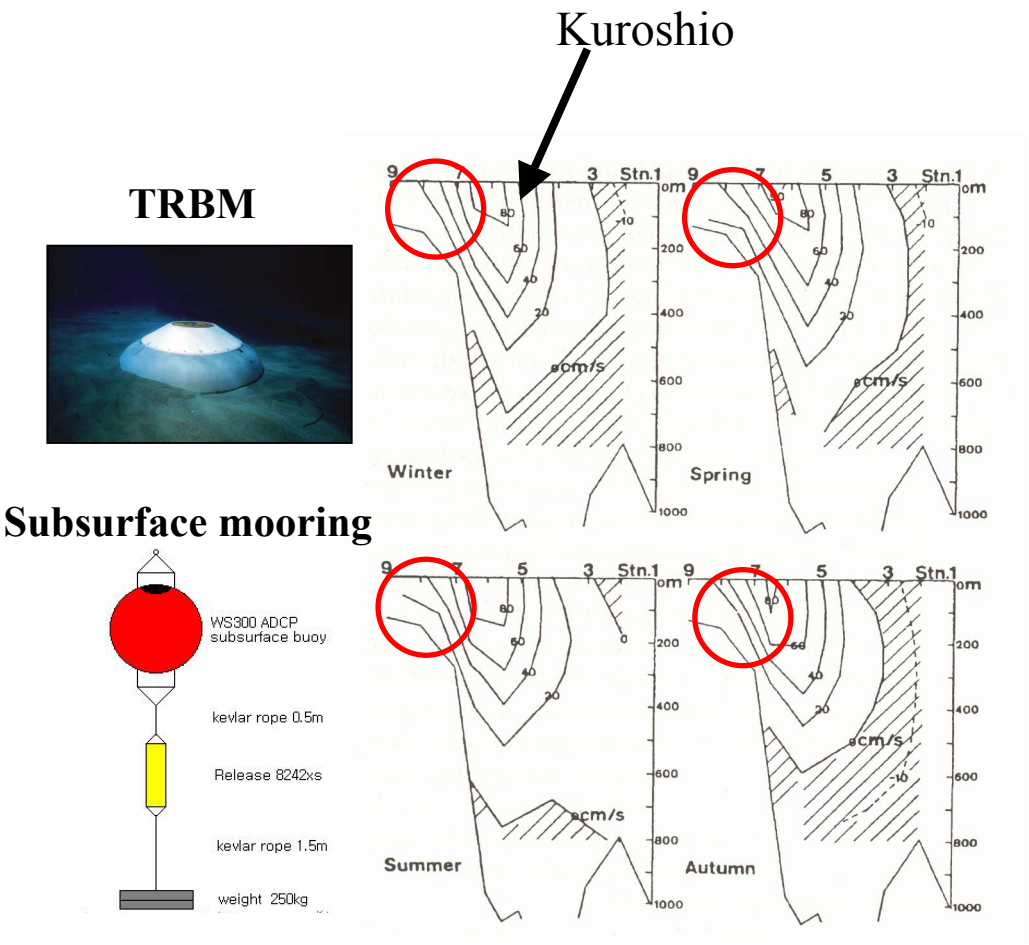

Figure 1. Vertical sections (right) of seasonal mean geostrophic current normal to the PN-line referred to GEK velocity (from Ichikawa and Beardsley, 2002). Red circles denote areas influenced by the northeastward flowing Kuroshio over the outer continental shelf. Acoustic Doppler current profilers housed in trawl-resistant bottom mount (TRBM; upper left) and subsurface buoy (lower left) will be used to measure this part of the Kuroshio. Shaded area indicates southwestward current.

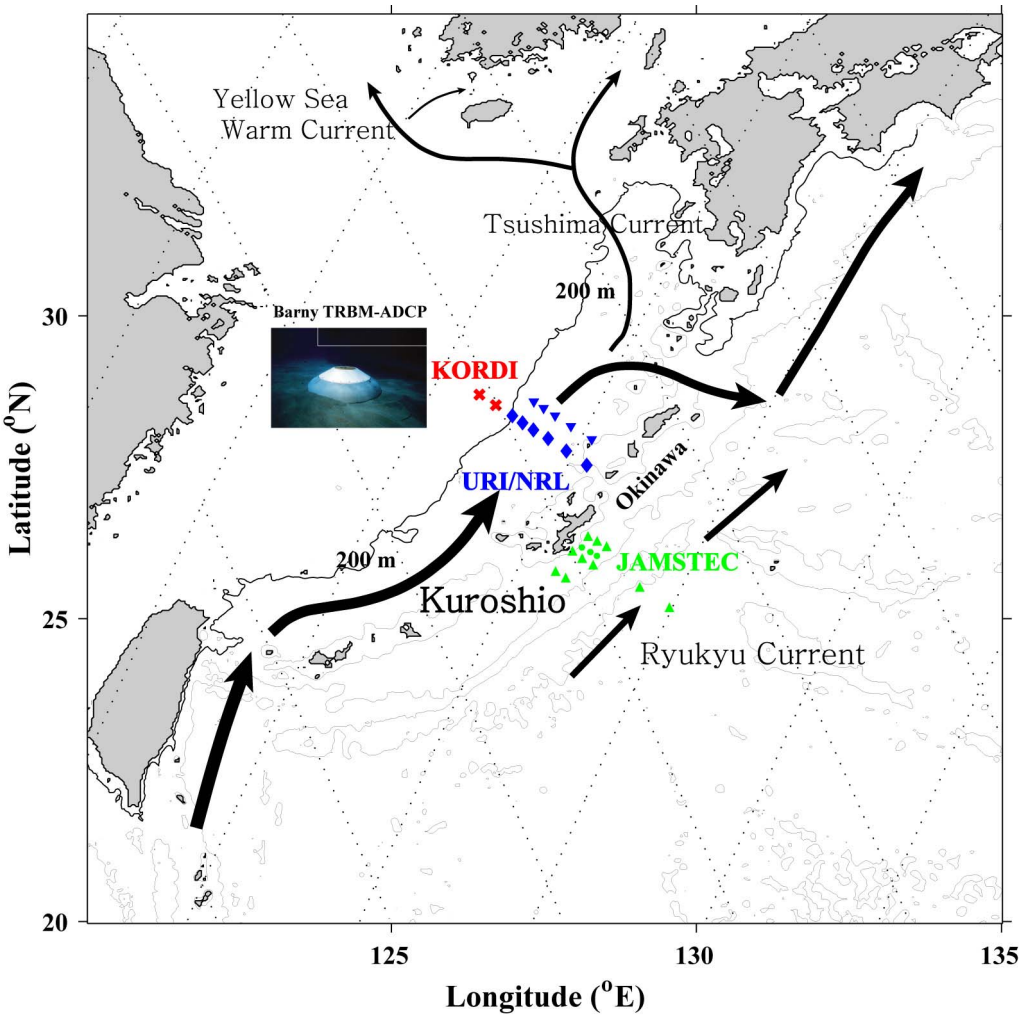

Figure 2. Schematic paths of the Kuroshio and its branches in the ECS together with locations of KORDI's ADCP moorings (red crosses) in the ECS and the IES array (blue diamonds and triangles) near the PN-line.