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, measuring the Kuroshio there for a nearly two-year time period (i.e., until November 2004). The IES array was deployed in the Okinawa Trough at depths deeper than 500m. The Kuroshio, however, extends to the outer continental shelf. This NICOP project aims

(1) to observe the part of the Kuroshio over the outer continental shelf of the ECS 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 position (from the IES data) and its transport over the shelf in order to estimate its total transport for the two-year period of IES deployment.

APPROACH

By deploying acoustic Doppler current profilers (ADCPs) in the ECS at 150 m and 280 m depths, near the IES array, we expect to measure the Kuroshio flow over the outer shelf. At the shallower site, one

ADCP is deployed in a trawl-resistant bottom mount (TRBM). At the deeper site one or two others are moored above bottom using subsurface buoys.

Two ADCP/TRBM packages were originally supported by another NICOP project, "Korean Coastal Currents," under a collaboration between Drs. 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 (Teague et al., 2002). The field work consists of four cruises to minimize loss of instruments in this region of enormously high fishing activity: initial deployment, 2 turnarounds, and final recovery. Currently, the ADCP/TRBM can only be used in areas shallower than 150m due to the limited length of the recovery line. To measure the Kuroshio in deeper waters, the ADCP must be housed in a subsurface buoy.

The ADCPs record current speed and direction profiles at 4 or 8m vertical intervals. They also record bottom temperature. 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 is also supporting this international project financially (KORDI's in-house project, contract number PE84100) and by providing ship-time on two Korean vessels, *R/V Onnuri* (KORDI) and *R/V Tamyang* (Pukyung National University). Additional ship-time is provided by a Japanese vessel.

WORK COMPLETED

Under KORDI support, the performance of the ADCP/TRBM packages was tested before deployment in the ECS. 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.

Written consent from the Japanese government was requested and obtained, to allow the Korean vessels to enter the Japanese EEZ for mooring deployment and recovery operations.

The two ADCP mooring sites are K1 at 28˚24'N, 126˚55'E (280m depth) and K2 at 28˚33'N, 126˚40'E (150m depth).

Here is a summary of the three deployments:

Leg I: Oct 2003 - Nov 2003
K1: one mooring with ADCP at 275m depth
K2: one ADCP/TRBM

Leg II: Nov 2003 - May 2004
K1: one mooring with ADCP at 275m depth
K2: one ADCP/TRBM

Leg III: May 2004 - Nov 2004
K1: one mooring with ADCP at 275m depth
and (K1-2) one mooring with ADCP at 120 m depth + RCM9 at 145m depth
K2: one ADCP/TRBM

On Leg III, two moorings have been deployed at the deeper site (K1) to obtain full-water-column current measurements using two ADCP's and a regular Aanderaa current meter (Figure 1). Leg III will end in November 2004 when all instruments are recovered.

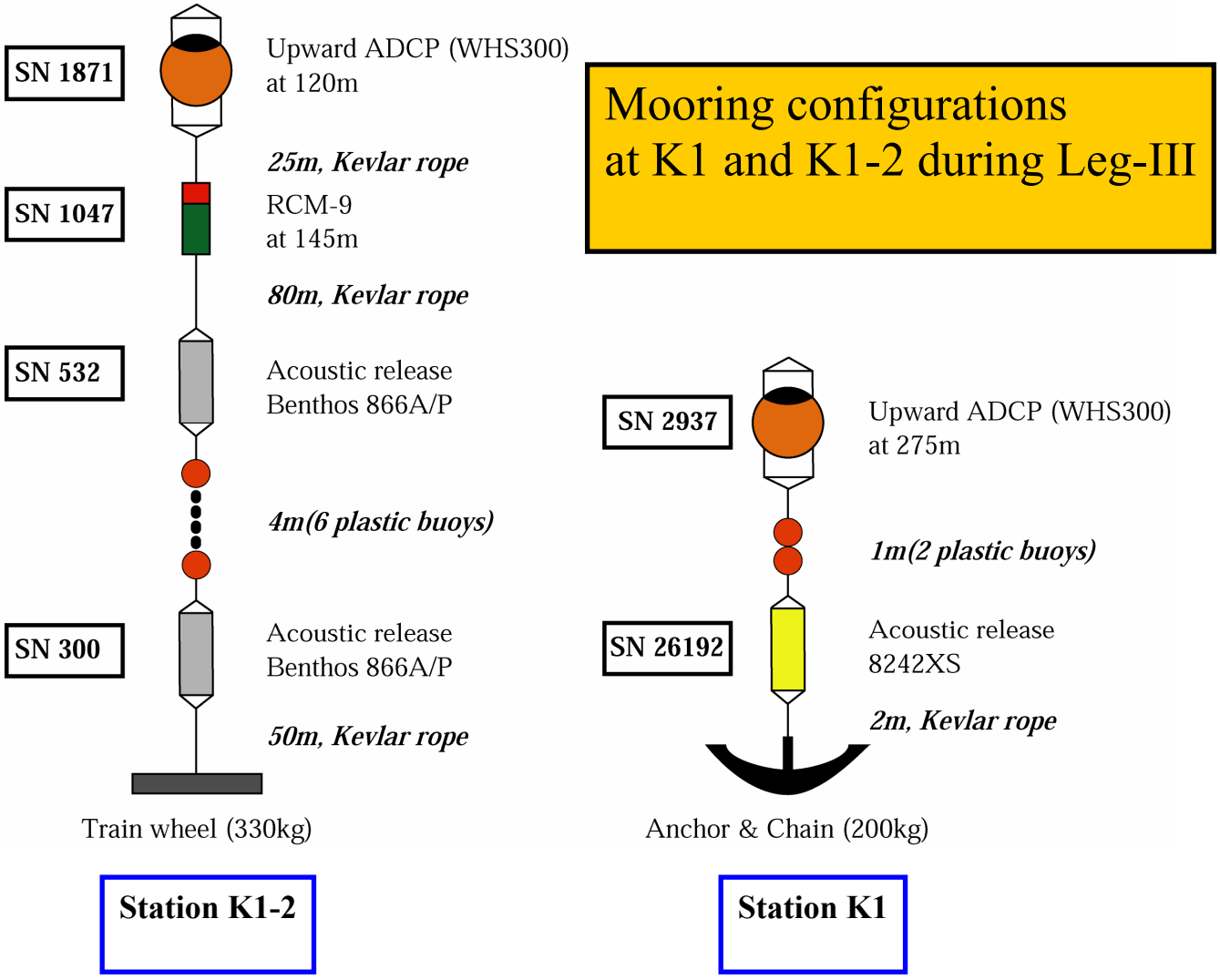

Figure 1. Diagram of the two moorings deployed in Leg III at Site K1 (280m depth). One mooring (labeled "Station K1") contains an ADCP at 275m depth. The other (labeled "Station K1-2") contains an ADCP at 120m depth and a current meter at 145m depth.

Figure 2 shows a map of the region, the locations of sites K1 and K2, and the locations C1-C9 of additional hydrographic stations taken on the Leg III deployment cruise. Hydrographic stations C1-C5 are close to the sites at which 6 IES's with pressure and current sensors were deployed by the University of Rhode Island (see RELATED PROJECTS section).

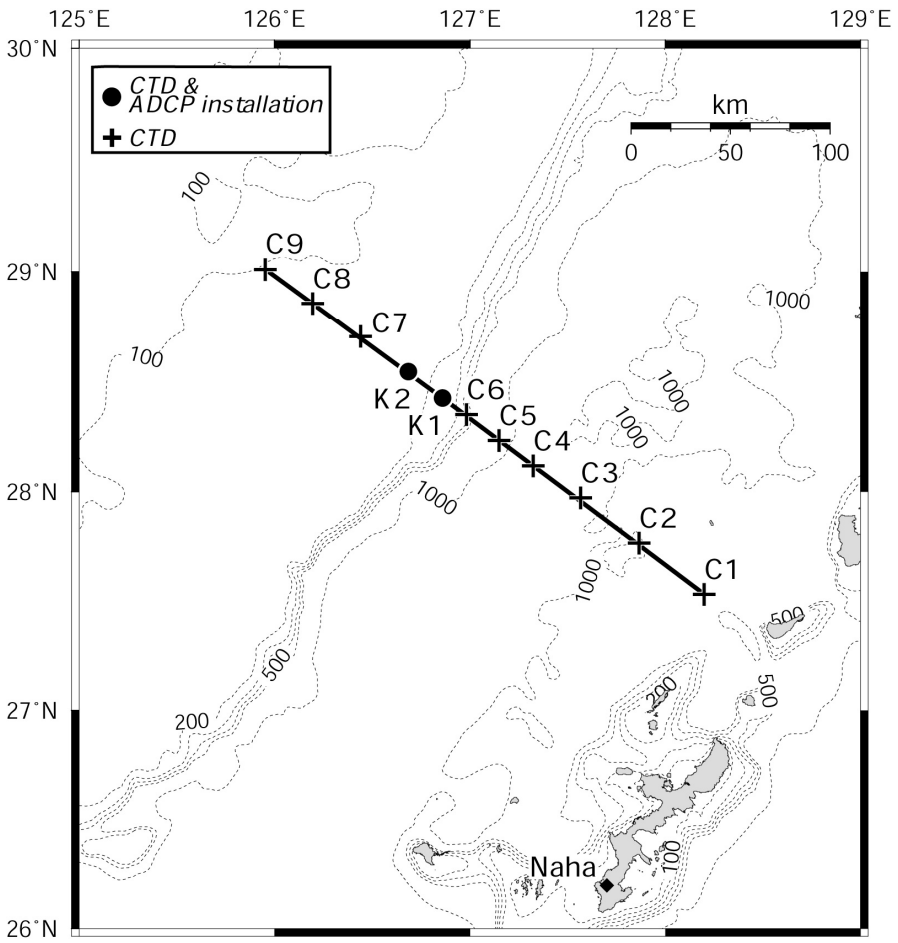

Figure 2. Map of East China Sea region north of Okinawa showing the locations K1 and K2 at which the ADCP moorings have been deployed. Also shown are the sites of additional hydrographic stations C1-C9 taken on the Leg III deployment cruise in May 2004.

RESULTS

During the first two Legs, good current velocity data were obtained from the ADCP at the deeper site (K1) for water depths between 162 and 268 m. Problems with the memory card in the ADCP at the shallower site (K2) have prevented any data recovery at the K2 site from the first two Legs. It is hoped that this problem is corrected for Leg III which is currently under way. Also, for Leg III, two moorings have been deployed at the deeper site (K1) to enable us to obtain full-water-column current measurements using two ADCPs and a regular Aanderaa current meter (Figure 1). Leg III will end in November 2004 when all instruments are 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 Japan/East Sea throughflow, the latter is being monitored by both submarine cable (Lyu et al., 2003) and ship-of-opportunity (Takikawa et al., 2003).

TRANSITIONS

Data will be made available after the final instrument recoveries in November 2004.

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 November 2004, thus providing spatiotemporal structure of the Kuroshio for a two-year time period.

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