

SOUND-SPEED STRUCTURE AND PROPAGATIONAL CHARACTERISTICS OF A COLD CORE EDDY IN THE BAY OF BENGAL

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ABSTRACT

An analysis of acoustic characteristics of a cold core eddy in the Bay of Bengal reveals that the eddy introduces an abrupt reduction in sound-speed by about 10 ms^{-1} . The depth of deep sound channel axis beneath the eddy remains constant whereas thickness of surface duct reduces by about 20 m across the eddy. Simulation studies showed that the rays passing through the eddy undergoes a reduction in the path length thereby reducing the travel time. Travel time delay caused by the eddy is of the order of 200 milliseconds.

INTRODUCTION

The conventional hydrographic surveys during the past few decades have generated considerable amount of information regarding hydrographic characteristics and to some extent, the general circulation. However, the existence of eddies and frontal

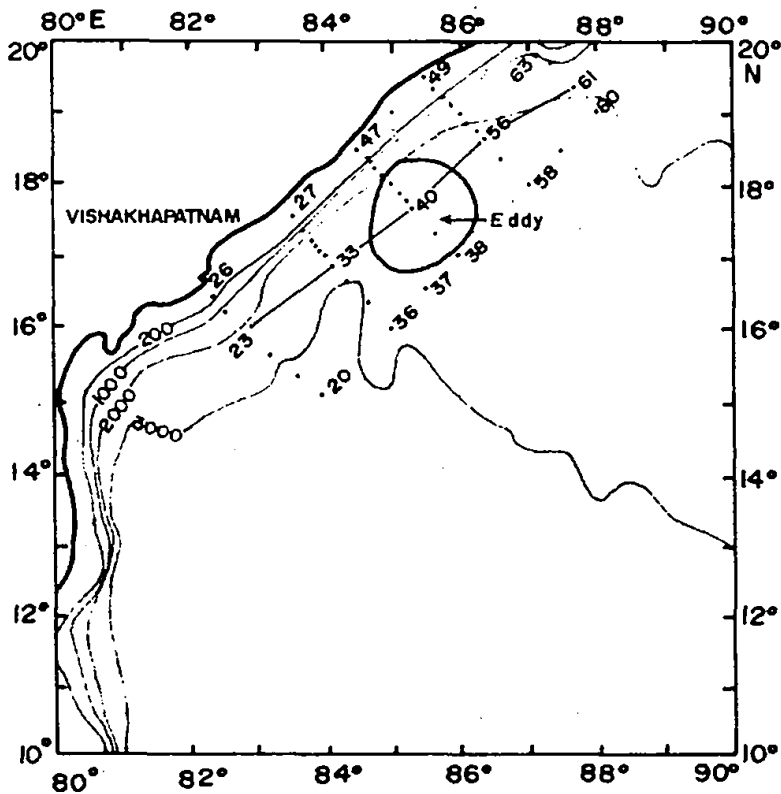


Fig. 1. Eddy configuration based on CTD data. Station locations and track parallel to the coast across the eddy are also shown.

zones and their energetics in relation to general circulation are yet to be documented.

A recent study (Babu *et al.* 1991) revealed the presence of subsurface cold core eddy in the north western Bay of Bengal (Fig. 1) during late July when typical southwest monsoon climate prevails. In this paper we present the acoustic characteristics of the cold core eddy. Attempts have also been made to delineate the effect of the eddy in long-range acoustic transmission and its implication to ocean acoustic tomography studies.

DATA AND METHODS

The hydrographic survey, carried out on board ORV Sagar Kanya during 21-29 July 1984, occupied a total number of 42 CTD stations near the western boundary of north Bay (Fig. 1). From these CTD data, sound-speed has been computed following Chen and Millcrio (1977).

RESULTS AND DISCUSSION

In order to examine the variability of sound-speed in the presence of cold core eddy, the sound-speed structure across the eddy (track parallel to the coast) is presented along with the vertical profiles (Fig. 2a & b). The profiles are all similar in shape having a well defined deep sound channel and a smaller duct near the surface (Fig. 2a). The profiles are all similar in shape having a well defined deep sound channel and a smaller duct near the surface (Fig. 2a). The sonic layer depth, which is the depth of near-surface sound-speed maximum, changed abruptly by about 20 m across the eddy. At the surface the sound-speed varied by 8 ms^{-1} with a decreasing trend from south to north. This variation is brought about by the presence of low saline cold water in northern Bay associated with freshwater discharge reducing the sound-speed value and the

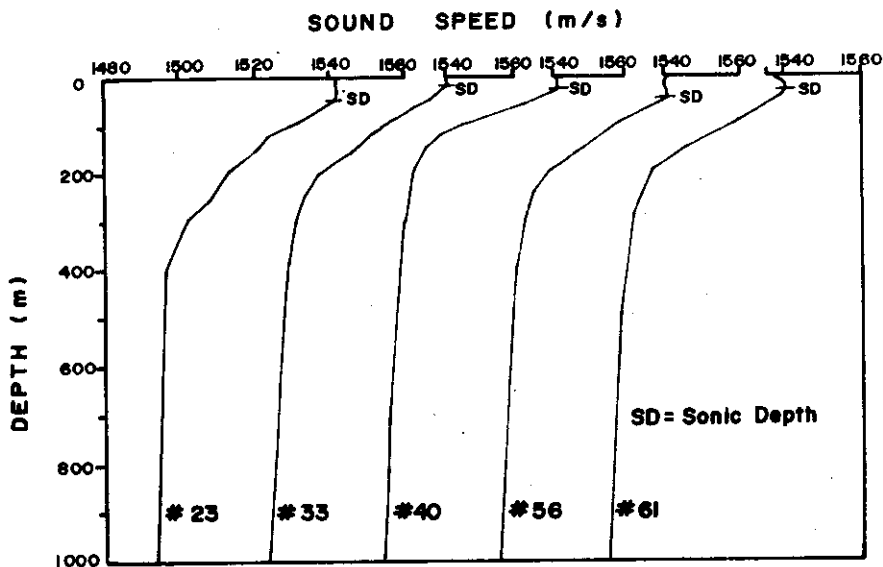


Fig. 2a. Vertical sound - speed profile along the track parallel to the coast.

comparatively high saline warm water present in the southern side giving rise to higher sound-speed value. Below the surface the eddy is clearly discernible from the uptilt of 1500-1520 ms^{-1} sound-speed isopleth (Fig. 2b).

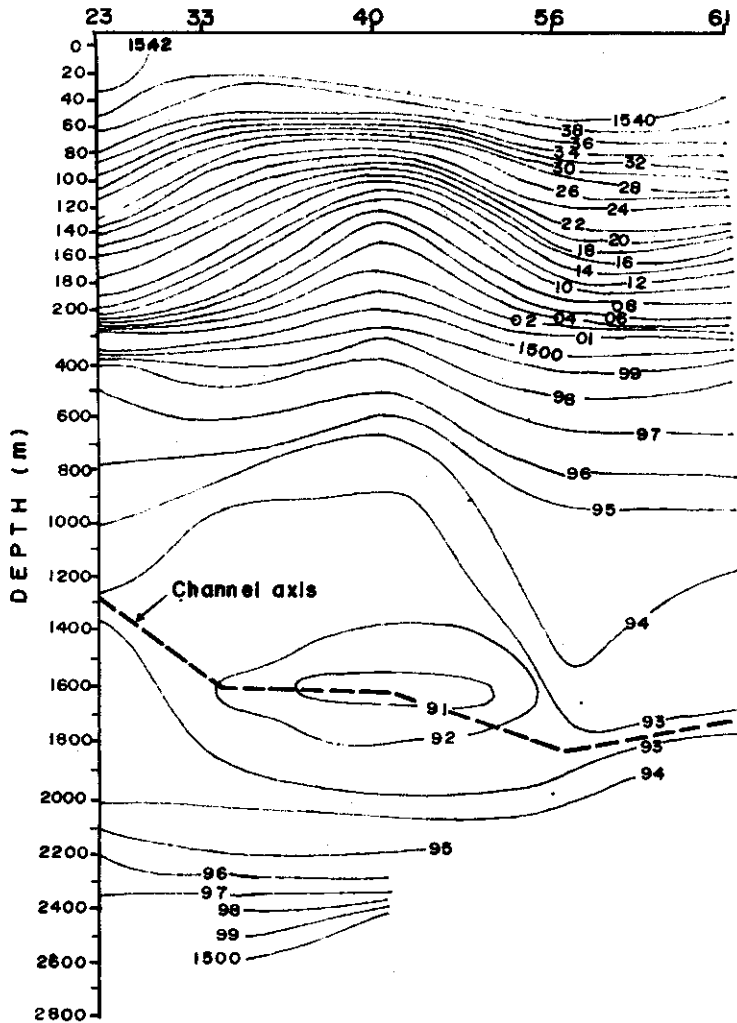


Fig. 2b. Vertical sound - speed structure across the eddy.

The presence of eddy brings about a reduction in the sound-speed. At 60 m depth, the sound speed reduces by 4 ms^{-1} across the eddy. A maximum reduction occurs at 120-140 m depth layer at the centre of the eddy where the sound-speed drops upto 14 ms^{-1} . Below 300 m depth the variability in sound-speed is less than 2 ms^{-1} . The effect of cold core eddy is to reduce the ambient sound-speed by approximately 10 ms^{-1} . Associated with this, the depth of channel axis and axial speed also undergoes changes. In general, the depth of deep sound channel axis increases from

south to north along the track parallel to the coast. However, below the cold core eddy, the channel axis depth remains constant (1600 m). Accordingly the sound-speed at the channel axis below the eddy reduces by about 1.5 ms^{-1} . In order to study the effect of eddy in long range acoustic transmission, simulation was carried out using acoustic ray tracing program (Ramana Murty *et al*, 1989). The ray tracing was carried out using the reference sound-speed profile and individual sound-speed profiles derived from CTD data along the track. The reference sound-speed profile is the average profile derived from all CTD data. Rays were traced for all the emerging angles between $+12.5^\circ$ to -12.5° with an angle increment of 0.5° keeping

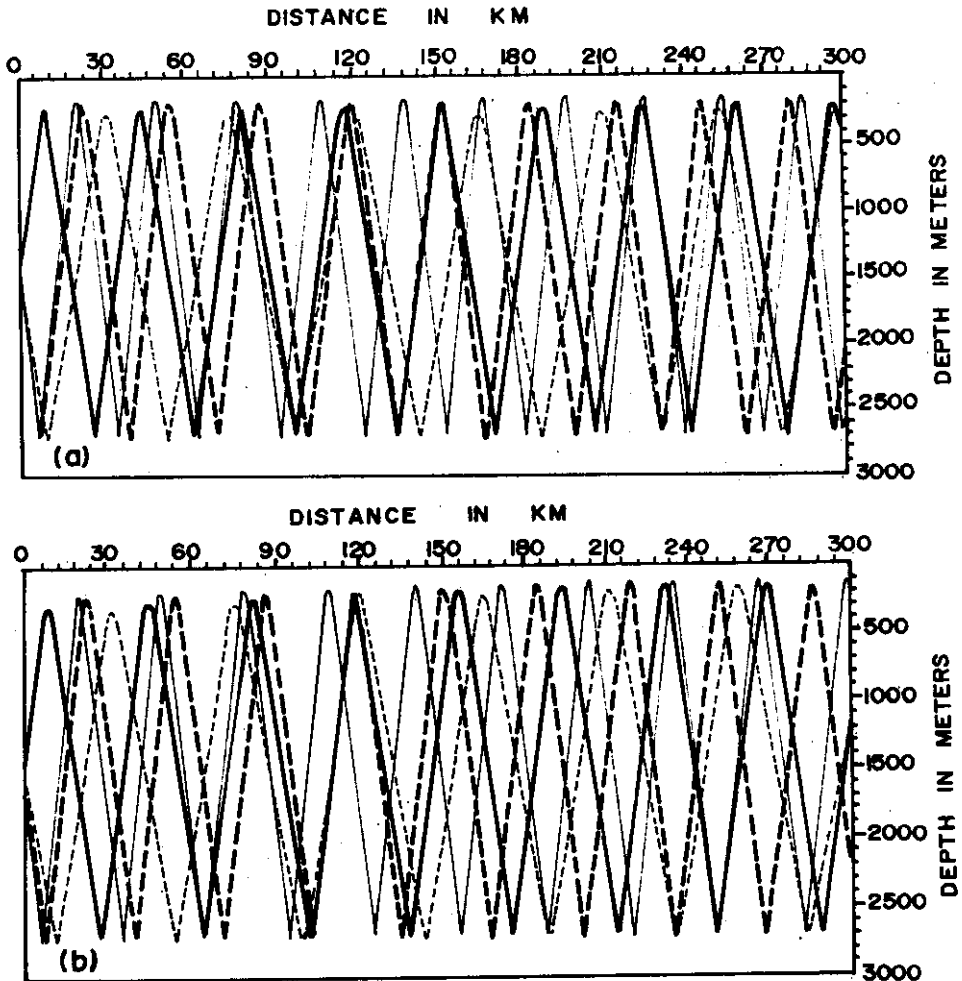


Fig. 3. Typical ray geometry for (a) sound speed profile and (b) sound speed derived from observed CTD profile over a range of 300 km. (— 9° , - - - -11° , - · - · -10° , · · · -7.5°).

the source depth as 1500 m and range 300 km (Fig. 3a & b). It could be seen from the figure that in the presence of the eddy ray path changes. Consequently, the path length and travel time also change (Table 1).

Table 1. Ray path length and travel time delay for selected ejection angles in the presence of the eddy.

Ejection angle (Degree)	Deviation in path length (Average - Original) (metres)	Travel time delay (Average - Original) (milliseconds)
-11.0	425.4	210
-10.0	128.3	10
-07.5	310.7	120
+09.0	130.9	10

For example, -11° ray undergoes the maximum change as it passes through the eddy (238 m) resulting in a travel time change of 210 milliseconds. -7.5° ray which passes just below the eddy (338 m) also shows significant travel time delay. However, the other rays do not show significant travel time delay as they are well below the eddy region.

The study indicates that the eddy introduces a travel time delay of the order of 200 milliseconds. This is well within the resolvable range of a tomographic receiver and hence such eddies can be detected using acoustic tomography technique.

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