THE SOUND VELOCITY STRUCTURE OF THE SHELF WATERS OFF VISAKHAPATNAM

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ABSTRACT

The vertical structure of sound velocity has been presented. The depth-sound velocity curves are drawn. The sound velocity is found to vary considerably in the surface waters during the period from November 1955 to April 1956. The variations in sound velocity have been discussed in relation to (1) sinking, (2) upwelling (3) advection and (4) diurnal and seasonal variations in temperature and salinity. The sound velocity in surface waters shows a general increase with the advance of upwelling season. The sound velocity decreases with depth in the surface layers in the upwelling season. In contrast, the sound velocity increases with depth in the surface layers during sinking season. At greater depths the sound velocity is found not to vary much during the entire period (November to April).

Introduction

Kuwahara[1] based on theoretical considerations prepared tables for calculating the sound velocity. Using these tables, the vertical structure of sound velocity distribution has been studied in relation to seasonal variations, such as sinking and upwelling. The data used has been collected by the personnel of the Geophysics Department of Andhra University. The physical oceanography of the area is presented in relation to the vertical structure of sound velocity. The data used comprises six cruises off Waltair.

Collection of data and analysis

Fig. 1 indicates the station section map off Waltair. Water samples have been collected by Nansen bottles and the temperatures were obtained by reversing thermometers. In addition, a bathythermogram was taken at each station. Salinity values have been obtained by chemical analysis. Then the raw data has been processed to obtain the temperature and salinity at standard depths. The sound velocity is then computed using Kuwahara's tables and the procedure adopted therein has been indicated in the previous paper by J.S. Sastry[2].

Fig. 2—7 gives the sound velocity structure in the vertical for the cruises 34, 42, 43, 44, 45 and 46.

Cruise 34 had been conducted during November 1955, while cruise 42 had been conducted during February 1946. Cruises 43, 44 and 45 had been undertaken during March (beginning of the upwelling season) while cruise 46 was during April (when upwelling was strong). The month of February may be considered as a transition period in that the ocean circulation and to some extent weather conditions change.

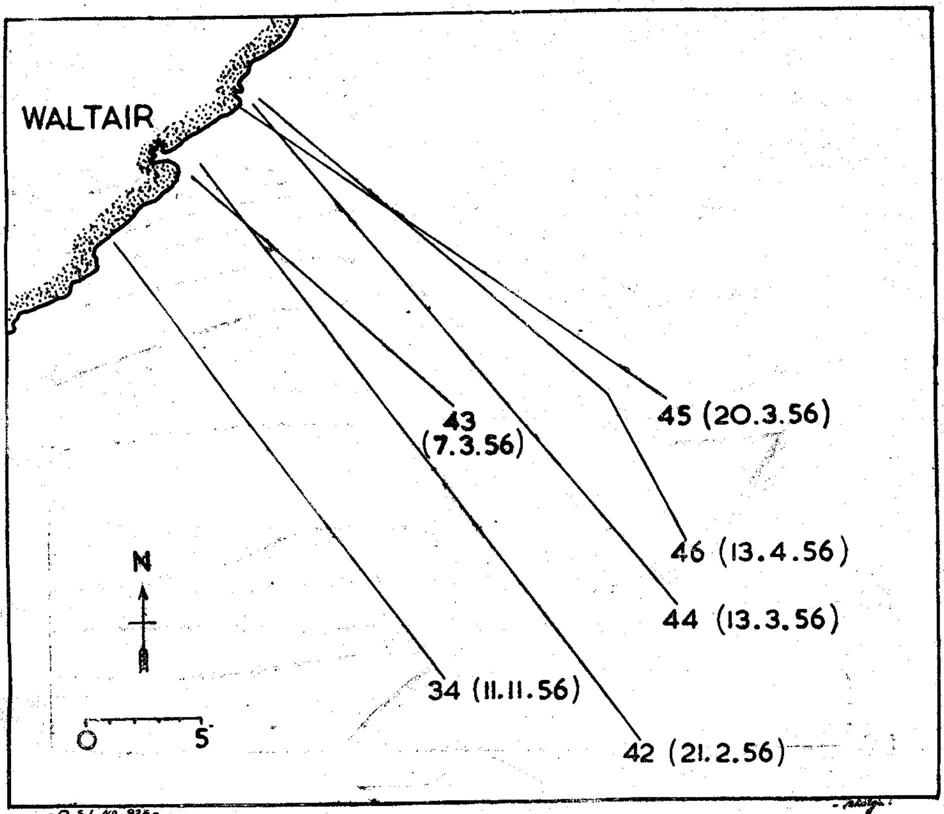

Fig 1— Section Location Map of Waltair

Discussion of the sound velocity structure

Fig. 2 gives the vertical structure of sound velocity off Waltair during November. This is in sinking season in which the surface waters are transported to the near shore and sinks. Sinking occurs at the station 284 and is more pronounced as we reach station 483 and gradually reduced towards the coast. The general distribution of the surface wind at Visakhapatnam is from North East[3] and this is most favourable for sinking near shore. It appears from the sound velocity studies that only the top 30 meters of surface layer are subjected to have the effects of the wind and in the top 5 to 10 m. the displacement is intense. From the structure of sound velocity which when compared to the temperature structure in the vertical[4] gives the picture that the sinking takes place at a distance of 5 miles from shore i.e. from 481 to 485.

Fig. 3 gives the vertical structure of sound velocity in a section off Waltair during February 1956. This is a calm season in which winds are low and to some extent variable in direction from morning to evening. The currents are weak in this period, change from NE direction during November to SW during March. This is a period of transition. The sound velocity structure shows

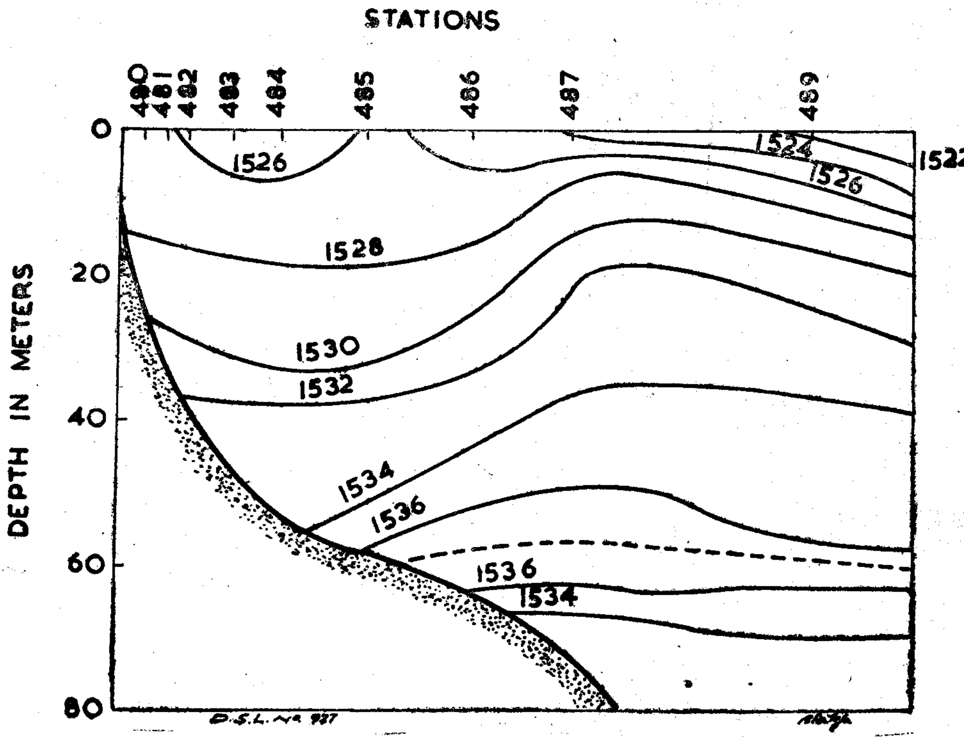

FIG 2—Vertical Structure of Sound Velocity (Cruise 34)

that in between stations 604 to 605 (nearer to station 605) the sound velocities are low when compared to near shore and coastal waters and this is borne out by the fact that there is a temperature discontinuity in between these two stations. At station 605 (at a distance of about 25 miles) the temperature is rather low while the salinity is almost the same as the shore waters. This discontinuity of temperature can be found from the temperature structure as well as the sound velocity structure up to a depth of about 85 m. The sound velocity structure in between stations 601 and 604 indicates that Southern Bay of Bengal water penetrates into the coastal waters at about a depth 65 m. Thereafter these waters mix with near shore waters and lose the characteristics of the southern Bay of Bengal waters. These waters, while mixing progresses, form some pockets of water defined by the isovelocity lines 1534 m/sec. and 1532 m/sec. The isovelocity contour representing 1534 m/sec. has been identified in the thermal structure also by C.B. Murty[4] in which he called this as the Bottom isothermal water mass. The contour of 1532 m/sec. isovelocity line mainly due to mixing and over-turning of surfaceayers since in this season intense cooling takes place and consequenty the density of surface waters increases creating unstable conditions. The depth of the mixed layer extends to about 80 m.

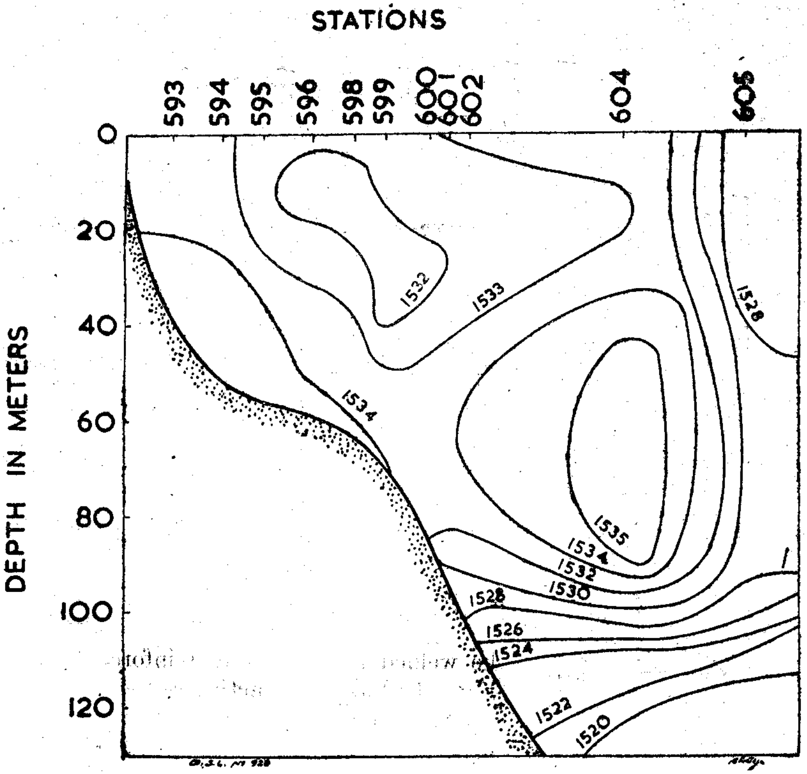

Fig 3—Vertical Structure of Sound Velocity (Cruise 42)

Figs. 4, 5 and 6 represent conditions of the coastal waters in March 1956 during the advance of the upwelling season. All these three sections were taken off Waltair. Fig. 4 indicates that upwelling has already begun at about stations 612 and the surface water flows away from the coast. The density of these waters is high compared to the heated surface layer. Mixing and overturning takes place creating a surface layer just below the top thermocline.

Fig. 5 indicates that the thickness of surface layer varies between 15 and 25 m.

Figs. 5 and 6 give the sound velocity structures during March 1956. In between these two cruises there was an easterly wind in the Bay of Bengal creating unsettled conditions in the Bay. The structures shown in these two figures do not at first agree with either that shown in Fig. 4 or Fig. 7 (taken in April when upwelling was very strong). Due to strong winds and possible movement of water masses it is supposed that intense mixing has taken place giving rise to almost parallel horizontal contours of isovelocity lines. Fig. 7 shows that the conditions are coming back to normal with slight indication of upwelling taking place very near the shore.

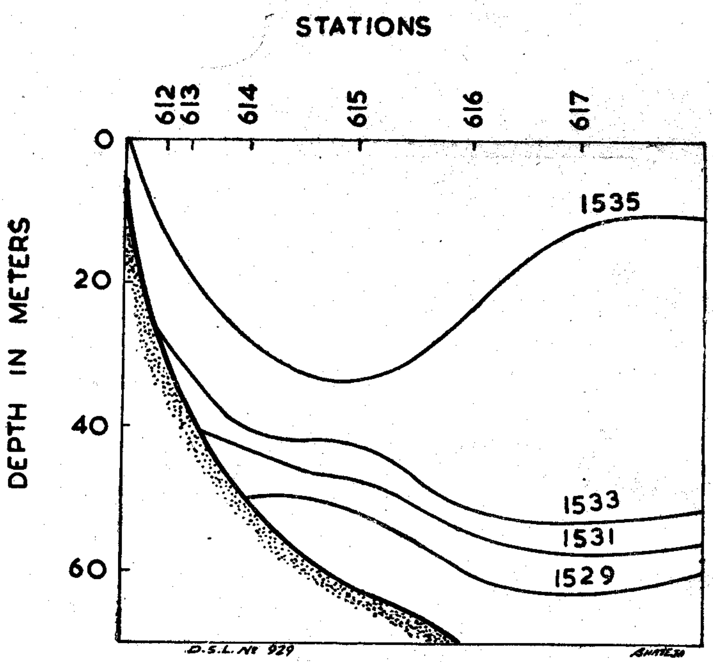

Fig 4—Vertical Structure of Sound Velocity (Cruise 43)

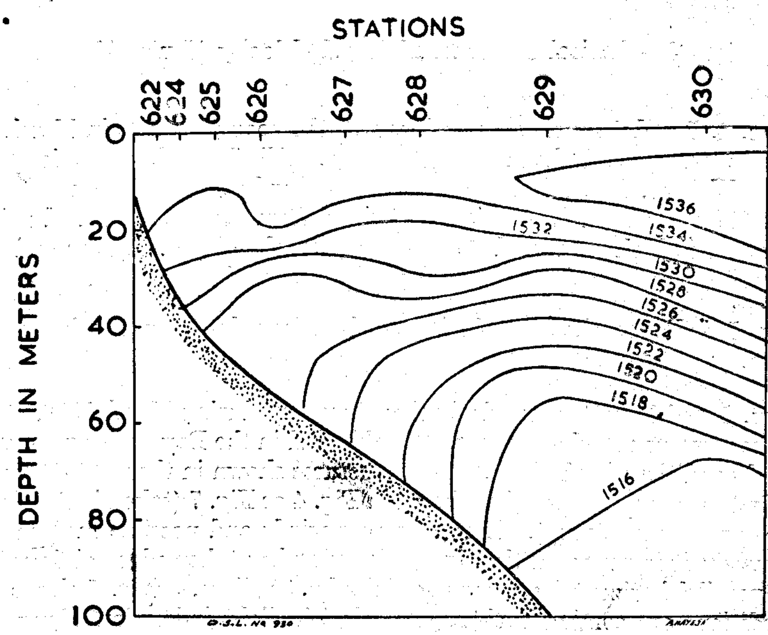

Fig 5—Vertical Structure of Sound Velocity (Cruise 44)

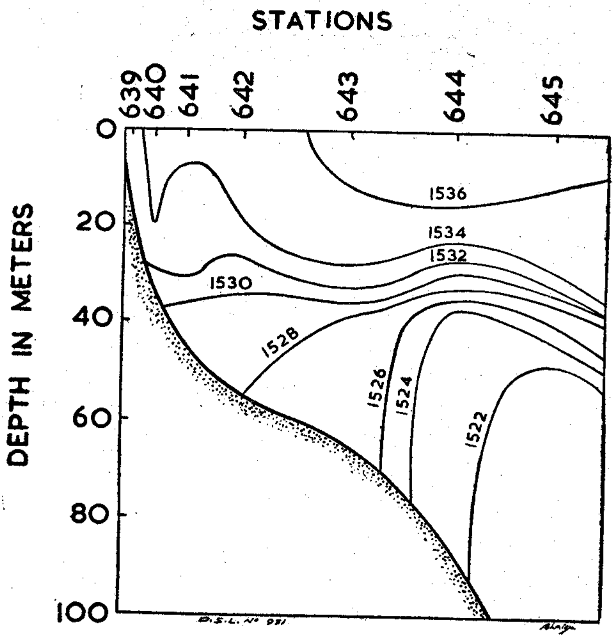

FIG 6—Vertical Structure of Sound Velocity (Cruise 45)

Fig. 7 gives the picture when upwelling is most intense, subsurface water between the isovelocity lines 1536 m/sec. and 1532 m /sec. rises to the coast and reaches the surface in between stations 665 and 667. This is the location where maximum upwelling is taking place. Further away from the coast, a surface layer developed and increased in depth to about 40 m. at station 672. The tongue like distribution near the bottom indicates a bottom isothermal layer of thickness about 20 m.

The diurnal variations of temperature affect the sound velocity in the topmost 5 meters and its effect in certain cases appear to change the sound velocity as much as 1·5 m/sec.

The depth velocity curves indicate that the changes in sound velocity in the surface layers is more than that in bottom layers. This is due to the fact that the subsurface waters are not much affected by river run-off upwelling and sinking.

Sound Channel

As these sections are small compared to that discussed by the author in an earlier paper[2], the top sound channel is not easily identified. As for cruise 34 (sinking season), there is a sound channel marked by lower sound velocities above and below at a depth of about 55 m. The origin of the sound channel may be clearly studied. The salinity as well as the temperature of the surface waters is low. The sound velocity decreases by these two factors giving rise to low sound velocity curves in the top layers. The temperature and salinity gradually increases with depth. The temperature gradients change in sign at about a depth of 55 m. Even though the salinity increases slightly below, the effect of temperature is in excess and the sound velocity falls slowly with increasing depth. In Fig. 7 the top sound channel as shown by the dotted line indicates the position of upwelling.

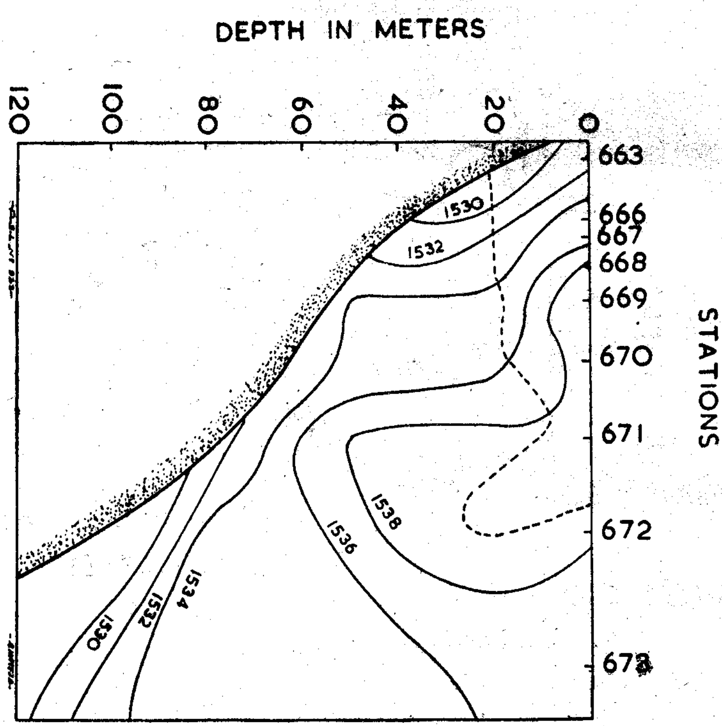

FIG 7—Vertical Structure of Sound Velocity (Cruise 46)

Acknowledgements

I thank Dr. R. Ramanadham for his valuable suggestions and continued interest in the subject. I thank my colleague Mr. C. Balarama Murty with whom I had a good many discussions on the subject and for permitting me to use his results which are being published separately. My thanks are due to Dr. J. N. Nanda and others whose criticism and suggestions during the symposium on oceanography of Bay of Bengal have been very valuable.

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