Current Fine Structure in the Florida Current[1]

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ABSTRACT

The current profile to a depth of 120 m has been measured in the Florida Current with a resolution of about 1 m in the vertical. The profile reveals a complex fine structure with regions of high shear.

Measurements of the vertical distribution of temperature and salinity in the ocean characteristically show considerable fine structure superposed on the mean gradients. It is of interest to inquire whether there is a corresponding fine structure in the velocity profile. This paper describes an instrument system for measuring current speed vs. depth with a vertical resolution of about 1 m. The results of a lowering made in the Florida Current in mid-August at 26° 10′N, 79°50′W are given.

The measuring system (Fig. 1) consists of a small governed winch mounted on the base of a spar buoy 15 cm in diameter and 3.5 m long. A 2-mm nylon line unwinding from the winch is used to lower two Savonius-rotor current meters and a depth recorder at a rate of about 1 m/min. A cast-iron weight of approximately 45 kg is used at the bottom of the series of instruments; 30 kg of this weight is compensated for by floats that help to keep the current meters erect. When the instruments reach a preselected depth, a pressure-sensitive release drops the weight and the instruments float to the surface. The three instruments record photographically, and each recording includes a clock; the clocks are mutually synchronized to 1 sec.

With this arrangement one can obtain profiles of the current speed by fixing the position of the spar as a function of time and by determining the speed difference between the spar and each Savonius rotor. The two rotors provide individual profiles, separated in time and displaced in space. During the two hours required to obtain the data presented here, the entire instrument system moved downstream at a rate that slowly decreased because of the in-

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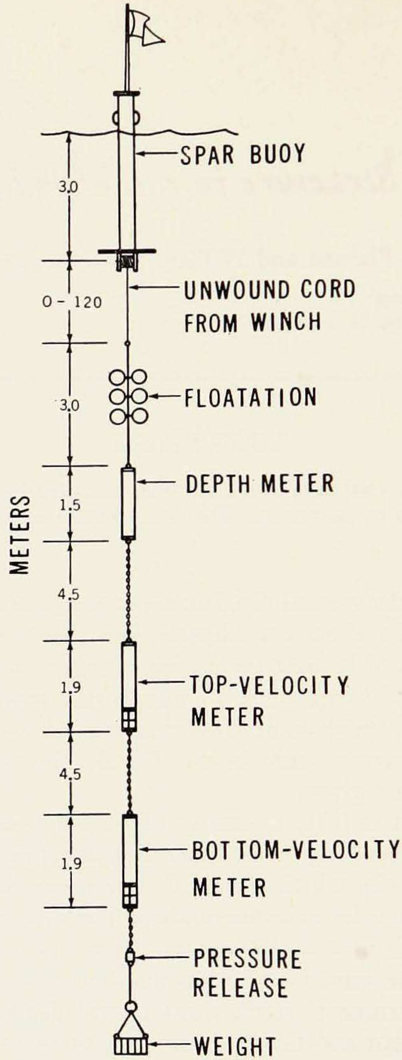

Figure 1.

creasing drag on the instruments as they decended into the more slowly moving waters. Figs. 2 and 3 show for each rotor the profile of current speed measured relative to the moving instrument system. The rotors are separated vertically by 6 m or, equivalently, by 6 min. The actual path traversed by each rotor is a diagonal extending to a depth of 120 m and for a distance of 9 km parallel to the axis of the current.

For a fixed depth, the velocities measured by the two rotors are separated

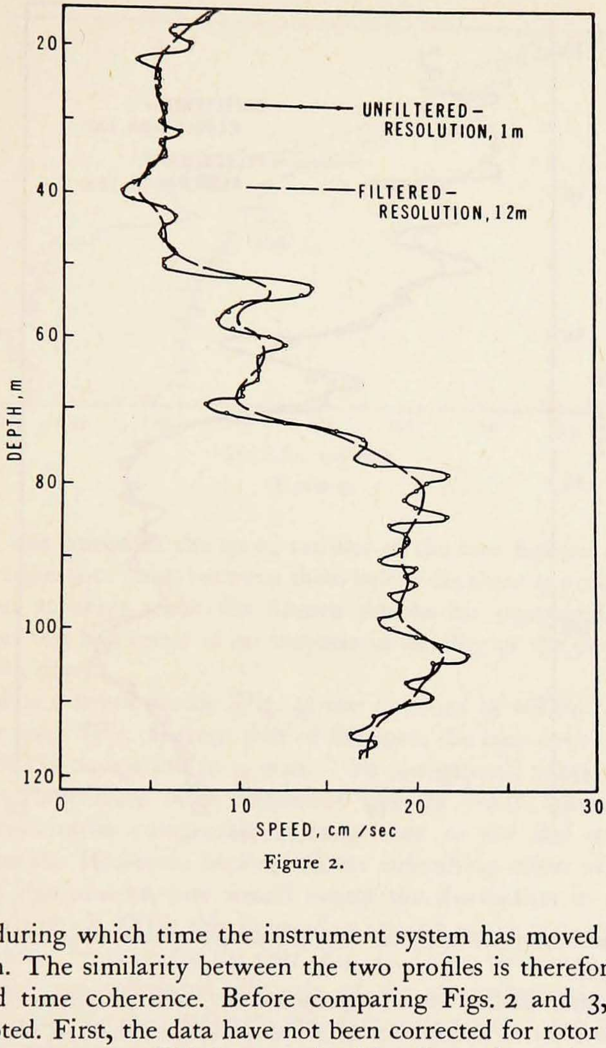

Figure 2.

by 6 min., during which time the instrument system has moved downstream about 450 m. The similarity between the two profiles is therefore a measure of space and time coherence. Before comparing Figs. 2 and 3, two points should be noted. First, the data have not been corrected for rotor tilt observed during the measurement. This has a noticeable effect only on the rotor, whose tilt angle was relatively constant until it passed through the strong shear at 70 m; thereafter it again assumed a constant but larger tilt. This explains why the mean velocity appears less in Fig. 2 than in Fig. 3 and why the apparent difference is greater below 70 m than above. Second, in processing the data the vertical spacing between the data points (distance between small circles in Figs. 2 and 3) has been treated as though it were the same for both profiles. In fact, they differ slightly. In drawing the two profiles, they have been aligned at mid-depth (70 m). The result is that all data points in Fig. 3 are compressed toward the mid-depth. The effect is, of course, most pronounced

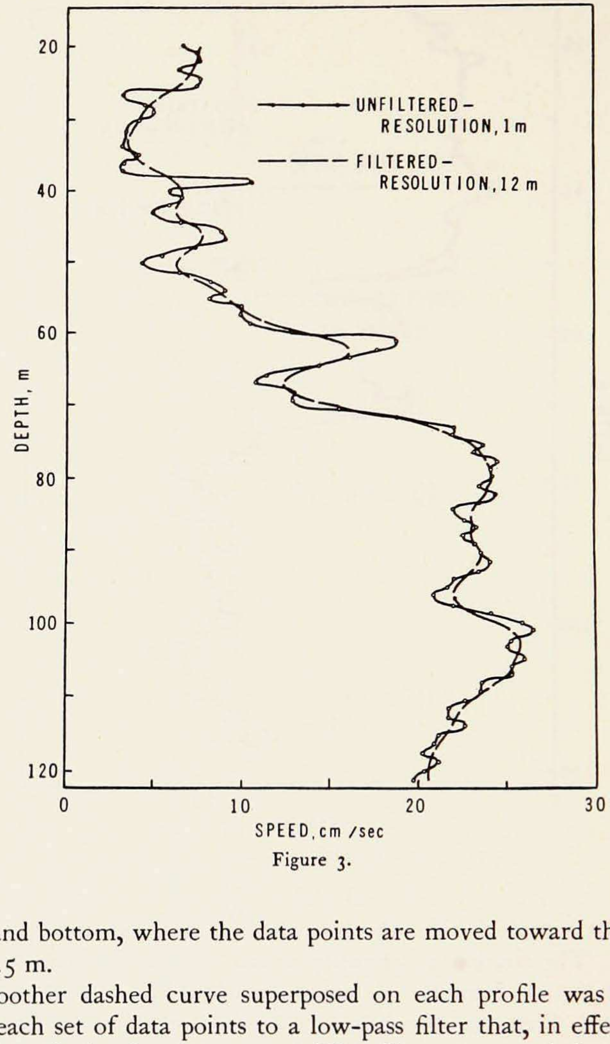

Figure 3.

at the top and bottom, where the data points are moved toward the mid-depth by about 2.5 m.

The smoother dashed curve superposed on each profile was obtained by subjecting each set of data points to a low-pass filter that, in effect, decreased the vertical resolution by about 12 m. The filter attenuated the smaller-scale features, i.e., those that would be expected to exhibit the greatest degree of space-time variability. The filtered profiles should, therefore, show greater coherence.

With these points in mind, it is interesting to compare Figs. 2 and 3. Perhaps the most dominant common feature is the region of large shear at about 70 m. Unfortunately, the experiment did not include temperature measurements, which might have allowed relating this shear to the temperature structure. A bathythermographic sounding made one week earlier at approximately the same location indicates that the bottom of the mixed layer was at a depth

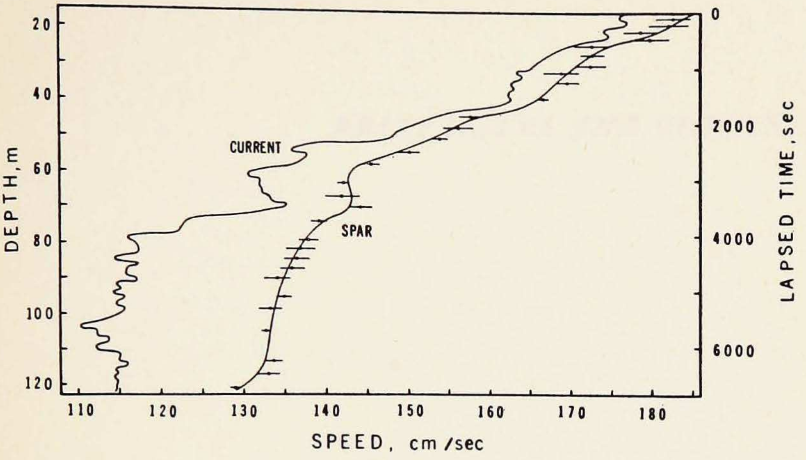

Figure 4.

of 20 m. If one compares the speed profiles of the two figures, it is apparent that greater coherence exists between them below the shear at 70 m than above. This is more apparent when the filtered profiles are compared. One might speculate that this is a result of an increase in stability as the current velocity decreases with depth.

The absolute current profile (Fig. 4) was obtained by subtracting the speed of the upper rotor (Fig. 2) from that of the spar; the spar position was determined by Hi-Fix navigation to ± 2 m. This navigational error is sufficiently large so that fixes taken more frequently than at 5-min. intervals result in velocity uncertainities comparable in magnitude to the fine structure, i.e., about 1.5 cm/sec. However, because of the smoothing effect of the drag of the series of instruments, one would expect the fluctuation in spar velocity to be relatively small. With this in mind, a smooth curve was drawn through the velocity-error brackets for the spar (Fig. 4). Using this curve, the absolute current profile was calculated. Because of the somewhat subjective means used to determine the spar velocity, any particular feature may be somewhat in error, but, taken as a whole, the results should be representative. Perhaps the most significant revelation from these observations is the considerable amount and intensity of the fine structure. Shears of 15 cm $sec^{-1} m^{-1}$ are superposed on the velocity gradient, which is about 0.5 cm $sec^{-1} m^{-1}$.

In the future, it would be desirable to include instruments in the series that would record the temperature and salinity profiles.

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