On the vertical structure of the Black Sea Currents

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The available measurements and diagnostic calculations generally provide a similar vertical structure of the horizontal current velocity (Latun, 1989a). Currents attain their maximum speed (about 90 cm/s) in the near-surface levels. Then, they tend to reduce typically by about 25% at the depth of 75m and drops by 50-60% towards 100m and then decrease gradually toward deeper levels. The flow is almost unidirectional within the zone of Main Black Sea Current (MBSC) down to the depths of 300-500m. In the deep anticyclonic eddies, where the vertical structure may extend down to the depth of about 1000m, the circular currents attain a difference of approximately 5 cm/s between the 500m and 1000m. On the other hand, such difference are virtually nonexistent outside the anticyclonic eddies.

The present work reports briefly findings of the hydrological and current measurements performed at five stations throughout the water column at eight levels between 10m and 1500m for about two weeks period (Latun, 1989b). The stations are situated in a cross-like grid with a distance of aproximately 20 miles to the central one which is located about 60 miles southwest of the tip of the Crimean peninsula. All these five current stations are found within the zone of MBCS. An additional current measurements have been performed for a longer period at some distance from the former mooring locations and outside the MBSC stream. It was found that the flow has a cyclonic character in the MBSC. In the 500-1000m layer, the mean velocity was about 2.5 cm/s. In the deeper layers, a stronger flow in the opposite direction is measured with maximum hourly- and daily-averaged values of 20 cm/s and 15 cm/s, respectively, at the depth of 1500m. The average value for whole measurement period of 12 days is found as 11 cm/s. The latter average value of deep currents was further found to be approximately geostrophic. Utilizing measured value of the mean meridional density gradient of $4.1*10^{-5}$ g cm^{-3}/20 miles for the 500-1500 m layer, zonal component of the geostrophic flow is determined as 11∓2 cm/s at the depth of 1500m.

The measurements demonstrated that the flow has considerable temporal variability throughout the water column. The periodogram, obtained by means of Buys-Ballot method, reflects presence of most dominant oscillations with periods of 17 and 4 hours, corresponding to the local inertial period and the first mode cross-sea seiching period, respectively. Inertial oscillations are observed at all depths and dominate the kinetic energy of the system at some levels when the geostrophic balance is disturbed. Inertial oscillations are found to be the most dominant wave in the MBCS stream oscillation. In one of the stations, the density of the surface flow kinetic energy is found to increase from 16 to 55 J/m^3 which in fact corresponds the maximum energy increase taking place during one inertial period. This feature is found to penetrate in the whole water column indicating its hydrostatic origin. After two inertial periods, the aperiodic component of the deep flow attains a new energy level as a result of the change in the geostrophic balance of the flow. At 300m depth level, the kinetic energy increases from 6 to 56 J/m^3 within two inertial periods, thereafter the contribution of inertial oscillations to the whole energy decreases from 91% to 17%. During the first inertial period, well-pronounced 4-hours seiche oscillations are also observed. The characteristic seiche flow velocity is estimated as 10 cm/s which contributes to 15% of the total kinetic energy. In the following inertial period, the seiche flow velocity is reduced by a factor of 4-5 and its contribution therefore becomes negligible. After the second inertial period, the oscillations are weakened considerably, the mean current is intensified with a change in its direction from cyclonic to anticyclonic. The anticyclonic character of the flow is preserved for at least two more inertial periods. On the other hand, at 1500m depth level, the anticyclonic character of the flow has been observed persistently throughout the 12 days measurement period. An increase of kinetic energy from 6 to 9 J/m^3 is observed even at this level.

A hypothesis on the deep countercurrent generation mechanism has also been made using the combined analyses of temporally and spatially varying density and velocity fields.

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