MEASUREMENT OF SEA CURRENTS BY MEANS OF DRIFT BOTTLES

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Bottles containing sand and tightly sealed, floating on the surface of seas or oceans suggested to sailors the existence of horizontal movements of water mass, which they called sea currents. The principle has generally been assumed that the drifting of bottles is caused by currents or by the action of wind, or by both factors. This principle persists up to the present day, and even oceanographic publications present data concerning bottles that have drifted and have then been recovered from the sea as evidence of the existence of surface sea currents.

In spite of the fact that undulation occurs on all oceans and seas, it has never been considered as a possible cause of the drifting of bottles.

To prove that the influence of waves may be of considerable importance for the movements of drift bottles, the Laboratory of the Hydraulic Institute in Gdansk performed several tests in 1959.

The tests were carried out in an experimental channel about 13 metres long and 2 metres wide, where a system of waves was established. Among others, bottles 210 mm high and 55 mm in diameter, or 140 mm high and 52 mm in diameter were used, and the extent of immersion was varied. The results of investigations are presented in Table 1.

If we assumed that the drifting of bottles was caused by the current, then the results presented in the table would show that with the same wave there exist currents of different speeds, and even of different directions.

In the case of a bottle 210 mm high, we should obtain a current in the direction of the wave propagation, or in the opposite direction, depending on how far the bottle is immersed. The direction opposite to the wave propagation has been marked with a minus sign in the table.

In the case of a bottle 140 mm high, we should obtain with the same wave either a current in the opposite direction to the wave propagation, when immersion is small, or no current at all, when the bottle is immersed deeply.

From this, we should conclude that the existence of a current of a certain direction and speed depends on the extent of immersion and the size of the bottle, which is utterly impossible.

TABLE 1

Bottle speeds in cm per second

Wave elements		Height of bottle			
Amplitude cm	Length cm	210 mm		140 mm	
		Extent of immersion			
		150 mm	210 mm	95 mm	140 mm
6.1	213	2.7 3.2	—1.00 —1.10	2.92 4.76	0
6.5	173	3.2 3.8	—0.37 —0.73	3.64 5.13	0 —0.93
7.0	136	2.7 2.7	0.58 0.64	2.91 6.25	0
7.5	104	2.8 3.4	2.06 3.86	4.77 5.60	3.33 3.64
9.3	86	0.9 1.7	0.92 2.02	6.41 7.41	2.23 3.02

However, it seems right to conclude that the direction and speed of the drift bottle depend on its size, shape and immersion, as well as on the direction and elements of the wave. During the experiments, no action of the wind could have influenced them, as all the trials were carried out in a closed room.

Other experiments performed on the Baltic Sea in the years 1959 and 1960 also proved that the movements of bottles depended on their dimensions, shape and immersion.

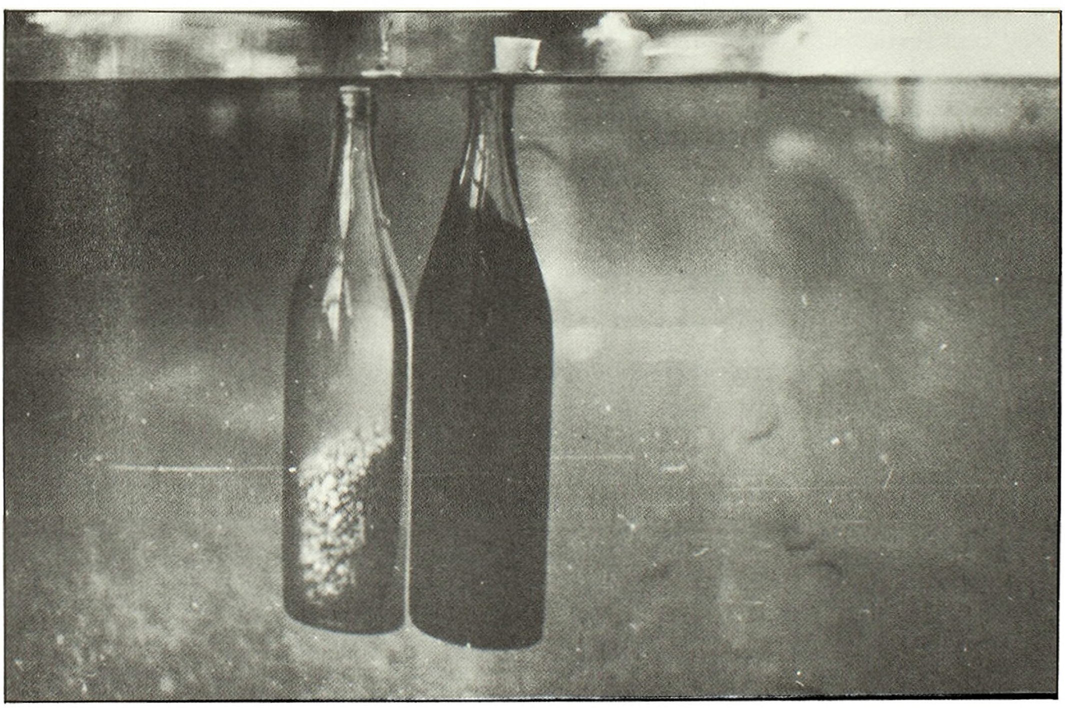

FIG. 1. — Bottles in still water.

In the laboratory, another test was performed in the following manner : two bottles differing in their immersion by only a few millimetres (fig. 1) were placed in the experimental channel. After the waves had been roused in the channel, the bottles began to move in opposite directions. The experiment shows clearly that even a slight difference in the extent of immersion may cause drifting in different directions under the influence of waves.

FIG. 2. — Bottles in undulating water.

The next experiment was similar to it, with the difference that water had been used for loading the bottles, instead of sand. In that case, they moved according to the direction of the wave propagation. Thus, we see that even the content of the bottles influences the direction in which the bottles drift.

If we place the bottle in a field of waves, as shown in figure 3, we shall then be able to compute horizontal speeds of the drifting of the bottle under the action of a wave, the characteristics of which are, say, $2h = 40$ m high, $2L = 40$ m and the period $= 5.06$ seconds.

Let us take as an example a bottle 300 mm high, 100 mm in diameter, and weighing 2.43 kg, and another one 200 mm by 60 mm and weighing 0.56 kg. The approximate computations of the drifting of these bottles have been compared in Table 2.

In all the computations it has been assumed that the extent of immersion of the bottles undergoes no change during the experiment. The speeds obtained in the table oscillate within the limits of 0.28 and 5.71 nautical miles per day for the wave elements that have been given. Naturally, on the sea the range of wave elements is much wider, therefore the speed of the bottles will fall within much wider limits.

TABLE 2

Speed of bottles in m/sec for waves of various amplitudes

Wave elements		Speed in m/sec of bottles of the height	
Amplitude m	Length m	300 mm	200 mm
1	40	0.006	0.011
2	40	0.022	0.035
3	40	0.047	0.070
4	40	0.070	0.101
5	40	0.078	0.119
5.6	40	0.083	0.123

Besides, as the bottles have a changeable and slightly delayed immersion in relation to the passing wave, the real speeds will differ considerably from the computed ones, and in certain cases the direction of the movement may be opposite to the direction of the wave propagation, which has been confirmed in the laboratory tests.

The influence of the action of the wind on drift bottles has also been computed. The formula of BOERGEN was applied :

$$2h = \frac{0.33\ W}{\left(1 - \frac{6.7\ W}{D}\right)\left(1 - \frac{1.86}{t}\right)}$$

where $2h$ is the amplitude of the wave in metres;

W is the speed of the wind in m/sec;

D is the fetch of wind action;

t is the duration of wind action in hours.

TABLE 3

Speed of bottle under wind action in m/sec

W Speed of wind m/sec	$2h$ Amplitude of wave m	w Speed of bottle m/sec
2.2	1.0	0.005
4.2	2.0	0.009
6.0	3.0	0.013
7.7	4.0	0.017
9.2	5.0	0.020
10.0	5.6	0.021

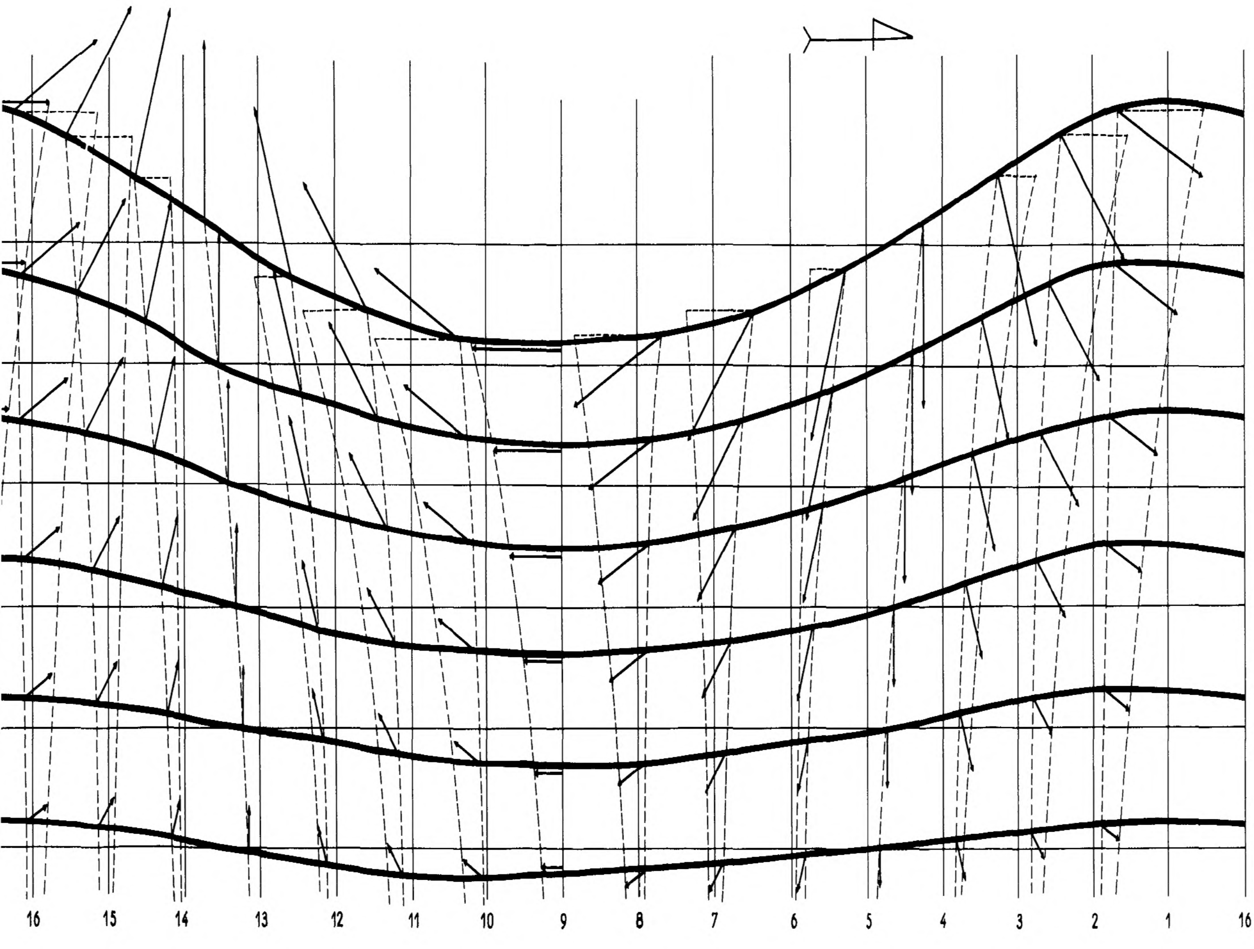

Fig. 3. — A field of waves the characteristics of which are :
$2h = 4$ m, $2L = 40$ m and $2T = 5.06$ seconds.

If we assume D = 300 km, $t = 8$ hours, the part of the bottle (300 mm high and 100 mm in diameter) projecting above the water being 0.10 mm, we shall obtain the following speeds for the movements of the bottle as given in Table 3.

Comparing the above with Table 2, we can see that the influence exerted by the wave is stronger than the influence of the wind, when the above assumptions are made. Naturally, the more the bottle is exposed above the surface of the water, the stronger will be the influence of wind action. The following conclusions may be drawn from the results of laboratory tests and experiments made in natural conditions, as well as from approximate computations :

1. The influence of waves on the drifting of bottles is undoubted.
2. The direction and the speed of the drifting of bottles depends on the direction and elements of the waves, as well as on the contents of the bottles.
3. The wind exerts an influence on the drifting of bottles, but only on the parts projecting above the surface of the water.
4. Defining surface sea currents, their direction and speed on the basis of drift bottles seems to be incorrect.

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