The Water Movements in the Neighbourhood of the English Channel—North Sea Junction. Drift Bottle Experiments.

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With 1 Chart in the Text.

Remarks Descriptive of the Available Data.

The following short paper is based upon the results of very extensive experiments made with both surface-floating and bottom-trailing drift bottles, by the Ministry of Agriculture and Fisheries during 1920–21.

At each of 7 lightvessels in the Southern North Sea, 25 of each type of bottle were put out each week for a year. One of the lightvessels taking part in the setting adrift of these bottles was the *Sandettie*, a French lightvessel moored at the position 51°15′N.–1°55′E. The full experimental results from the carrying out of this programme are shortly to be published by the Ministry.

The lightship referred to is really within the North Sea, being situated near its southern extremity, but the movements of drift bottles put out there will obviously give us valuable information as to the water movements in the junction area between this sea and the English Channel. The participation of this French lightvessel in the experiments was rendered possible by the courtesy of the scientific officers of the " Office Scientifique et Technique des Pêches Maritimes." As was the case with the English lightvessels, the officers of the *Sandettie* lightvessel were engaged throughout the period during which bottle liberations were made, upon log and wind observations. The results of the latter have been published.* The wind observations were made and recorded 6 times daily. Monsieur Heldt of the Station Aquicole at Boulogne-sur-Mer kindly lent the log books to the writer, in order that the wind data might be extracted. This was done, and a suitable conversion table was calculated, so that the French records (entered up according to the

* H. Heldt, Les Courants de Marée au Bateau-Feu du *Sandettie*. *Notes et Mémoires No.* 27.

wind scale in use by the Service des Phares) would become comparable with the English lightship records. A cursory examination of the movements of the surface drift bottles and of the winds prevailing at the time, revealed a marked interdependence between them. Thereupon the wind data were worked up into such a form as would enable the degree of correspondence to be more clearly seen. The 2,200 single observations were so compounded as to yield the residual equivalents for periods of weeks, months, quarters, and for the whole year. This so-called residual wind is that wind which, supposed constantly blowing for the stated period, could be substituted for all the individual winds recorded during that period—in other words, it is the vector average of all the individual observations recorded, whereas the corresponding resultant would be their vector sum. This detailed study of winds was *a priori* absolutely necessary in order that it might later be possible to decide whether any seasonal changes which might appear to characterise the set or strength of the currents, were independent of, or operative through the prevailing winds, which might themselves be of seasonal incidence.

From the position of the lightship, direction sectors (the 16 main divisions of the compass) were drawn out, and the movements of the bottles referred to them. These sectors are shown on the key map.

The Movements of the Surface Bottles.

Of the 1,275 surface bottles put out at the *Sandettie* lightvessel, 852 were returned—a percentage recovery of 66·8.

If these 852 bottles be distributed over the 16 sectors, the following table is obtained :—

Stranding Sector.	N.	NNE.	NE.	ENE.	E.	SSE.	S.	SSW.	SW.	W.	WNW.	NW.	NNW.	All Sectors.
No. of Bottles ..	16	3	175	499	63	9	7	7	1	9	13	18	32	852

It is seen how greatly the E.N.E. sector predominates, followed in order of importance by N.E. and E.

Our present inquiry has the object of deciding the relative frequency of occurrence of the two surface-water movements.

Channel—→ North Sea
and
North Sea—→ Channel.

A glance at the key map will make clear to what directions we must devote attention. The fact of chief importance is not the gross number

of bottles which (having regard to the total returns of the experiment as a whole) stranded within a certain sector. We must ascertain the number of liberations from which bottles so stranded. The truth of this follows from the following considerations. If the current at a certain

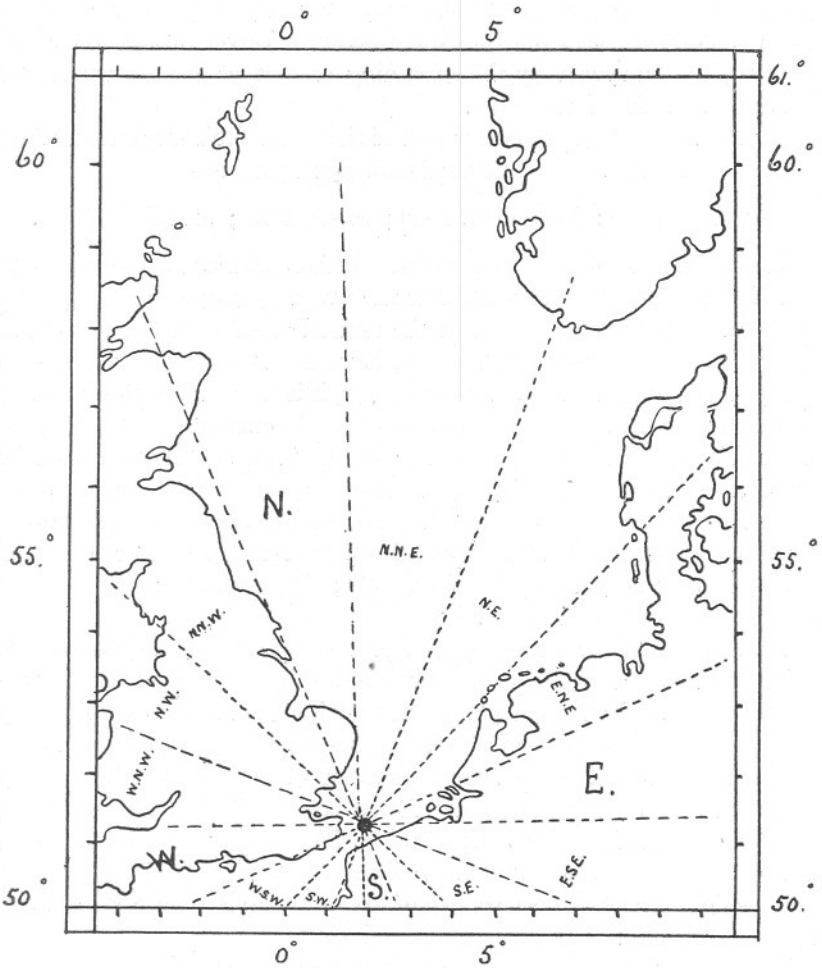

CHART showing the Position of *Sandettie* Lightvessel. Pecked lines define the Direction Sectors referred to in the text.

time be setting in an unusual direction, only a small proportion of the bottles put out at the time may actually strand in that direction. On the current resuming its normal set, the majority of the bottles (which did not strand) will be carried away and stranded in the most usual direction. This would—failing the evidence of the few earlier stranded

bottles—lead one to suppose that the direction of the current had not departed from the normal.

Here it will suffice to say that for the whole period of the drift bottle liberations at *Sandettie* lightship (i.e. from 4.10.20 to 10.10.21), the surface-water movements, as indicated by floating bottles, were always from the Channel to the North Sea, excepting for a few occasions when the current set from the North Sea into Dover Straits for a brief interval, as evidenced by the stranding of surface bottles within the W. and S.W. direction sectors.

Such a definite temporary reversal of the usual E.N.E.'ly current from the Channel only occurred in the following months :—

November, 1920 ; December, 1920 ; April, 1921 ; and June, 1921.

At certain times there was a distinct set from *Sandettie* on to the Kent and Essex coasts, which means that the water issuing from the Channel must, in view of the reversal of the normal* surface-water movement along the Belgian and Dutch coasts, have been either checked or constrained to hug the Kent and Essex coasts, if it were still making its way into the North Sea. On these occasions, also the current from the Channel to the North Sea must have been checked, if not actually reversed for a time. Such a state of affairs when there was a set on to the east coast of Kent and the coasts to the north as far as Norfolk (although no bottles actually stranded within the Channel) occurred during six months out of the twelve, namely, during October, 1920 ; August, 1921 ; and the four months just mentioned above.

In all these cases the movements of the bottles, or rather of the currents which transported them, are entirely explicable as the result of the prevailing winds. From each liberation yielding evidence of a temporary reversal of the usual water movements, bottles were later returned from the E.N.E. and N.E. sectors. In illustration of the effect of wind it may be stated that during the whole of October, 1920, there was a strong set of the current from *Sandettie* on to the East Anglian and Kent coasts, and that the residual wind for the month was 9·4 m.p.h. S.78°E. true—a value which implies the occurrence of exceptionally strong S.E.'ly winds during the month.

In short, it may be said that for the whole period of the experiment there was a movement of the surface water from the Channel to the North Sea, excepting during times when strong and persistent N.E.'ly–E.'ly winds prevailed. Only for 11 out of the 51 liberations was there any evidence of a check to and temporary reversal of the E.N.E. moving current in the Southern Bight ; these 11 liberations occurred during the

* See reference to work of Van Der Stok and Jacobsen in *Bulletin Hydrographique* for 1913–14, p. 41.

6 months mentioned, and only 5 of them yield definite evidence of a temporary reversal of the usual E.N.E.'ly surface-water movements in Dover Straights.

As has been mentioned, these reversals occurred at a time of strong E.'ly winds. In view of this it was natural to study long period wind tables for various observing stations over the length of the Channel to see whether there existed any periodicity in the incidence of winds from different quarters. The investigation can only be referred to here, but the result was to show that reversals of the "Channel-to-North-Sea current" are most likely to occur in May and September (followed by April and June), and least so in August and December (followed by July and January).

Previous Surface Drift Investigations.

The well-known experiments of Garstang* proved that the surface water of the Channel can move along from the Eddystone region right on up the Channel and through into the North Sea, except when strong E.'ly winds prevail. Later experiments made by the Board of Agriculture and Fisheries (unpublished but embodied in Admiralty Chart 327) yielded valuable information as to the surface-water movements in the North Sea–Channel junction area, and particularly showed how important is the rôle played by the wind, for it was found that the surface water off the Kentish coast could, under the influence of strong E.'ly winds, be pushed back into the Channel to as far west as 1°W. longitude. This W.'ly movement was recognised to be only temporary and dependent upon the persistence of the E.'ly wind.

The Movements of the Bottom Bottles.

Throughout the whole period of the experiment the movements of the bottom-trailing bottles were mainly towards the N.E., pointing to the existence of a persistent bottom current from the Channel to the North Sea.

In a recent paper (in the Press†), the writer has described an experiment carried out in mid-Channel when both surface and bottom bottles were put out between the Isle of Wight and Cherbourg, from which the bottom bottles moved E.'wards, rounded Kent, and stranded on the Kent and Essex coasts.

* Report on the Surface Drift of the English Channel and Neighbouring Seas during 1897. *Journ. Mar. Biol. Assoc.*, N.S., Vol. V, No. 2, April, 1898.

† "The Water Movements in the Southern North Sea in Relation to the Geographical Distribution of Young Herring." Being an Appendix to *Fishery Investigations*, Series II, Vol. VII, No. 4, 1924.