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Investigations on the Migration of a Western Baltic Herring Stock

by
W. Nellen

The Schlei (fig. 1) is a narrow, 40 km long glacial fjord at the east coast of Schleswig-Holstein. A population of the spring spawning herring of the Western Baltic comes for spawning into this fjord during the months March to May every year. It has been assumed that this stock of the so called "Schlei-herring" has a fixed spawning behaviour. So there is a good opportunity for general herring investigations because every year this stock on its isolated spawning grounds is free from other Western Baltic herring populations.

In the following results will be reported which were gained by investigations on the changes of the yields of the herring fishery in the Schlei. Fig. 2 shows the annual yields of the herring fishery in the Schlei. The catches made during the last years of the last century are higher than those made lately. The average is 214.4 tons a year from 1876 to 1909, 76.1 tons from 1925 to 1935, and 73.3 tons from 1950 to 1964. By this time the yields of the herring catches have gone down to one third as against the yields made during the years around the turn of the century.

I think three reasons may serve to explain these facts:

1. A change in the quality of the water by pollution or salinity change.
2. An overfishing of the herring stocks in the Western Baltic.
3. A change of meteorological conditions.

The result of an accurate examination of the first two points was that neither a change in the quality of the water nor overfishing can be the reason for the decrease of the yields. To see if meteorological conditions are of importance the migrations of the herring to its spawning grounds were analysed in detail for the years 1953 to 1963. Into consideration come three meteorological factors which may influence the spawning migration; the temperatur, the wind and with this, the current conditions and finally the whole weather conditions which affect the fishery.

Table 1 helps to illustrate the dependency of the length of the fishery season on temperature conditions. It shows the beginning, end and duration of the fishery season in the years 1953 to 1963. The beginning of the fishery season is equal to the beginning of the immigration of the herring because there is a fishery of different kinds of fishes in the Schlei throughout the year. So there is permanently a good control of those fishes which are in the fjord.

The beginning of the herring immigration into the Schlei and especially the duration of the fishery season of every year vary importantly within the period under review. K. E. NEB (1952) describes the so called "secondary spawning grounds" of the spring spawning herring of the Western Baltic. The herrings have to go to these places when they find conditions no longer suitable for spawning on the main spawning grounds which are normally within fjords. These conditions will be affected by temperatures. Depending on weather conditions the temperatures necessary for spawning will sooner or later not be found anymore on the main spawning grounds. Important fluctuations within the stocks of spring spawning herrings are not to be expected (Ch. HESSLE 1925, R. KÄNDLER 1952) because in general the conditions for developing and growth of the brood is very constant at least in spawning areas like the Schlei where there is always enough food for the small herrings. To repeat: The main spawning grounds will be resorted to more, the more there are the right temperatures. To deal with this factor more acurately the water temperatures of the mouth of the Schlei were observed. Probably they influence the herring to go on its spawning grounds. Slide 1 shows the curves of the overlapping five day mean water temperatures at the mouth of the Schlei two weeks before to two weeks after the beginning of the immigration of the herring in the years 1953 to 1963. The course of the curves is - except one - similar every year. Immediately at the beginning of the immigration the extremes of the five days average temperatures vary between 2.2 and 3.2°C within 10 to 11 years and so they lie close together. The average of 10 years is 2.8°C. The curves of the year 1961 takes another course. The reason for this irregularity is not to be explained clearly. Probably the booking of the first herring catches was too late this year.

At the end of the fishery season temperatures are to be found which are similar every year too. Slide 2 shows the curves of the overlapping five days mean temperatures 2 weeks before to 2 weeks

after the end of the fishery season. The extremes vary between 8.8 and 10.0°C immediately at the end of the immigration. The 10 years average is 9.3°C. Again there is one year that does not fit into the others; therefore it was not taken into consideration. The early end of the fishery season during 1960 may probably be traced back to the very bad weather conditions after May 4th when strong eastern winds, which were dominating in those days, forced the fishermen to stop their work. According to the curves of the water temperature spawning must have taken place until May 10th. In spite of very little spreading of the mean temperatures at the beginning and the end of the catching season, there is of course more or less strong variation according to the date of the beginning or the end of the immigration. This is to be seen already by the fact that after the fishery has come to an end, the temperature curves of some years still remain in the same temperature range which dominated before and the same goes for the beginning of the immigration. The mean temperatures which limit the catching season should be interpreted so that one may say that at this temperature the immigration will begin and end respectively. Between these temperatures there must be an optimum which culminates in the migration of the herrings. To find this optimum the average yield per catching unit - that is here per day - was calculated for the years 1953 - 1961. The result is to be seen in table 2. The fishermen got the best catches between 3° and 8°C.

The fishermen of the Schlei say that western winds favour the immigration of the herrings. Probably there is a current that decoys the fishes because western winds, at least in the beginning, result in an outpassing surface current which helps the herrings to find their spawning grounds. During the herring season in the year 1953 to 1961 on 187 days eastern winds and on 274 days western winds dominated; days with changing winds were neglected. While the wind was blowing from the east the average of a catching unit was 675 kg and while it was blowing from the west the average was 972 kg. Obviously the wind has a definite effect on the catch. Further this becomes evident by a study of the wind direction during days of good yields. During 54 very good catches within the years 1953 to 1962 44 times (that is 81.5 %) western winds dominated and 10 times (18.5 %) eastern winds. The percentage distribution of the winds during the whole fishery season of the 9 years is composed of 59 % western and 41 % eastern winds. It is obvious that the herring favours the Schlei when western winds are blowing. On the grounds that the immigration of the herrings does not only depend on tem-

perature but also on wind direction, I tried to make out a system of points in that the sum of the points expresses a quantitative valuation of each of the meteorological factors. The sum of the points must then correlate with the yields made in the specific year. Besides temperature and wind direction, the general wind circumstances were taken into consideration too because the whole state of the weather is not without importance. This was expressed in average wind velocity per day during the catching season. Besides this, the days with an average wind velocity more than force 6 Beaufort are brought into the valuation system, because during a stormy time the fishery will be closed down all together. The dispersion of the points is shown in table 3. In table 4 one will find for each year the five different factors that were consulted for the valuation. In table 5 are the numbers of points allied to the different factors.

With a decline of the number of points in general thereis to be observed a decline of the catching yield. When this bilateral decline does not go exactly parallel, this should not be too surprising for it is nearly impossible to find all factors influencing the immigration of the fishes and the fishery. Surely there are things that easily escape notice as there are mistakes in the fishery statistics, unforseable events during the fishery season, or unobserved hydrographic factors also. A very clear discrepancy between fishery yields and number of points is to be seen in 1961. Within this year the fishermen changed their fishery method which might have been followed by relative bad catches. In summary the investigations on the immigration of the herring into the Schlei result in that only meteorological factors limit the immigration and with this the herring catches in a discernible manner. Unfortunately these analyses could be made only for the years 1953 to 1963. So it is finally not possible to say absolutely, unambigously that the big differences in the herring yields are sdely attributeable to the environmental conditions which were discernible as influencing the immigration of the herrings. If it is right that meteorological factors do influence the results of the herring fishery in the Schlei in a predominant manner, than one can assume that the decrease of herring catches within the years after 1925 is correlated with the change of the climate that took place in about 1920 and effected an increase of the average temperature (R. SCHERHAG 1937, J. SMED 1949). This change of course, had biological consequences (P. JESPERSEN 1949, A. FRIDRIKSSON 1949, R. KÄNDLER 1949).

Such an influence on the migration of the herring into the Schlei may explain the small catches which were observed already in the years 1925 to 1935. An increase of the average temperature might have caused the effect that the curves of the increasing water temperature in the Schlei takes a steeper course in spring and the time during which temperatures are suitable for spawning on average has become shorter.

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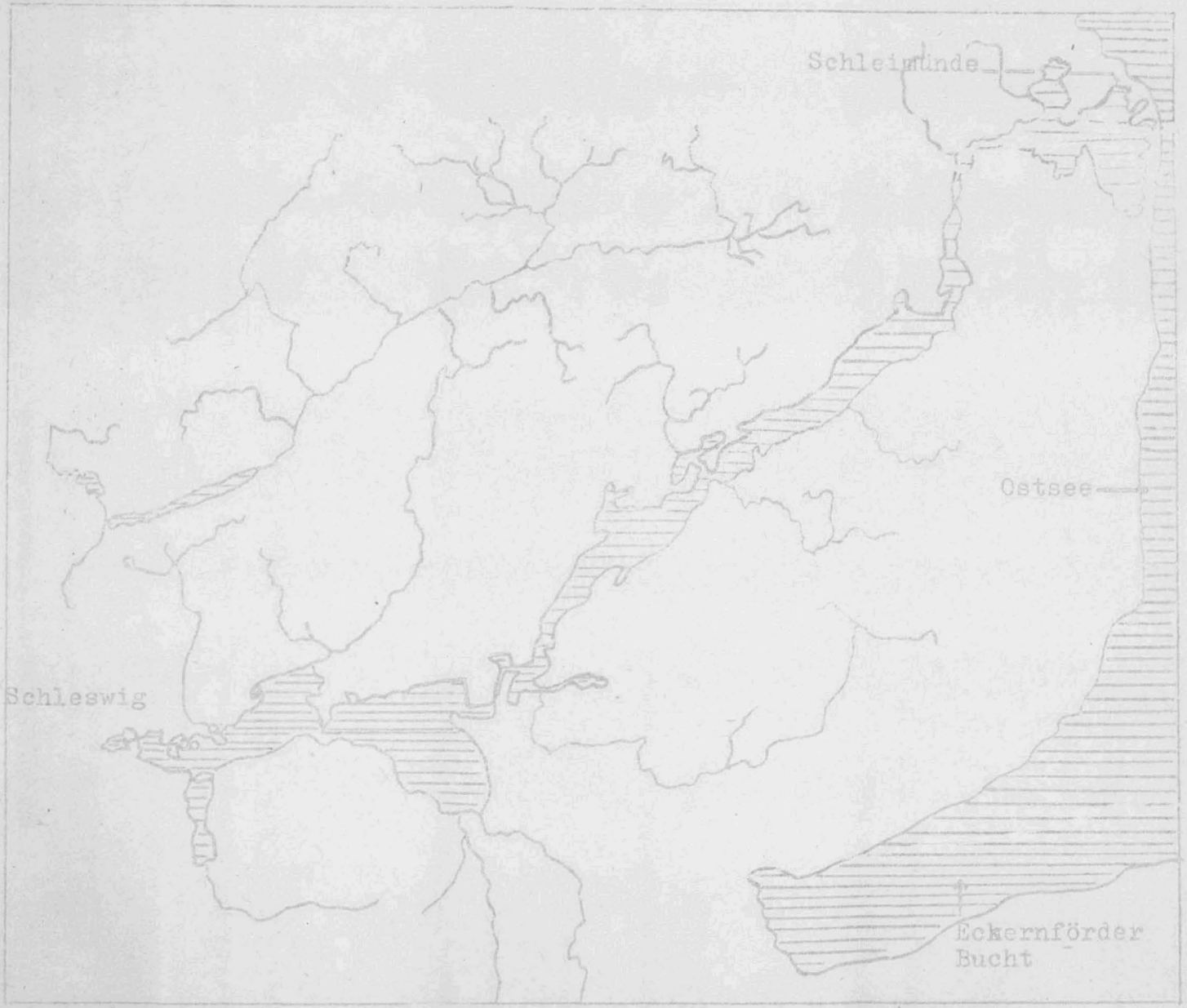

Fig.1 The Schlei

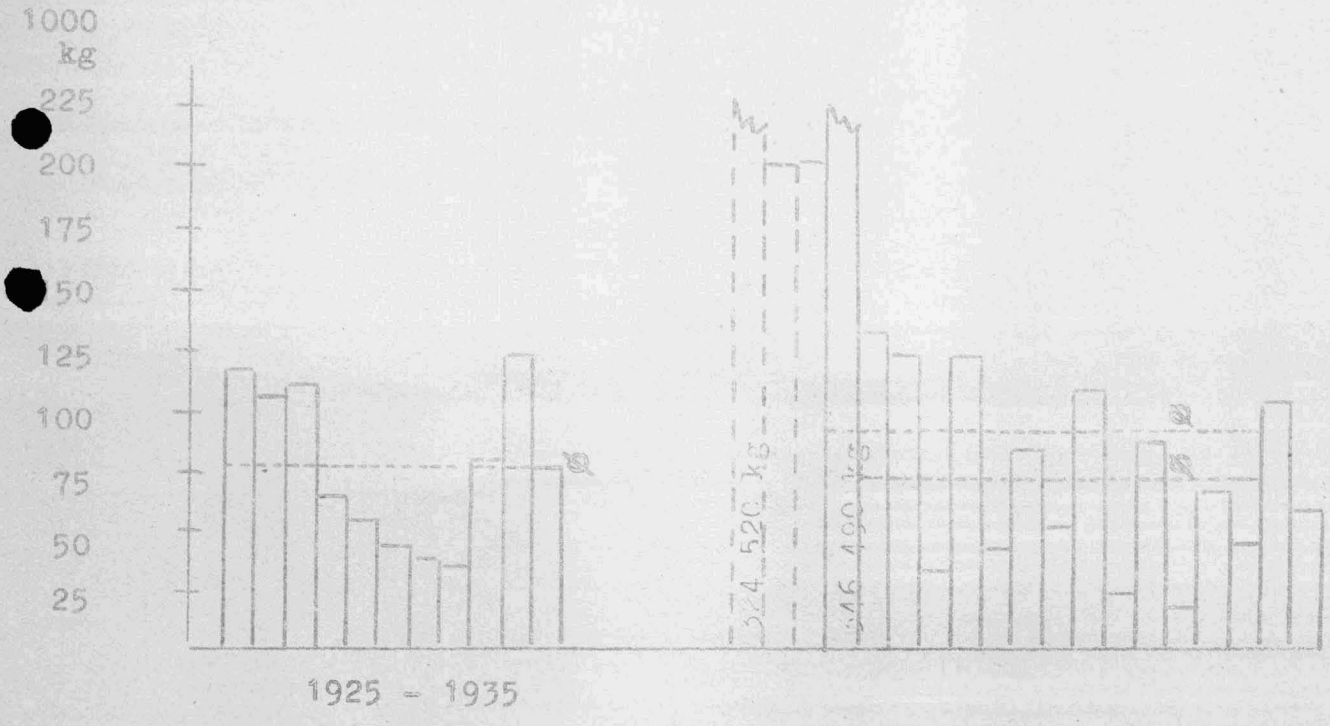

Fig. 2 : Yields of the herring-fishery

Table 1 : Date and lasting of the fishing-seasons

1953:	24. II. - 1. V. 67 days	1959:	8. III.- 1. V. 55 days
1954:	1. IV. - 8. V. 38 days	1960:	2. IV. - 4. V. 33 days
1955:	2. IV. -27. V. 56 days	1961:	1. III.- 2. V. 63 days
1956:	2. IV. -23. V. 52 days	1962:	3. IV. - 7. V. 35 days
1957:	12. III.-15. V. 65 days	1963:	4. IV. -26. V. 43 days
1958:	11. IV. -18. V. 38 days	1964:	4. IV. -22. V. 46 days

Table 2 : Catches of herring at different water-temperatures at Schleimünde.
Average of the years 1953-1961

°C	catching days	total catch kg	average catch per day kg	average catch per day %
<2	7	349	50	0,6
2	48	16 924	353	4,6
3	54	41 067	761	10,0
4	72	81 779	1 136	14,8
5	82	83 890	1 023	13,4
6	62	96 932	1 564	20,5
7	58	74 802	1 790	16,8
8	39	32 126	824	10,8
9	46	23 707	515	6,8
>9	39	4 675	120	1,6

Tabel 5:

Number of catching-days	Number of points	Number of the days with a water temperature between 3 °C and 8°C	Number of points	Sum of velocities of the western winds	Number of points
<40	0	21 - 30	0	20 - 50	0
40 - 49	++	31 - 40	+	50 - 80	+
		41 - 50	++	80 - 110	++
50 - 59	+++	51 - 55	+++		
				>110	+++
60 - 70	++++	>56	++++		

Average wind velocity within the catching season	Number of points	Number of days with wind velocities more than 4	Number of points
>3,2	0	>14	0
2,7 - 3,2	+	10 - 14	+
2,0 - 2,6	++	5 - 9	++
<2,0	+++	<5	+++

Table 4 and 5 :

Year	Yield kg	Number of catching-days	Number of the days with a water-temperature between 3° and 8°C	Sum of velocities of the western winds	Average wind velocity per day within the catching season	Number of days with wind velocities more than 4
1953	121860	67	61	127	2,7	10
1954	41660	38	35	70	2,7	6
1955	82240	56	49	164	3,3	24
1956	48950	52	31	101	3,2	16
1957	107390	65	58	110	3,0	14
1958	22320	38	26	101	3,3	14
1959	86150	55	39	71	2,9	5
1960	16500	33	33	62	3,5	12
1961	65000	63	49	91	2,1	5
1962	42600	35	34	26	1,8	2
1963	105460	43	32	32	1,4	0

year	points						
1953	13	121860	++++	++++	+++	+	+
1957	12	107400	++++	++++	++	+	+
1963	9	105460	++	+	-	+++	+++
1959	8	86100	+++	+	+	+	++
1955	8	82200	+++	++	+++	-	-
1961	12	65100	++++	++	++	++	++
1956	7	48900	+++	+	++	+	-
1962	7	42600	=	+	-	+++	+++
1954	5	47700	-	+	+	+	++
1958	3	22300	-	-	++	-	+
1960	3	16500	-	+	+	-	+