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Stock Strength and Rate of Mortality of the Norwegian Spring Spawners as indicated by Tagging Experiments in Icelandic Waters.

by

Olav Dragesund
Norway

and

Jakob Jakobsson
Iceland

1. Introduction.

Since 1948 large scale herring tagging experiments have been carried out during the Norwegian winter fishery and the Icelandic North coast summer fishery. Reports were published in 1950 and 1952 (Fridriksson and Aasen), giving a detailed account of the methods applied as well as the very encouraging results which illustrated the validity of the methods. Later, Aasen (1958) dealt with the first estimation of stock strength based on the tagging experiments 1948-1954. A new report based on the experiments up to 1960 is being prepared by the present authors. Since the report is not yet ready for publication, it was considered necessary to present its most relevant section for this symposium.

2. Methods and Material.

2.1. General.

The methods used in this paper for calculating the stock strength and the survival rates are based on the theoretical considerations of Aasen (1958), as well as on those of Beverton and Holt (1957) especially as regards estimation of the instantaneous fishing mortality coefficient F.

The equation

$$\frac{y}{S} = \frac{n}{N} \quad \dots\dots\dots\dots\dots\dots\dots \quad (1)$$

where y denotes the fishery yield
S the stock present
n the number of recaught fish
N the tagged fish present
is used in the present paper as basic equation for stock strength calculations.

A necessary condition for this basic assumption, i.e. that untagged and tagged fish are caught in the same proportions, is that the tagged herring are randomly distributed in the stock, since it is not given that the boats fish at random.

Since the reduction plants are scattered along the coast and each plant receives herring which mainly come from a particular part of the fishing grounds, it is reasonable to suppose that if the tags are randomly distributed between the reduction plants the tagged herring will be randomly spread in the stock. We will then exclude the possibility that the tagged herring, which mainly consist of old herring, are recaptured only in the beginning of the season when most of the oldest herring are caught, and not mixed up with the younger year-classes, entering the fishing ground later in the season.

By using the mean number of tags per 100.000 hectolitres of reduced herring as the expected number and comparing it to the actual number of returns per 100.000 hectolitres in each reduction plant, it proved possible to carry out χ^2 tests on the returns of the above mentioned experiments during the six years period 1952-1957 inclusive. Throughout this period, tags from the Icelandic North coast experiments in the preceding summer were randomly distributed ($0.90 > p > 0.05$) between reduction plants. Unfortunately, in the years 1958-1960 the returns were too few for statistical analyses, but we make the assumption that they were randomly distributed also in this last period.

Generally, the returns from the Norwegian experiments did not comply with the basic assumption (page one) so for that and other reasons which will not be discussed here, only the returns from the Icelandic experiments and those carried out by the R/S G.O. Sars in the open ocean proved suitable for stock size analyses.

The method of estimation of each component in equation (1) will now be discussed.

2.2. y & n.

Since the opinion of the present authors is in conformity with Aasen's theoretical discussion of the parameters y and n in equation (1), they wish to refer to his discussion and only state that here they use

$$y = \bar{a} \times c \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

where $\bar{a}$ denotes the average number of individuals per hectolitre and c the landing figure in hectolitres.

The calculated number of returns may then be expressed by the equation:

$$n = \frac{r}{e} \times \frac{c}{p} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

where r is the actual number of returns
- e the efficiency of the magnets
- c the landing figure, and
- p the quantity reduced in plants with known efficiency.

2.3. N.

When considering N, i.e. the number of tagged fish present on the Norwegian winter herring fishing grounds, we must consider the characteristics of the herring tagged in the Icelandic experiments as well as the succession of events which happen to the herring during the period from liberation in July or (infrequently) August off the North and North-east coast of Iceland till they enter the winter herring fishing grounds off the West coast of Norway.

With regard to the characteristics of the herring of the North coast of Iceland, it must be borne in mind that the herring concentrations are varying mixtures of Icelandic and Norwegian herring tribes.

In order to find N_N, i.e. the number of tagged herring which will seek the spawning grounds off the West coast of Norway, we must make the assumption that only spring spawners with Norwegian type of scales will do so (see e.g. Fridriksson, 1944 and 1958). By considering scale analyses of samples taken at the time of the tagging and from the catches in the tagging areas, it proved possible to estimate the proportion of the Norwegian type of scales for each liberation of the tagging experiments during the period 1951-1960 (Fridriksson, 1953-1960 and unpublished data). Having thus estimated N_N (the number of tagged herring with Norwegian type of scales) we proceed to consider the succession of events which will reduce N_N before they reach the fishing grounds off the West coast of Norway the following winter season. These losses can be due to (1) effect of tagging and (2) fishing and other causes including natural mortality. Considering these in turn we have:

2.3.1. Effect of tagging.

Although experiments on herring tagged with internal steel tags show very low mortality and shedding of tags due to tagging, it must be borne in mind that the Icelandic experiments were carried out in unsheltered waters under varying circumstances and the herring used for tagging were taken from different catches, and hence the condition of the herring may have varied from liberation to liberation. By considering the total returns in Norway from each experiment there is a significant variation in returns from the various liberations within the same experiment. This difference can either be due to (a) varying tagging or fishing mortality or (b) non random distribution of tags in the Norwegian catches.

Since the returns from any one liberation within an experiment are too few for testing statistically, whether they are randomly distributed in the Norwegian catches, sufficient number of returns from 3 or 4 liberations (giving the highest percentage recaptures) were taken and tested. Having found these returns randomly distributed and thus ruling (b) out, the percentage returns (A) from such "standard liberation" was calculated. Then the effective number of tagged herring (of the Norwegian type) was

$$N_{Ne} = \frac{B}{A} 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

where A is the percent returns of the "standard liberations" and B the total number of returns from a given experiment (see also Anon, 1959).

2.3.2. Fishing mortality and Other causes.

It is clear that during the period from the tagging (July) to the beginning of the Norwegian winter season (January) the number of tagged herring in the stock will be reduced further by fishing and natural mortality. Since only a very little part of this fishery is reduced in reduction plants, the Norwegian winter fishery will be considered as the sole cause of the instantaneous fishing mortality coefficient F and all other fishing included in "other causes" of the instantaneous mortality coefficient X. Before attempting to arrive at estimates of F and X separately, their sum, or rather the rate of survival, will be considered.

Since the Icelandic tagged herring (Table 2) recaptured in Norway generally show a regular series of returns during the period in question the authors wish to refer to Aasen's discussion of the survival rate and denoting it by

$$\varrho_1 = \frac{N_{2Ne} \times r_1^{(3)}}{N_{1Ne} \times r_2^{(3)}} \ldots\ldots\ldots\ldots\ldots \quad (5)$$

where ϱ_1 is the survival rate of any one year

N_{1Ne} the effective number of tagged herring in that year

N_{2Ne} the effective number of tagged herring the following year

$r_1^{(3)}$ the number of returns of N_{1Ne} in the third year

$r_2^{(3)}$ the number of returns from N_{2Ne} the following year.

Using analogus denotation the ratio

$$\frac{N_{2Ne} \times r_1^{(n)}}{N_{1Ne} \times r_2^{(n)}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5\,a)$$

is constant after the third year. Thus a series of estimations of the annual survival rate ϱ for any given year can be calculated.

Denoting the annual survival rate of two successive years by ϱ_1 and ϱ_2 and using corresponding indices as used in 5 we have:

$$\varrho_1 \times \varrho_2 = \frac{N_{3Ne} \times r_1^{(4)}}{N_{1Ne} \times r_3^{(4)}} \ldots\ldots\ldots \quad (6)$$

by deviding (6) by (5) we get an estimation of ϱ_2 and similarly to (5) this ratio is constant for any year after the 4th year. Series of estimates can then be calculated for ϱ_2, which is independent of the series calculated from (5).

Further using analogus denotations:

$$\varrho_1 \times \varrho_2 \times \varrho_3 = \frac{N_{4Ne} \times r_1^{(5)}}{N_{1Ne} \times r_4^{(5)}} \quad \ldots\ldots\ldots (7)$$

and dividing (7) by (6) yet another independent series of estimates can be calculated for ϱ_3. Thus for ϱ_1 one such series of estimates can be calculated, two for ϱ_2, three for ϱ_3 etc. (Tables 3 and 4). Clearly a relatively accurate estimate of ϱ, and hence (F+ X), can thus be obtained if the tags from any one experiment are returned in sufficient numbers for several years. This method is, however, limited to the total annual mortality rate and does not give direct information about the reduction of the number of the tagged herring from the time of liberation to the beginning of the Norwegian winter season.

Using, however, N_{Ne} (table 1) i. e. the number of effectively tagged Norwegian herring in equation 1 and solving for S i. e.

$$S = \frac{yN_{Ne}}{n}$$

it is clear that estimates thus obtained for the stock strength S are too high and hence any direct calculations of F' from S' and yield figures c (Table 1) will be too low. Nevertheless if the obtained values of F and S are applied to calculate X' and these figures are used to reduce N_{Ne} from the tagging month (July) to the beginning of the Norwegian herring season (January), i. e. six months ($\frac{X'}{2}$), a new estimate of the stock size (S'') is obtained. This estimate of the stock strength, however, is too small, and hence F'' becomes too high, but both the figures are nearer to the true values than S' and F' respectively. A new value (X'') is then calculated and hence new S''' and F'''. The figures for S''' are then too high and F''' too small, but nearer to the true value than S'' and F''. The calculations should continue until successive estimates approach each other.

Table 5 and 6 show the stock size and F and X resp. according to this method. The resulting estimates of N are shown in Table 1.

In order to get another set of estimates of the instantaneous fishing mortality coefficient due to the Norwegian fishery for comparison with whose calculated from the stock size yield data and the total annual mortality the authors wish to refer to Beverton and Holt's (1957) discussion, pp. 184-191, and their resulting formula (14.15)

$$F = \frac{\frac{n1}{\tau} \log\left(\frac{n1}{n2}\right)}{N_0 \left(1 - \frac{n2}{n1}\right)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

where n_1 and n_2 denote the number of recaught fish in two successive years

N_o the initial number of effectively tagged fish

τ the time interval

In order to use this equation the fishing intensity should be constant in the period dealt with. This is approximately the case during the Norwegian winter herring fishery, when we compare two successive years. The duration of the Norwegian herring season, however, is only two-three months, and the mortality rate due to fishing during the rest of the year will not be included in the estimates of F.

Even if the fishing intensity outside the Norwegian season is varying with time, and also different from the Norwegian one, an attempt has been made to apply equation (8). In order to get a series of estimates of F (Table 8) N_o has been recalculated N_o^1, i.e. the tagged herring present in the beginning of each new tagging year, according to the values obtained for ϱ (Table 4).

Further estimation of the natural mortality (X_n) can be obtained by plotting the fishing effort in the different years against (F + X) and fitting a straight line to the data. The effort is calculated as:

$$\text{The number of Norw. purse seiners x days on grounds x} \frac{\text{Total catch}}{\text{Catch Norw. purse seiners}}$$

It should be noted that the estimate of X_n obtained from these effort data is not directly comparable with that obtained indirectly from equation (8) and the "approach method" since there the mortality rate due to all other causes than the Norwegian winter fishery is included in X, whereas in the former case X_n does not include mortality due to Icelandic, Russian and Norwegian (summer) fishery and fishery carried out by other nations.

3. Results.

3.1. General.

Table 1 (second column) shows the total number of tagged herring during the Icelandic North coast summer seasons from 1951-1959 (inclusive). Tagging experiments before 1951 (i.e. in 1948 and 1950) are excluded because the returns from these experiments were rather few and the tagging technique had by then not reached the same standard as in later years. The table clearly shows how the proportion of Norwegian herring (ξ_1) gradually decreases from over 0.9 at the beginning of the decade to less than 0.3 in the last years. On the other hand during the years of 1951-1957 the tagging survival rate ξ_2 was remarkably steady, only varying from 0.72-0.80 with an average of 0.77. Thus the proportional variations in the calculated number of effectively tagged herring ($N_{Ne} = N_T \xi_1 \xi_2$) are mainly due to the great changes in ξ_1 the proportion of the Norwegian type of herring.

Table 2 shows the actual number of returns, the number of hectolitres reduced in plants with tested magnets as well as the per mille returns per million hectolitres (in brackets).

The table clearly shows that, generally, the number of returns for any given experiment reach a maximum in the first year after the tagging and then gradually decrease as the years go by. The only exception to this is the experiment of 1951, the returns of which reach a maximum in 1953 instead of 1952. As a result of this the survival rate ϱ_1, (Table 3) becomes absurdly high and hence its use for calculations of fishing and natural mortality rates are meaningless. Trusting that there have not been great variations in survival rates from 1952 to 1953, the authors use ϱ_2 for the purpose of calcualting rates of fishing and natural mortality in both 1952 and 1953.

Whereas estimates of ϱ_1 were obtained from the rations of returns from the experiments 1951-52 equation (5) estimates of ϱ_2 are obtained by this method as well as ratios of recaptures from the 1952-53 and the experiments according to equations (5), (6) and (7). Thus ϱ_2 is the mean of 10 estimates. Similarly ϱ_3, ϱ_4 .... ϱ_8 (Table 4) are the means of 9-15 estimates derived according to equations (5), (6) and (7). The estimates obtained show a gradual reduction of the survival rate $\varrho = e^{-(F + X)}$ during the period 1953 to 1958 inclusive - or from 0.77 to 0.54. The survival rate for 1959 ϱ_8 on the other hand proved to be absurdly high 1.24. With reference to this it should be noted that in 1960 the per mille returns are generally very high. The only exception of relatively high returns in 1960 are those from the 1959 experiment. Since all three estimates (Table 3) of ϱ_8 are proportional to the ratio between the high per mille returns of the previous experiments and the relatively low returns from the 1959 experiment the values for ϱ_8 become too high.

For the purpose of estimating the number of tagged herring present in 1959, the calculated survival rate for that year (Table 3 and 4) can not be used, especially because the general tendency is clearly shown to be decreased survival rate during the period in question. The authors therefore consider themselves justified in using the survival rate of the previous year for the calculation of tags present in 1959 rather than omitting that year altogether. It must, however, be borne in mind that only future series of recaptures can show, whether in this case the above treatment of survival rates is the right one. Excluding these irregularities the series of returns from the Icelandic tagging experiments during the Norwegian winter season clearly show the regularity with which the North Coast Herring of Iceland visits the spawning grounds off western Norway.

Using the number of effectively tagged herring N_{Ne} as shown in Table 1 and the annual survival rates shown in Table 4 (with the exception of 1952 and 1959), the number of tagged herring (N_o) present in the beginning of each new tagging year for all the experiments were calculated and presented in Table 5, along with the calculated number of tags recaptured during the Norwegian winter herring season according to equation (3) and values shown in Table 1.

3.2. Stock size.

Using the data presented in Tables 1, 2, 3 and 4 and applying the methods described in section 2, estimates of y, n and N were calculated (equations 2, 3, 4 and the approach method) and inserted in equation 1 which was then solved for S_1, i.e. the stock size. The results of these calculations are shown in Table 6 and Fig. 1. Judging by these estimates the Norwegian tribe was at a peak at the beginning of the period (1952), then it decreases until 1954. In 1955 there is a secondary recovery of the stock but since 1956 there has been a steady decline in the stock size in 1959 being only a quarter of the 1952 estimates. These results are in good agreement with age analyses and other Norwegian stock size investigations.

3.3. Fishing and Natural Mortality.

With reference to the discussion in 2. 3.2. it is clear that the calculations of the estimates of the instantaneous fishing mortality coefficient (F) due to the Norwegian winter herring fishery and that of all other causes (X) are interrelated and based on the same principles as the stock size calculations and hence the data used for calculations of F and X according to the approach method are the same as used in 3.2. The results of these calculations are presented in Table 6. In order to get another estimate of F and hence X, the data in Table 5 were used to calculate a series of estimates of F and X according to Beverton and Holt's method (equation 8). The results of these are presented in Table 8.

Comparing the results of these two methods (Tables 6 and 8) it is clear that both show the same general trend i.e. that in spite of a sharp increase in the total instantaneous mortality coefficients (F + X) during the period in question (see also Tables 3 and 4) there is no such increase shown in the instantaneous fishing mortality coefficient. Fig. 2 shows how the Norwegian winter herring fishery has decreased since 1956. Since this decrease is accompanied by a general decrease of the stock (Fig. 1) great changes in F cannot be expected. The increase in the instantaneous mortality coefficient (F + X) is on the other hand in good agreement with the increase in other fisheries as shown in Fig. 2.

Fig. 3 shows the results of fitting a straight line to corresponding data of the effort converted from the Norwegian purse seiners. The value of X_n (0.232) is the upper limit of the instantaneous natural mortality coefficient since mortality due to other causes (tagging mortality and shedding of tags) is included in the estimate.

Taking the differences between (F + X) and X_n estimates of the total instantaneous fishing mortality coefficient (F_T) is shown in Table 9.

Table 9.

Year	1952	1953	1954	1955	1956	1957	1958	1959
F_T	0.029	0.029	0.199	0.184	0.422	0.348	0.384	0.384

Since we are partly dealing with a purse seine fishery where availability often is of great importance fluctuations in the total fishing mortality coefficient (F_t) are to be expected, but in spite of this the data presented in Table 9 show the general tendency of increased total instantaneous fishing mortality coefficient since 1952.

Table 1

Year of tagging	Actual nr. of tagged herring	Proport. of Norw. spring spawners	Tagging survival rate	Number of effectively tagged herring	Number of tagged herring present at the beginning of the Norwegian winter season	Year of recapt.	Nr. of recapt. in the Norw. plants	Yield of Norw. fishery in mill hl.	Quantity processed in plants	Mean number of individuals per mill. hl (mill. number)
	N_T	ε_1	ε_2	$N_{Ne} = N_T \varepsilon_1 \varepsilon_2$	N		r	e	e x p	$\bar{a}$
1950	1827		0.77	1232		1951	9	9.548	2.553	
1951	5076+	0.84	0.73	3121	2806	1952	53	8.822	4.114	296.176
1952	17308	0.92	0.72	11152	10420	1953	212	7.205	2.740	290.696
1953	10181	0.95	0.80	7671	6484	1954	285	11.744	5.573	302.752
1954	8783	0.69	0.79	4759	4039	1955	118	10.381	4.358	342.811
1955	9241	0.72	0.77	5346	4013	1956	142	12.32	4.866	321.635
1956	8443	0.46	0.77	2977	2330	1957	88	8.555	3.816	334.419
1957	7550	0.29	0.77	1674	1264	1958	19	3.713	1.063	299.760
1958	5644	0.24	0.77	1034	794	1959	22	4.477	1.490	285.259
1959	9946	0.29	0.77	2224		1960	31	3.227	0.986	285.944

+) 2012 of these tags were tagged in open ocean by R/S "G.O.Sars"

Table 2

The actual number (r) of returns in reduction plants and the per mille returns per mill.hl. (in brackets).

Year of tagging	Number of effectively tagged herring	Year of recapture: 1952	1953	1954	1955	1956	1957	1958	1959	1960
	Quantity processed in plants (mill.hl.)	4,114	2,739	5,572	4,373	4,836	3,811	1,063	1,490	0,986
1951	3,121	53(4,13)	49(5,73)	86(4,95)	30(2,20)	31(2,05)	13(1,09)	1(0,30)	2(0,43)	1(0,32)
1952	11,552		212(6,70)	327(5,08)	110(2,18)	101(1,81)	63(1,43)	12(0,98)	15(0,87)	4(0,35)
1953	7,671			275(6,43)	100(2,98)	112(3,02)	48(1,64)	9(1,10)	9(0,79)	8(1,06)
1954	4,759				118(5,67)	83(3,61)	44(2,43)	11(2,17)	11(1,55)	3(0,64)
1955	5,293					151(5,90)	80(3,97)	15(2,65)	23(2,91)	3(0,57)
1956	2,977						88(7,75)	23(7,27)	16(3,61)	14(4,77)
1957	1,674							19(10,68)	22(8,82)	10(6,06)
1958	1,034								22(14,28)	21(20,59)
1959	2,224									31(14,13)

Table 3

Survival rates calculated from the North Coast tagging experiments

Year of recapture	Year of tagging 1952	1953	1954	1955	1956	1957	1958	1959	
1953	0.85								
1954	0.97	0.77							
1955	1.01	0.74	0.39						1951
1956	1.14	0.68	0.57	0.35					
1957	0.76	0.67	0.45	0.28	0.14				
Mean:	0.95	0.72	0.47	0.32	0.14				
1954		0.79							
1955		0.73	0.38						
1956		0.60	0.50	0.31					
1957		0.86	0.59	0.36	0.19				1952
1958		0.88	0.45	0.37	0.14	0.09			
1959		1.10	0.56	0.30	0.24	0.10	0.06		
Mean:		0.83	0.49	0.34	0.19	0.10	0.06		
1955			0.53						
1956			0.84	0.52					
1957			0.68	0.42	0.21				1953
1958			0.51	0.42	0.15	0.10			
1959			0.51	0.27	0.22	0.09	0.06		
1960			-	-	0.22	0.17	0.05	0.07	
Mean:			0.61	0.41	0.20	0.12	0.06	0.07	
1956				0.62					
1957				0.62	0.32				
1958				0.82	0.30	0.20			1954
1959				0.54	0.43	0.18	0.11		
Mean:				0.65	0.35	0.19	0.11		
1957					0.51				
1958					0.36	0.24			1955
1959					0.81	0.33	0.20		
1958						0.68			
1959						0.41	0.25		1956
1960						0.78	0.23	0.34	
Mean:						0.62	0.24	0.34	
1959							0.62		1957
1960							0.30	0.43	
Mean:							0.46	0.43	
1960								1.44	1958

Table 4

The Annual Survival Rates (ρ) in the Period 1952 - 1959

	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	ρ_7	ρ_8
	1952	1953	1954	1955	1956	1957	1958	1959
	0,92	0,71	0,74	0,64				
	0,95	0,76	0,65	0,68	0,44			
		0,83	0,60	0,68	0,56	0,58	0,60	
			0,61	0,67	0,49	0,60	0,50	1,17
				0,65	0,54	0,54	0,58	
					0,56	0,52	0,69	
						0,62	0,39	1,42
							0,46	0,91
								1,44
Mean:	0,95	0,78	0,62	0,66	0,52	0,56	0,54	1,24

Table 5

The calculated number of tagged herring (N_o) present in the beginning of each new tagging year and the number of recaptures (n) during the Norwegian winter herring fishing

	Year of recapture																	
		1952		1953		1954		1955		1956		1957		1958		1959		1960
Year of tagging	N_o	n	N_o	n	N_o	n	N_o	n	N_o	n	N_o	n	N_o	n	N_o	n	N_o	n
1951	3121	113	2403	129	1850	181	1203	71	794	79	413	29	231	3	125	6	68	3
1952			11552	558	8895	690	5782	261	3816	257	1984	141	1111	42	600	45	324	13
1953					7671	580	4986	237	3291	284	1711	108	958	31	517	27	279	26
1954							4759	280	3141	211	1633	99	915	38	494	33	267	10
1955									5293	384	2752	179	1541	52	832	69	449	10
1956											2977	197	1667	80	900	48	486	46
1957													1674	66	904	66	488	33
1958															1034	66	558	69
1959																	2224	101

Table 6

1952	1953	1954	1955	1956	1957	1958	1959	1960
				Mill. hl.				
218	134	131	149	129	101	71	54	-
				Mill. number.				
64.566.368	38.953.264	39.660.512	51.078.839	41.490.915	33.776.319	21.282.960	15.403.986	-

Table 7

Estimates of $F^{\phi\phi\phi}$ and $X^{\phi\phi\phi}$ estimated from the "approach-method".

	1952	1953	1954	1955	1956	1957	1958	1959	1960
$F^{\phi\phi\phi}$	0.041	0.053	0.095	0.073	0.101	0.085	0.054	0.083	-
$X^{\phi\phi\phi}$	0.220	0.208	0.336	0.343	0.553	0.495	0.562	0.533	-

Table 8

Estimates of F according to equation (14.15) (Beverton and Holt, 1957)

Year of tagging	Year of recapture 1952	1953	1954	1955	1956	1957	1958	1959	1960
1951	0,034	0,045	0,152	0,057	0,158	-	-	-	
1952		0,044	0,121	0,047	0,090	0,123	0,037	--	
1953			0,114	0,044	0,135	0,111	0,035	0,053	
1954				0,068	0,096	0,094	0,042	-	
1955					0,104	0,113	0,029	-	
1956						0,100	0,061	0,054	
1957							-	0,101	
1958								0,064	
1959								-	
Mean:	0,034	0,045	0,129	0,054	0,117	0,108	0,041	0,068	

Estimates of X as the difference between (F+X), calculated from Q and F

0,227	0,216	0,302	0,362	0,537	0,472	0,575	0,548

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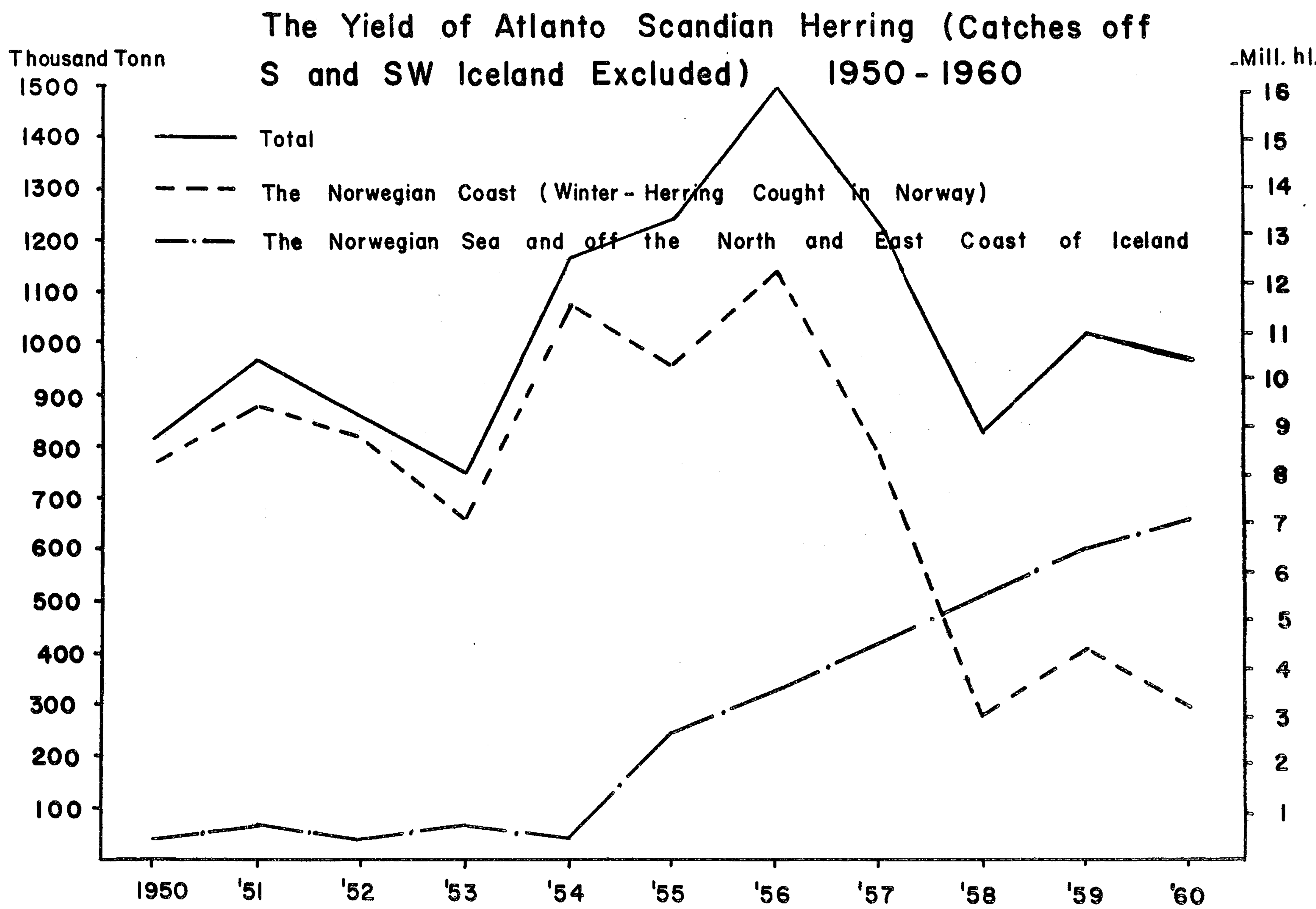
Stock Strength of the Norwegian Herring in mill. hl.

Fig. 1



The Yield of Atlanto Scandian Herring (Catches off S and SW Iceland Excluded) 1950 - 1960
Thousand Tonn
-Mill. hl.
Total
The Norwegian Coast (Winter - Herring Cought in Norway)
The Norwegian Sea and off the North and East Coast of Iceland
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1950
'51
'52
'53
'54
'55
'56
'57
'58
'59
'60

Fig. 2

Effort Data According to purse - Seiners

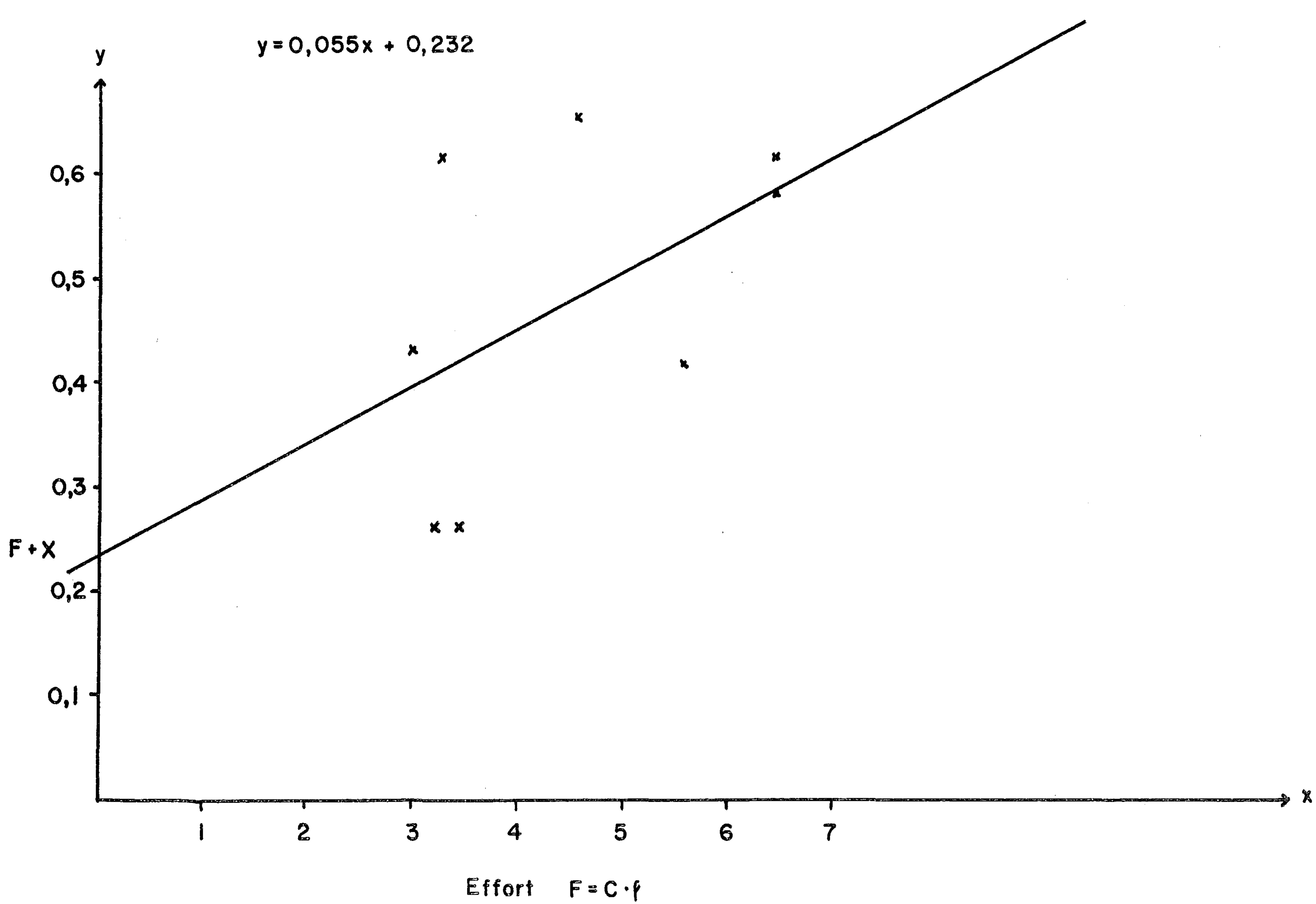


Fig. 3