

SOMMAIRE

1. Les proportions relatives des stocks de maquereaux de la mer du Nord et de l'Ouest des Iles Britanniques dans le Minch ont été estimées selon deux méthodes possibles grâce aux marqueurs norvégiens récupérés.

2. Les résultats des calculs selon les deux méthodes étaient identiques et indiquaient qu'entre 1974 et 1976, la population du Minch provenait, à raison de 80 à 90%, de stocks de l'Ouest des Iles Britanniques. Cependant, le pourcentage est probablement plus élevé en réalité du fait de la présence de poissons provenant de l'Ouest des Iles Britanniques dans le secteur de la mer du Nord au moment du marquage.

3. Le communiqué considère les sources d'erreurs probables de chaque méthode et met l'accent sur la nécessité de nouvelles investigations portant sur la question du mélange des stocks dans tous les secteurs.



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THE STOCK COMPOSITION OF THE MINCH MACKEREL FISHERIES 1974-1976

by

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SUMMARY

1. The relative proportions of North Sea and W. British mackerel stocks in the Minch were estimated by two alternative methods from recoveries of Norwegian tags.
2. Results of calculations by both methods were similar and indicated that from 1974 to 1976 on average between 80% and 90% of the population in the Minch came from the W. British stock. In practice the percentage, however, was probably higher because of the presence of W. British fish in the N Sea tagging area.
3. A discussion of likely sources of error in each method is given and the need for further investigations into the question of stock mixing in all areas is stressed.

INTRODUCTION

Norwegian tagging experiments indicate that substantial mixing of North Sea and W. British mackerel populations occurs to the north and west of Scotland during the summer and autumn months (Hamre 1975). Estimates of the relative proportions of these two populations in the Shetlands fishery have been made on the basis of internal tag returns in Norwegian commercial landings. The object of this paper is to estimate the relative proportions in the Minch from Norwegian internal tags returned from the Scottish landings in this area.

BACKGROUND INFORMATION

The Norwegian Tagging Experiments

For the purpose of this paper the tagging experiments from 1970 to 1975 inclusive have been used. Before 1970, experiments using internal tags were carried out in the North Sea, but it was not until 1970 that experiments were carried out both to the west of Britain and in the North Sea, and a standard procedure to catch fish for tagging was adopted in each area. From 1970 mackerel were caught using hook and line, by jigging to the west of Britain and by trolling and jigging in the North Sea.

The North Sea experiments were carried out between July and September mainly off the south and south-west coasts of Norway. To the west of Britain the experiments were carried out in May or June mostly south-west of Ireland. The numbers of mackerel tagged in each statistical rectangle from 1970 to 1975 are given in Figure 1a and b and details of the numbers tagged in each year and sub-area are given in Table 1.

Since the relatively small numbers of fish tagged to the west of the Orkneys and Shetlands and to the east of the Shetlands are of uncertain origin they have been excluded. Age composition data for each tagging experiment were supplied by the Institute of Marine Research, Bergen. These were determined from length compositions of the tagged fish and from age-length keys of untagged fish caught during the experiments.

Tag Returns From the Minch

The first returns of Norwegian internal tags from the Minch were made in 1974 so that no estimates of stock mixing are possible before that time. Over the period 1974 to 1976 the number of tags returned increased progressively as a result of a growing fishery for mackerel in the area. The number of tags returned and the landings for fish meal, human consumption and other purposes in the Minch from 1974 to 1976 are given below.

Year	Landings (t)			Nos Norwegian internal tags recovered
	Fishmeal	Human consumption and other outlets	Total	
1974	4 204	2 674	6 878	9
1975	9 676	4 629	14 305	29
1976	16 239	10 476	26 715	90

The Mackerel Fishery in the Minch

The fishery is prosecuted by purse seiners, pair trawlers and ring netters in the area shown in Figure 1a. Catches are made from May to November but the main fishery takes place between the end of August and the end of October, with the bulk of landings in September.

The beginning of the main fishery at the end of August was marked in the years investigated by a sudden increase in catch rate and by a marked change in biological composition of the catches from younger to older adult fish. The first appearance of these larger and older adults generally occurs at the northern end of the Minch and suggests an immigration from the north. As the season progresses landings are taken over a wide area of the Minch and, towards the end of the season, most landings are taken in the south, suggesting a southerly migration through the Minch.

For the purpose of this paper only the landings and tag returns made from late August to the end of the season are considered, these making up over 95% of the total catch and almost all of the tag returns.

CALCULATIONS OF STOCK COMPOSITION IN THE MINCH

Two alternative methods were used to determine the relative proportions of each stock in the Minch.

Authors method:- In this method the ratios of $\frac{r}{N_t}$ for each stock were first calculated, where r is the number of tags recovered in the Minch and N_t is an estimate of the total number of tagged fish alive at the same time, calculated from mortality rates derived from cohort analysis. On the assumption that tagged fish from either stock are equally prone to capture, once in the Minch, the ratio of $\frac{r}{N_t}$ (N Sea stock) to $\frac{r}{N_t}$ (W. British stock) gives a measure of the relative proportions of each population in the Minch when the two stocks are of equal size. When the stocks are of unequal size, as in these investigations, their relative proportions are determined by raising the fractions $\frac{r}{N_t}$ according to the estimated population size of each stock.

Hamre's method:- In this method, which was first used by Hamre (1975) to determine the stock composition in the Shetlands, the number of North Sea tags per unit catch are compared in the tagging area (NE North Sea) and in the Minch. On the assumption that all the fish tagged in the N Sea are of North Sea origin the proportion of North Sea fish in the Minch is given by the formula: $\frac{r}{C}$ (Minch) \div $\frac{r}{C}$ (NE North Sea), where r is the number of North Sea tags recovered and C is the corresponding catch in numbers adjusted to the magnet efficiencies of the fish meal plants from which the tags were returned.

The essential difference between the two methods is that while the author's method compares tag recoveries in the Minch from tagging experiments in the North Sea and the Celtic Sea, Hamre's method only uses tag recoveries from North Sea experiments but compares recoveries of these in the Minch with recoveries in the tagging area itself i.e. the NE North Sea. In addition Hamre's method uses ratios of tag recoveries to catch while the author uses ratios of tag recoveries to estimates of numbers of surviving tagged fish.

Parameters used in author's method

1. Numbers of fish tagged in each year in the North Sea and to the west of Britain (Table 1)
2. Number of tagged fish recovered in the Minch from tagging experiments in each area (Table 2)

Fish recaptured in the year of tagging have been excluded from the calculations because they are not likely to have had time to mix randomly amongst their respective populations. Furthermore the timing of the North Sea tagging experiments was probably too late to expect returns from the Minch in the same year, i.e. only one month later.

3. Tagging mortality

Following Hamre (1975), this is assumed to be 15% for the North Sea experiments and 25% for the West UK experiments.

4. Annual mortalities (Table 3)

Annual instantaneous mortality rates, covering the period 1 January to 31 December, for each stock from 1972 to 1976 were taken from the 1977 Mackerel Working Group Report (Anon 1977). The fishing mortalities were estimated from cohort analysis assuming a natural mortality rate of 0.2 in all cases. To extend the series to cover the years 1970 and 1971 annual fishing mortalities in the North Sea in these years were estimated by VPA using numbers at age in the 1970 and 1971 catches given in Hamre (1975). The same method of allocation of part of the Shetland catch to North Sea stock was adopted for these years as in the 1977 Working Group Report, (i.e. Hamre's method described also in this report).

For the West UK stock it was assumed that annual mortality rates in 1970 and 1971 were the same as in 1972 since no age composition data were available in these years and it was not therefore possible to carry out a VPA. In practice this is probably a reasonable assumption since, although the catches in 1970 and 1971 were rather less than in 1972, fishing mortality in 1972 was low and by far the main component of total mortality resulted from natural mortality.

To estimate N_t , the number of tagged mackerel alive at the mid-point of the Minch fishery, it has been assumed that tagged fish are subject to the same fishing and natural mortality as the total populations of each stock. Where mortality over periods of less than one year have had to be calculated, such as for example from the mid-point of each tagging experiment to 1 January the following year, a seasonal breakdown of catch has been used to estimate F 's over the requisite period while natural mortality M has been assumed to operate uniformly over the 12 month period.

5. Annual stock sizes (Table 4)

For the purposes of calculation stock size was taken as the number of three year old and older fish in each stock in mid-September each year (1974 to 1976). These figures were determined from the annual stock size estimates for 1 January from cohort analysis given in the 1977 Working Group Report reduced by the appropriate mortality for the period 1 January - mid-September.

Fish of less than three years of age were excluded from the calculations because they contributed insignificantly to the Minch catches. For the sake of comparability, tagged fish of less than 3 years of age in the year of catch were also excluded from the calculations.

Parameters used in Hamre's method

1. Number of tagged fish recovered in the Minch and in the NE North Sea from North Sea tagging experiments (Text table p 5).

As in the author's method, and for the same reasons, fish captured in the year of tagging have been excluded from the calculations. The number of tags recovered from the NE North Sea were obtained from the 1977 Working Group Report (Anon 1977 Table 3.1.1.).

2. Landings in numbers of fish from the NE North Sea and Minch, processed for fish meal, screened for tags and adjusted for magnet efficiency of fish meal plants (Text table p 5).

The data for the NE North Sea were taken from Table 3.1.1. of the 1977 Mackerel Working Group Report. The data for the Minch were determined from landings in weight processed by Scottish fish meal plants and estimates of magnet efficiencies for these plants given in Table 6, and from estimates of average fish weight per season given in Table 7.

Results using author's method

The ratios of $\frac{R}{N_t}$ (West UK tagging) : $\frac{R}{N_t}$ (North Sea tagging) in 1974 to 1976 are given in the text table below. The values of N_t were calculated from parameters given in the previous section and are shown in Table 5.

Recovery year	$\frac{r}{t}$ (West UK tagging)	$\frac{r}{t}$ (North Sea tagging)	Ratio
1974	$\frac{4}{8\ 141}$	$\frac{3}{15\ 070}$	2.47 : 1
1975	$\frac{12}{9\ 038}$	$\frac{7}{12\ 802}$	2.43 : 1
1976	$\frac{44}{8\ 324}$	$\frac{22}{13\ 881}$	3.34 : 1
		unweighted mean	2.75 : 1

These figures imply that, if the North Sea and west UK stocks were of equal size over the period 1974 to 1976, one might have expected there to be between 2 and 3 times as many fish from West UK waters in the Minch as from the North Sea.

Adjusting these ratios to take into account the estimated sizes of the two stocks (parameter 5 Table 4) gives estimates of their relative proportions in the Minch. The results of these calculations are given below:

Year	Relative proportion of stocks in Minch	
	West UK	North Sea
1974	4.96	: 1
1975	4.29	: 1
1976	5.67	: 1
unweighted mean	4.97	: 1

Results using Hamre's method

Using the parameters given for this method in the previous section, the proportions of North Sea fish in the Minch were estimated as in the text table below:

Year	1974		1975		1976	
	NE N Sea	Minch	NE N Sea	Minch	NE N Sea	Minch
Nos N Sea tags recovered	1 109	3	1 047	6	234	22
Catch in nos x 10 ⁻⁶	168.6	4.8	176.2	12.9	52.9	21.4
Nos tags per 10 ⁶ fish	6.58	0.63	5.94	0.46	4.42	1.02
Percentage N Sea fish	100	<u>9.50</u>	100	<u>7.83</u>	100	<u>23.24</u>

DISCUSSION

To perform the calculations given in this report it was necessary to assume values for several parameters about which very little is known.

In the authors method, for example, the values assumed for tagging mortality would seem to be very much open to question and in addition the estimates of stock size and total instantaneous mortality rate are very dependent on assumed values of natural mortality, as is pointed out in the Mackerel Working Group Report (Anon 1977) from which they were taken.

In Hamre's method the main shortcoming is that fish tagged in the North Sea are assumed to be pure North Sea stock whereas in fact it is clear from the returns of Celtic Sea tags in the North Sea tagging area (i.e. the NE North Sea) that this is not the case. Although this assumption is not implicit in the author's method, the estimates of stock size used were also calculated on the assumption that all landings from the NE North Sea were from the North Sea stock because no other more precise data were available. As a result calculations by both methods will overestimate the proportion of North Sea stock in the Minch, although not necessarily to the same extent.

Despite the shortcomings of both methods a comparison of results, given in the text table below, indicates a reasonable degree of similarity between the means for the three year period, although results for individual years show greater differences.

Year	Estimated percentage North Sea stock in the Minch	
	Author method	Hamre's method
1974	16.8	9.5
1975	18.9	7.8
1976	15.0	23.2
Unweighted mean	16.9	13.5

Results from both methods indicate that for 1974-1976 by far the greater proportion of the Minch population, i.e. between 80 and 90%, came from the W. British stock, and for reasons discussed above this is probably an underestimate.

One advantage of the author's method over Hamre's method is that, because it uses recoveries from both the North Sea and Celtic Sea tagging experiments, it can be used to give a rough estimate of the proportion of west British stock in the NE North Sea. A preliminary estimate suggests a figure of about 30% in that area in 1976.

In view of the importance of estimates of stock mixing to assessments of stock size and TAC it is important that this question receives further investigation, in particular in the NE North Sea where the proportion of west UK fish appears to be larger than has been assumed in assessments carried out so far.

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Table 1 Summary of nos. mackerel tagged in Norwegian tagging experiments by year, month and area.

A. WEST OF BRITAIN		1970	1971	1972	1973	1974	1975	1976
Sub-area	Year Month	May- June	May	May	June	May	May	May
S W Ireland		4 566	3 839	4 010	7 172	10 028	10 004	9 849
N W Ireland		-	633	1 006	1 043	-	-	-
W of Orkney/Shetlands		-	528	70	-	-	-	-
Total		4 566	5 000	5 086	8 215	10 028	10 004	9 849
*Total excluding Orkney/Shetlands		4 566	4 472	5 016	8 215	10 028	10 004	9 849
B. NORTH SEA AND SKAGERAK		1970	1971	1972	1973	1974	1975	1976
Sub-area	Year Month	July -Aug	July -Aug	July -Aug	July -Aug	Aug- Sept	July -Sept	Aug
*S W Norway		3 505	11 803	11 818	7 304	4 493	10 000	1 764
E of Orkney/Shetlands		1 029	643	-	-	-	-	-
Total		4 534	12 446	11 818	7 304	4 493	10 000	1 764

* These totals were the ones used in the estimation of stock mixing.

Table 2 Mackerel tag recoveries from the Minch

Year of Capture	Area of tagging	Nos. recoveries from each years tagging							Total 1	Total 2	Minch catch for fish used (in tons)
		1970	1971	1972	1973	1974	1975	1976			
1974	W Britain	1	0	0	3	2			6	4	4 204
	N Sea	0	0	1	2	0			3	3	
1975	W Britain	1	2	1	2	6	9		21	12	9 676
	N Sea	0	4	1	1	1	1		8	7	
1976	W Britain	2	4	3	4	13	18	23	67	44	16 239
	N Sea	2	7	2	2	2	7	1	23	22	

Note:- Total 2 is the total of recaptures excluding those fish recaptured in the year of tagging.

Table 3 Estimated annual mortality on different age groups of mackerel
(From 1977 Mackerel Working Group Report)

a) N Sea stock

Mortality	Age Group	1970 ¹	1971 ¹	1972	1973	1974	1975	1976
F	1	0.014	-	0.004	0.015	0.005	0.013	-
	2	0.209	0.026	0.090	0.021	0.079	0.019	0.100
	2+		0.090	0.051	0.115	0.114	0.135	0.186
M	all	0.200	0.200	0.200	0.200	0.200	0.200	0.200

b) W UK stock

F	1	0.004 ²	0.004 ²	0.004	0.028	0.039	0.025	0.120
	2	0.008	0.008	0.008	0.021	0.025	0.059	0.240
	2+	0.067	0.067	0.067	0.105	0.143	0.379	0.400
M	all	0.200	0.200	0.200	0.200	0.200	0.200	0.200

Notes:- 1 These data were not given in Working Group Report (Anon 1977) but were back-calculated by VPA from nos. alive on 1 January 1972 (Anon 1977) and from international catch data in 1970 and 1971 given in Hamre (1975)

2 These data were not given in Working Group Report but are assumed to be the same as in 1972.

Table 4 Estimated stock size in millions derived from cohort analysis
(From 1977 Mackerel Working Group Report)

N Sea stock

Year	Nos x 10 ⁻⁶ by year class (3 year olds and older fish)						Total (1 Jan)	Total by Mid Sept
	'68	'69	'70	'71	'72	'73		
1974	783.29	2 597.50	245.58	512.02	-	-	4 139.39	3 441.9
75	552.61	1 903.80	165.76	397.83	207.40	-	3 232.40	2 659.6
76	371.27	1 388.01	110.53	287.37	155.12	472.28	2 785.58	2 183.9

W UK stock

1974	4 569.29	617.19	1 077.87	2 143.54	-	-	8 707.89	6 913.2
1975	3 227.98	331.74	784.30	1 643.20	861.13	-	6 848.34	4 699.3
1976	1 559.85	146.95	476.35	1 079.96	622.87	1 532.79	5 418.77	3 704.3

Table 5 Estimated nos. tagged fish surviving in each year

A From N Sea taggings

Year of tagging	Nos. fish tagged	Estimated nos surviving tagging x .85	Estimated nos. surviving to specified dates each year								
			1971 1 Jan	1972 1 Jan	1973 1 Jan	1974 1 Jan Mid-Sept		1975 1 Jan Mid-Sept		1976 1 Jan Mid-Sept	
1970	3 505	2 979	2 453	1 877	1 460	1 066	886	779	641	557	437
71	11 803	10 033	-	9 175	7 081	5 168	4 297	3 775	3 106	2 700	2 117
72	11 818	10 047	-	-	9 028	6 589	5 479	4 813	3 960	3 443	2 699
73	7 304	6 208	-	-	-	5 301	4 408	3 872	3 186	2 770	2 172
74	4 493	3 819	-	-	-	-	-	3 240	1 929	2 320	1 819
75	10 000	8 500	-	-	-	-	-	-	-	7 161	5 675
		Total 1					15 070		12 822		14 919
		*Total 2	(Nt)				15 070		12 802		13 881

B From W UK taggings

Year of tagging	Nos. fish tagged	Estimated nos. surviving tagging x .85	Estimated nos. surviving to specified dates each year								
			1971 1 Jan	1972 1 Jan	1973 1 Jan	1974 1 Jan Mid-Sept		1975 1 Jan Mid-Sept		1976 1 Jan Mid-Sept	
1970	4 566	3 425	2 915	2 232	1 709	1 259	1 000	894	614	501	343
71	4 472	3 354	-	2 818	2 157	1 590	1 262	1 128	775	632	432
72	5 016	3 762	-	-	3 162	2 331	1 851	1 654	1 137	927	634
73	8 215	6 161	-	-	-	5 074	4 028	3 601	2 475	2 018	1 380
74	10 028	7 521	-	-	-	-	-	5 875	4 037	3 292	2 250
75	10 004	7 503	-	-	-	-	-	-	-	4 806	3 285
		Total 1					8 141		9 038		8 324
		*Total 2	(Nt)				"		"		"

Notes* Total 2 Fish of less than 3 years of age excluded

Table 6 Annual landings of mackerel from the Minch (1974-1976) processed by different fish meal plants with estimates of magnet efficiency of each plant

Name of plant	Fraserburgh	Stornoway
Estimated magnet efficiency	.65	.68
Annual landings (in tons)		
1974	1 124.1	3 039.9
1975	5 071.5	4 868.5
1976	7 652.5	7 868.3

Table 7 Average weights of mackerel in the Minch autumn fisheries 1974-1976

Season	Average weight (gms) per fish
1974	587.39
1975	513.51
1976	481.64

Figure 1a

Numbers of mackerel tagged in Norwegian experiments to the west of Britain from 1970-1975 inclusive and area of Minch fishery.



