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Demersal Fish (Northern) Committee.

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REPORT OF THE NORTH SEA FLATFISH WORKING GROUP

Charlottenlund, 22 - 26 January 1973

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1. Introduction

The ICES North Sea Flatfish Working Group met in Charlottenlund from 22 to 26 January 1973 with the following members participating:

J F de Veen	Netherlands (Chairman)
D W Armstrong	United Kingdom (Scotland)
R C A Bannister	United Kingdom (England)
R De Clerck	Belgium
H Knudsen	Denmark
E Nielsen	Denmark
G Rauck	Fed. Rep. Germany

The Group was convened with the following terms of reference (C.Res.1972/2:17) which is as follows:

> the North Sea Flatfish Working Group will meet for five days, 22 - 26 January 1973, to continue its studies of the flatfish stocks in the North Sea and to consider in particular the effects of the increase in effort exerted by beam trawlers, the effects of a possible increase in the minimum size of plaice, and to investigate, if possible, the mortality rate of discarded fish. The Irish Sea and Bristol Channel sole should be studied in conjunction with the North Sea sole.

2. The effects of the increase in fishing effort exerted by beam-trawlers on the flatfish stocks in the North Sea

The introduction of the beam-trawl as a sole-catching gear resulted from the change in the Dutch flatfish fisheries from plaice fishing with sole as a by-catch to sole fishing with plaice as a by-catch. This change started in the fifties when the Dutch fishermen modified their otter-trawls for sole fishing. By attaching chains to this gear, the catch per unit of effort of sole was increased and the fishermen continued to attach more chains to further increase the efficiency of the gear. It was found ,however, that with more than five chains the net would not remain open during fishing. For this reason the fishermen devised the heavy sole beam-trawl to which it is possible to attach ten or more chains. In order to tow this gear, which is considerably heavier than the otter-trawl, higher engine power was required and this has resulted in a more or less continuous increase in average horse-power in the Dutch beam-trawler fleet. The remaining otter-trawlers also increased their average horse-power, but to a much smaller extent. Every year, increasing numbers of fishermen have gone over to beam-trawling and at the beginning of 1972, more than 80% of all the vessels were rigged with this gear.
The simplest calculation of the change in efoort due to the advent of beam-trawling involves

a. calculating the most likely level of otter-trawl effort if there had been no change to beam-trawling and

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b. comparing this with the observed effort in the mixed otter-and beam-trawl fishery but with the beam trawl effort converted to equivalent otter-trawl hours to allow for the change in efficiency.

The simplest simulation of otter-trawl effort assumes, that

1. Netherlands fishermen continued to fish solely with the otter-trawl but with the same numerical expansion observed in the beam-trawl fleet and

2. there would have been little change in the average horse power of the fleet.

and on this basis we can assume that the otter-trawl fleet would have fished about the same number of hours as the present mixed beam- and otter-trawl fleet, without any need to consider changes in efficiency (see column 3 in Table 1, which shows the observed fishing effort data in the Dutch sole fishery for the period 1960-1971). The correction of the present beam-trawl effort to equivalent otter-trawl hours can be made on the basis of a comparison between the catch per effort of the beam-trawl and the otter-trawl. Since 1962 the ratio between the catch per effort of the beam-trawl for sole to that of the otter-trawl has steadily increased, reaching a relatively constant level in 1968. This change is shown in Fig. 1. The ratio from 1968 to 1972 is probably too high, because in this period a number of otter-trawlers visited the same grounds as the beam-trawlers in order to fish for cod and plaice with modified gears. In 1970 and 1971, experimental fishing for sole took place in the Irish Sea. The ratio between catch per effort for the beam-trawl to that of the otter-trawl in this specific sole fishery was the same in both years, viz: 3:1. For this reason it has been assumed that from 1968 the efficiency of the beam-trawl in the sole fisheries has been three times that of the otter-trawl, and that from 1962 till 1968 it increased gradually from 2:1 to 3:1. Thus the number of hours fished by a beam-trawler is now equivalent to three times the same number of hours fished by an otter-trawler. The total hours fishing in the sole fisheries can therefore be expressed in otter-trawl units by multiplying the beam-trawl hours by a factor derived from Fig. 1. Column 5 of Table I and figure 2 show the total Dutch effort on sole in otter-trawl units. The effort rose quickly to a high level in 1967 and has since remained more or less at that level.

The ratio between the number of fishing hours in otter-trawl units in the present Dutch fishery to that of the fishing hours in the simulated non-beam-trawl fishery is given in column 6 of Table I, and shown in Fig. 3. The ratio demonstrates that the fishing effort in the present Dutch mixed beam-trawl - otter-trawl fishery, say in 1970-1971, is more than 2.5 times the effort estimated in the case of the simulated fishery using otter-trawl alone. In other words, if the beam-trawl had not been introduced and only otter-trawls had been used, the fishing effort would have been $\frac{1}{2.5}$ = 40% that of the present effective Dutch fishing effort on sole. Raised to the total international fishing effort on sole, an all-otter-trawl would actually have been about 45% of the present effective international fishing effort on sole, becauseonly the Netherlands and Belgium use the beam-trawl. The advent of the beam-trawl has therefore involved an estimated <u>122%</u> $\left(\frac{100 - 45}{45}\right)$ increase over the most likely level of effort obtained without the change to beam-trawl fishing.

If as appears to be the case, the efficiency of the beam-trawl relative to the otter-trawl is about the same for the plaice as for the sole, then Dutch plaice effort would again be only 40% of the present level in the simulated non-beam-trawl fishery. However, in the plaice fisheries, the Netherlands catches only just over one third of the total catch, so that on an international basis the all-otter-trawl effort would actually have been about 80% of the present level observed. For the plaice the advent of the beam-trawl has increased the total fishing effort by about 25% $\left(\frac{100 - 80}{80}\right)$.

3. The effects of a possible increase in the minimum landing size of plaice.

In their last report (ICES CM 1972/F:2) the Working Group considered that the present favourable position in the plaice fishery should be consolidated. To this end it investigated the effect of an increase in the minimum landing size of plaice, aimed at discouraging future concentration of effort on small plaice. This could achieve its object in the otter-trawl fisheries, where there would be no discarding problem, but in the beam-trawl fishery, where the concentration of effort on sole already leads to discarding of small plaice, an increase in minimum landing size would have to be accompanied by an appropriate change in mesh-size if it were to be effective. In the previous report the Group concluded that a moderate increase in mesh size would in theory produce some gain in weight for the sole and would be beneficial for roundfish, but would not be sufficient to change the present plaice discarding pattern in the Dutch sole fisheries. On the other hand a large increase in the mesh size would certainly eliminate the problem of the present discarding of undersized plaice by the beam-trawlers, but this would seriously affect the landings of other fish species, principally the sole.
This conclusion draws attention to the fact that the regulation of the North Sea fishery for plaice cannot proceed independently of that for the sole and vice versa. Bearing in mind that the need for conservation of the sole stock had already been investigated and established (ICES CM 1970/F:14) the Group decided to follow up the problem of increasing the minimum landing size and mesh size for plaice in the wider context of an up to date reassessment of the current state of both the sole and plaice stocks. Accordingly the Group carried out a virtual population analysis for sole for the period 1957-1971 and used the results of a corresponding v.p.a. on North Sea plaice presented by Dr. Bannister. For both stocks the male and female populations were considered separately. For sole the total international landings per sex were calculated on the basis of the Dutch landings. For plaice sex ratio data were available for the whole period from the United Kingdom and the Netherlands and additional recent information on sex ratios were submitted by Germany (1967-1971) and Belgium (1970,1971).

3.1 The Sole Assessment

The results of the v.p.a. for the sole fisheries show that the total mortality rate is still gradually increasing over the high level reached in 1967 reflecting the high level of fishing effort. Since the situation has not improved since 1969 when the Group reported on the sole fisheries and an increase in fishing effort in the Dutch sole fishery may be expected in the near future, due to the addition of new vessels and increases in horsepower, bringing the North Sea sole stock to a state of increased overfishing, the Group decided to give priority to the sole analysis and follow the consequences of this analysis for the plaice fisheries.
In order to visualize the effects of changes in effort on the present sole stock it was decided to predict total catches and catch per unit effort for the next five years for different changes in the present fishing mortality. For this purpose a computer programme by H. Lassen was used.
In order to see whether this programme could be used for predicting total catch in sole, a simulation run was made for female sole starting with the observed age-composition of the international landings in 1957 and predicting the corresponding numbers and weight for the catch and stock (index for catch per unit effort) in 1958, 1959, 1960, 1961 and 1962. A weight at age relationship derived for the period 1966-1970 and the relationship of fishing mortality with age for 1957, calculated in the v.p.a., was used. For predicting 1958, observed values for the recruitment and maximal F (mode of the F with age ralationship) in 1958 were fed into the computer. The predicted 1958 stock was then used to predict catch and stock in 1959 using again observed recruitment and maximal F values. For 1960 the same procedure was repeated based on the 1959 predicted stock, a.s.o. for the next years. The results demonstrated the validity of the programme as can be seen in Fig. 4, where numbers and weight of the total catch predicted and observed can be compared. The accuracy is good, although part of it should be attributed to the fact, that real recruitment and fishing mortality values in the successive years were used.
Starting from the 1971 stock and using a constant recruitment (average of the 5 preceding years) and the average F with age relationship over the period 1966-1970 seven runs were made, for both sexes apart and combined thereafter, to study the effect of a number of realistic changes in fishing mortality over a five year period.

Natural mortality rate was assumed to be .15 (ICES CM 1970/F:14).
Recruitment in sole may vary widely. In the last 5 years recruitment has on average been of only moderate strength when compared to the strength of the very strong yearclasses of 1947, 1958 and 1963. Naturally a very good yearclass might appear sometime in the next five years, with a corresponding effect on catches, but this is essentially a bonus which cannot be relied on and it would not materially change the long term stock position. Consequently the Group considered it would be more realistic to assume only a moderate level of recruitment for the next five years in order to emphasize the changes which would result from changes in the level of fishing mortality.
The effects of the following strategies were examined:

run 1 effort increased gradually in 5 years to reach a level in which fishing mortality is 1.3 times the F for 1971.

run 2 effort kept constant at the 1971 level.

run 3 F reduced gradually in 5 years to .8 times F_{71}.

run 4 F reduced gradually in 5 years to .6 times F_{71}.

run 5 F reduced gradually in 5 years to .4 times F_{71}.

run 6 F increased in 1 year to 1.3 times F_{71} and kept at that level.

run 7 F reduced in 1 year to .4 times F_{71} and kept at that level.

The results of these runs are given in table 2 and in figure 5, which gives the changes in F for each run and the corresponding predicted catch and catch per effort in units of the 1971 values. As a baseline for comparison the observed international catch in 1968, 1969 and 1970 has also been given. Since 1967 total catch has decreased, particularly as a result of the declining abundance of the strong 1963 yearclass. In 1971 the increase in total catch over that of 1970 represents the effect of the good 1969 yearclass, but the 1972 Dutch catch, which was down by 10% in 1972, suggests that the influence of this yearclass too is now declining and that although the 1972 data for other countries are not yet available the international landings would show a similar drop. The prediction of a 1972 drop in catch for runs 1 to 5 therefore seems to be quite realistic.
With no further change in the fishing mortality rate (run 2) both the catch and the stock continue to decline steadily from their present level until 1974 and then begin to level out. This trend reflects the exit of the 1963 yearclass and the declining influence of the 1969 yearclass and marks the gradual transition towards the steady state condition at which, with no change in R of F, the catch and stock would probably stabilise round about 1978.
Runs 1 and 6 show that further increases in fishing mortality will be of no long term value in increasing the catch. With the gradual rise in fishing mortality (run 1) the long term catch is virtually the same as that for run 2. On the other hand if fishing mortality increases suddenly in the first year and is then maintained over the period (run 6) the catch shows an initial rise but finally falls to a level rather below that of the run 2 baseline.
For these two runs the stock falls to levels correspondingly below the level reached at the end of run 2 and so the increase in fishing mortality does not maintain the catch rate.
Run 7 shows that the only way of maintaining the present stock (i.e. catch rate) is by an immediate and drastic reduction in fishing mortality. This emphasizes the value to be placed on representing the results of an assessment in catch per effort terms because for this run the catch alone shows a severe initial loss before it climbs back to the level of run 2.
With run 3, 4 and 5, in which there is a more gradual decline in fishing mortality, the stock is still in a transitional stage in 1976 but is beginning to respond by increasing above the run 2 level. The catch, however, has still not progressed beyond the immediate loss phase.

In the presentation in figure 5 the results are clear enough, but they are not as clear as they might be because, as run 2 shows, we have to allow time for the fishery to reach the new steady states. This effect can be eliminated, as shown in figure 6 and table 3, by presenting all results as a proportion of the run 2 result. The catch picture does not materially alter, but big changes in stock, particularly for runs 3, 4, 5 and 7, are clearly emphasized.

These results would be expected from what is known of the sole stock from previous assessments, namely, very little gain in catch but a marked fall in catch rate as fishing mortality increases and a small gain in catch, but a large gain in stock and catch rate as fishing mortality decreases. However, the very close similarity between the catches at the end of runs 1, 2, 6 and 7 suggests that the yield curve for M = .15 must be rather more flat-topped than was estimated previously.

It is worth emphasizing that as the stock rises, there will be a corresponding rise in the average age of the stock and the catch. This makes the sole fishery less dependent on the strength of the incoming recruit yearclass because there are more yearclasses to rely on. This will tend to reduce those fluctuations in landings arising because of variations in yearclass strength.

The Group is of opinion that the need for conservation of the sole stock in the North Sea, expressed in its report in 1970 is still present, the more so in the light of future developments in the sole fisheries and recommends regulation of the sole fisheries either by effort or by quota regulation.

3.2 The Plaice Assessment.

In a previous report (ICES CM 1971/F:14) the Working Group concluded from the available data that the present relation between yield per recruit and fishing mortality for the North Sea plaice stock rises to a maximum which is more or less constant over a wide range of fishing mortality coefficients. There were differences between the mortality values calculated in the convential catch curve manner from different sets of national age composition data but even so the resulting fishing mortality estimates were all within the range giving the maximum sustainable yield. These findings showed that although the stock and hence the catch rate would decrease if fishing mortality increased, the international catch would not be expected to change, provided that recruitment remained constant as is borne out by the catch and catch rate data for 1966-1971, once the bonus provided by the excepttionally strong yearclass 1963 has been allowed for.

Estimates of fishing mortality, obtained by a virtual population analysis by Dr. Bannister, using estimated international landings updated to 1971, were taken as the baseline for a prediction to be undertaken along the lines described previously for the sole. The v.p.a. calculation assumed a value of .1 for the natural mortality coefficient and a value of .2 for the terminal fishing mortality coefficient. The function of fishing mortality against age for the prediction programme was based on the mean values for the period 1966-1968 (to exclude the errors involved in using the most recent yearclasses for which the estimates of F are unduly influenced by the chosen terminal value of .2).

From the known 1971 catch the programme was to be used to predict catch and catch per effort up to 1976 on the basis of an average recruitment over 1966-1971 (161.9 times 10^6 for males and 187.5 times 10^6 for females, data by Dr. Bannister). The following fishing mortality strategies, of which two differ slightly from those used for the sole, were used:

run 1a : effort increased gradually in 5 years to reach a level in which fishing mortality is 1.4 times the F for 1971.
run 2 : effort kept constant at the 1971 level.
run 4 : F gradually reduced in 5 years to .6 times F for 1971.
run 6a : F increased in one year to 1.4 times the F for 1971 and kept at that level.
run 7 : F reduced in one year to .4 times the F for 1971 and kept at that level.

In order to get an impression of the validity of the method for plaice the predicted catch of females for the period 1968-1971 was calculated based on the landings in 1967 and a constant value for F. In table 4 the predicted and observed catches are given and it follows that in all cases the prediction was an underestimate, mainly caused by the recruitment figures used, based on only a few age groups. However, this will only affect the absolute values of the predicted catches and not the trends of the various runs.

Table 5 and figure 7 give the changes in F for each run and the corresponding predicted catch and catch rates in units of the 1971 values for plaice of 2-20 years old at the end of each of the years 1971-1976. Plaice older than 20 years are disregarded in these calculations, thus making the values slightly underestimated, whereas the trends are unaffected. The observed international catch in 1968, 1969 and in 1970 is also given in units of the 1971 catch as a baseline for comparison. With a constant fishing mortality both catch and catch rate (stock) will practically remain constant. Runs 1a and 6a show an initial increase as can be expected. With the gradual increase in fishing mortality (run 1a) the catch is rising to about 15 % in 5 years. In the case of a sudden increase in fishing mortality in the first year (run 6a) the catch shows an initial rise of over 40 % but falls back to a level slightly above the run 2 baseline. As run 1a is an increase of fishing intensity of the same magnitude as run 6 we may expect that the catch in run 1a may level off in later years to the same value as run 6 reached in 5 years. In both runs stock size falls to levels correspondingly below the level reached at the end of run 2 and so the increase in fishing mortality leads to a decrease in the catch rate.

In run 4, with a gradual decline in fishing mortality, the catch is falling to a loss of 30 % in 1976 in the short term phase, but will climb back again in later years, reaching ultimately the level which run 7 has obtained after 5 years. This is demonstrated more obviously in run 7, where fishing mortality is suddenly increased in one year. Initially this run will lead to a severe drop in the catch of over 50 %, but in the succeeding years the catch will increase again. Stock size, however, will increase, slowly in the case of run 4 but rapidly in run 7.

The results shown in figure 7 show what would be expected from the previous assessments namely little gain in catch in the long term and an obvious decrease in the catch rate as fishing mortality increases and no appreciable gain in catch but a marked rise in the catch rate as fishing mortality decreases, which corresponds with the fact that the plaice fisheries are near the optimum sustainable yield point. In runs 7 and 4 we find the situation that the fishery is brought below the optimum point leading to a reduced catch but a high catch rate.

Comparison of the predicted catches and stock sizes of sole and plaice (fig. 6 and 7) reveals differences in the trends for both species. These differences are most pronounced in the runs 6(a) and 7, where fishing mortality is changed abruptly. In the sole the catch, after an initial rise or drop, is rapidly moving back towards the level of run2, whereby run 6 arrives at a lower level than that of run 2. This suggests that the long term equilibrium level can be attained fairly quickly, say in 5 or 6 years. In the plaice, however, the fishery seems to be still in the transitional phase in runs 6a and 7 and to reach equilibrium will need more years. In plaice run 7 will never reach the level of run 2, because this run brings the fishery below the point of optimum sustainable yield.

In stock size the changes in the sole fisheries are much more pronounced than in the plaice fisheries. In plaice stock level at the end of run 4 is 113 % but in sole 135 % (1971 = 100 %). At the end of run 6(a) stock size in plaice is 83 % and in sole 75 %. In run 7 stock size in plaice is in 1976 142 % and in sole 204 %.

The prospects for the fisheries for sole and plaice differ also,(fig. 5 and 7). Stock size of sole can only be maintained by abruptly reducing fishing mortality with 60 % (run 7), whereas in plaice stock size can be kept unchanged by not changing fishing mortality.

A reduction in fishing mortality necessary for the sole fisheries will bring the plaice fisheries to a point rather below the optimum sustainable yield. It is not possible to regulate effort on both species separately, for they are not independent. In the Belgian and Dutch fisheries e.g. plaice and sole are caught in the same fishing operation in the fishing grounds frequented. In this respect a quota regulation of the landings will be better than an effort regulation, leaving the fishing industry with the problem how to handle surplus effort. For this reason the Group is of opinion that in order to safeguard the sole fisheries and to maintain the plaice fisheries at the present, nearly optimal, level, a regulation by means of catch quota is desired.

4. The mortality rate of discarded fish.

The Group realised that at present only very limited information is available concerning the mortality rate of discarded fish. In the major North Sea fisheries discarded fish die either as a result of being dragged across the sea bed during the haul or from the effects of exposure on deck and mechanical damage during the sorting of the catch or from a combination of these factors.

Apart from an inconclusive series of experiments by Borley (1909) no data are available on mortality due to exposure during sorting. Preliminary results have, however, been obtained on the mortality rates of flatfishes in the net in relation to time trawled. These investigations were carried out during two cruises by the Dutch research vessel "Tridens" in November 1972, the species studied being plaice, sole and dab. The gear used was a beamtrawl net with otter-doors and 5 chains and one light tickler chain. The duration of the hauls was alternatively 20 minutes, one and two hours. The degree of overall damage to the skin of the plaice, sole and dab was assessed in five stages. The average damage was related to the duration of the haul and the filling of the net. In sole, there was an obvious correlation of average damage to duration of the haul, but hardly any with the size of the catch. In dab, however, and in plaice too, the correlation of damage to total net filling was much more pronounced than with the duration of the haul.
Even in the case of hauls of 20 minutes, the average damage was quite high, presumably owing to the rather bad weather conditions and possibly owing to the number of chains used.
Plaice and sole were placed in separate tanks, graded by stage of damage and duration of haul and examined twice a day. It was found that even after 5 days the apparently undamaged plaice were still alive even when they were taken from 2 hour hauls. Thus the influence of being in a rather small tank and being subjected to the movements of the ship did not introduce extra mortality.
Mortality increased with increasing degree of damage, but after about three days mortality stopped. The situation on the third day was then taken for constructing survival curves for the five stages of damage in order to relate the mortality of the plaice to the time trawled, thereby using the information on damage collected in each of the 52 hauls. Under the conditions prevailing during the cruises (rather cold weather and wind forces ranging from 5-8) 40 % of the plaice from hauls of 20 minutes would have died later if they had been discarded immediately. The corresponding values for one and two hour hauls are 60 % and 74 %.
Mortality in sole was obviously higher than in plaice but the highest mortalities were found in the dab.

It stands to reason that these results should be confirmed by experiments in other seasons and under other circumstances and that the effects of exposure on deck during sorting should be studied.

5. Assessments of the Irish Sea and Bristol Channel sole fisheries.

The Group studied the paper by Mr. M.J. Holden presented to the 1972 Council Meeting and dealing with an assessment of the Irish Sea and Bristol Channel sole stocks. It was understood that the present situation in both areas is more favourable than in the North Sea. Although in the case of the Irish Sea differences of opinion could exist over the magnitude of the total mortality rate, these differences are of limited importance when compared with the situation facing the North Sea sole stock.

The English data estimate fishing mortality to be .4 at which level the yield and catch per effort could be increased by a decreasing F, a good argument for regulating the fishery. In the case of the Belgian data, however, the value of F derived from the catch curves is .2. As Holden points out this is likely to be an underestimate because the older fish, previously less heavily fished as recruits than the present day recruits, are probably overrepresented in the catch curve. However, even with F at .2, the stock would be at the maximum sustainable yield point and there would therefore still be a strong incentive to preserve the fishery at that point.

The sole fishery in the Irish Sea and Bristol Channel is not independent of the North Sea sole fishery. There is a strong possibility that surplus effort from the North Sea fishery will enter the Irish Sea and Bristol Channel fishery when catches are falling in the North Sea. In view of the limited size of both former stocks this surplus effort will have a much more pronounced effect than when left in the North Sea. For this reason the Group endorses the conclusions made by Mr. Holden that there is a good case for regulation in the Irish Sea and Bristol Channel sole fisheries by means of a quota system, implemented either before or at the same time as that for the sole in the North Sea.

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Table I. Number of fishing hours in the Dutch mixed otter-trawl - beam-trawl fishery and number of beam-trawl hours in equivalent otter-trawl hours.

year	number of fish. hrs. otter-trawl $x\ 10^{-3}$	beam-trawl $x\ 10^{-3}$	A total $x\ 10^{-3}$	beam-trawl hours in equivalent otter-trawl hours	B total hours in equivalent otter-trawl hours $x\ 10^{-3}$	ratio B/A
1960	678	0	678	0	678	1.00
1961	770	0	770	0	770	1.00
1962	811	97	908	178	989	1.09
1963	722	152	874	279	1002	1.15
1964	665	289	954	564	1229	1.29
1965	545	424	969	940	1485	1.53
1966	554	515	1069	1431	1985	1.86
1967	459	1015	1473	3045	3504	2.38
1968	494	829	1323	2488	2981	2.25
1969	430	673	1103	2017	2448	2.22
1970	188	723	911	2170	2357	2.59
1971	179	841	1019	2522	2700	2.65

Table 2. Total sole catch and catch per unit effort predicted for the years 1972-1976, starting from the observed age-distribution in 1971 and using different patterns of changes in fishing mortality (runs 1 - 7) as shown in the upper diagram in figure 5, expressed in units of the 1971 values.

year	run 1	run 2	run 3	run 4	run 5	run 6	run 7
catch							
1971	1	1	1	1	1	1	1
1972	.90	.86	.84	.81	.78	1.10	.40
1973	.82	.77	.74	.70	.62	.82	.48
1974	.64	.63	.60	.56	.51	.58	.50
1975	.55	.54	.51	.48	.42	.59	.50
1976	.51	.49	.47	.42	.34	.45	.50
catch p.u. effort							
1971	1	1	1	1	1	1	1
1972	.78	.79	.81	.82	.83	.68	1.01
1973	.58	.62	.65	.67	.71	.48	1.01
1974	.49	.54	.59	.64	.69	.41	.99
1975	.43	.50	.56	.63	.71	.38	.98
1976	.40	.48	.55	.65	.77	.36	.98

Table 3. The same data as shown in table 2 but predicted catches and catch per unit effort of runs 1, 3, 4, 5, 6 and 7 expressed in units of the predicted values of run 2 where fishing mortality is stabilized at the 1971 level.

year	run 1	run 2	run 3	run 4	run 5	run 6	run 7
catch							
1971	1	1	1	1	1	1	1
1972	1.05	1	.98	.94	.91	1.28	.47
1973	1.06	1	.96	.91	.83	1.06	.62
1974	1.03	1	.95	.89	.81	.92	.79
1975	1.02	1	.94	.88	.78	.91	.91
1976	1.04	1	.96	.86	.69	.92	.96
catch p.u. effort							
1971	1	1	1	1	1	1	1
1972	.99	1	1.03	1.04	1.05	.86	1.28
1973	.94	1	1.06	1.08	1.15	.77	1.63
1974	.91	1	1.09	1.19	1.28	.76	1.83
1975	.86	1	1.12	1.26	1.42	.76	1.96
1976	.83	1	1.15	1.35	1.60	.75	2.04

Table 4. Predicted catch for female plaice compared with the observed catch. F is kept constant.

year	predicted catch in number	observed catch in number	% deviation
1968	123064	139207	- 11.6 %
1969	120439	138677	- 13.2
1970	112178	146664	- 23.5
1971	109729	121083	- 9.4

Table 5. Total plaice catch and catch per unit effort predicted for the years 1972-1976. starting from the observed age-distribution in 1971 and using different patterns of changes in fishing mortality (runs 1a, 2, 4, 6a and 7) as shown in the upper diagram in figure 7, expressed in units of the 1971 values.

year	run 1a	run 2	run 4	run 6a	run 7
catch					
1971	1	1	1	1	1
1972	1.15	1.07	1.01	1.44	.46
1973	1.18	1.05	.92	1.30	.51
1974	1.20	1.03	.87	1.21	.56
1975	1.23	1.04	.81	1.16	.60
1976	1.23	1.04	.76	1.14	.64
catch p.u. effort					
1971	1	1	1	1	1
1972	.97	.98	.99	.92	1.08
1973	.94	.97	1.00	.87	1.16
1974	.91	.97	1.02	.84	1.23
1975	.88	.97	1.06	.82	1.30
1976	.85	.97	1.10	.80	1.39

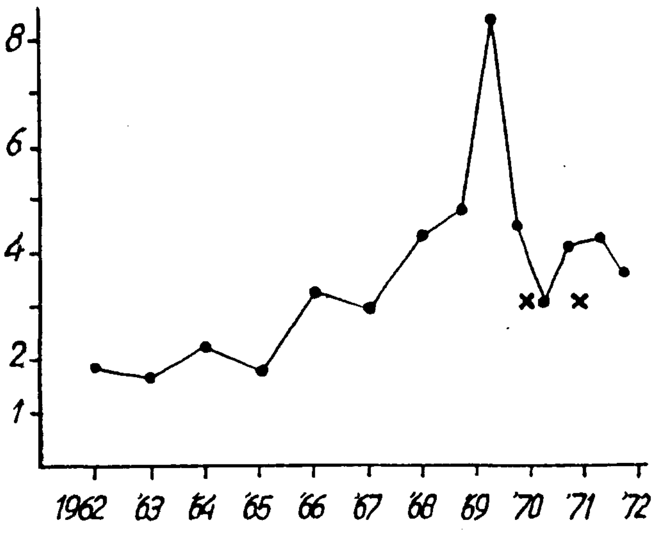


Fig. 1

ratio between catch p.u.e. of the beamtrawl and catch p.u.e. of the ottertrawl on mutual fishing grounds in the Dutch sole fishery

× Irish Sea

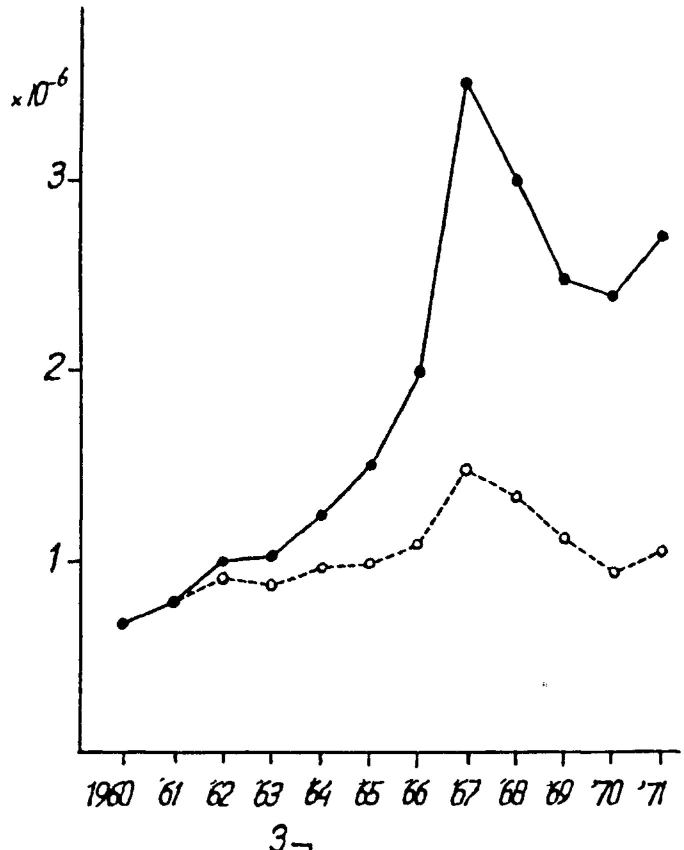


Fig. 2

total number of fishing hours in ottertrawl units in the Dutch mixed beamtrawl-ottertrawl fishery

total number of fishing hours in a simulated Dutch all ottertrawl fishery

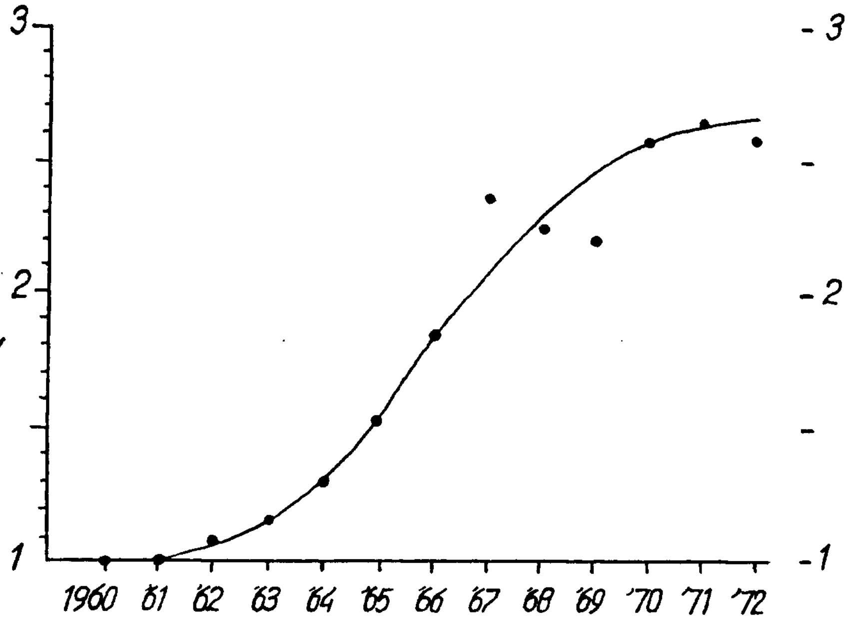
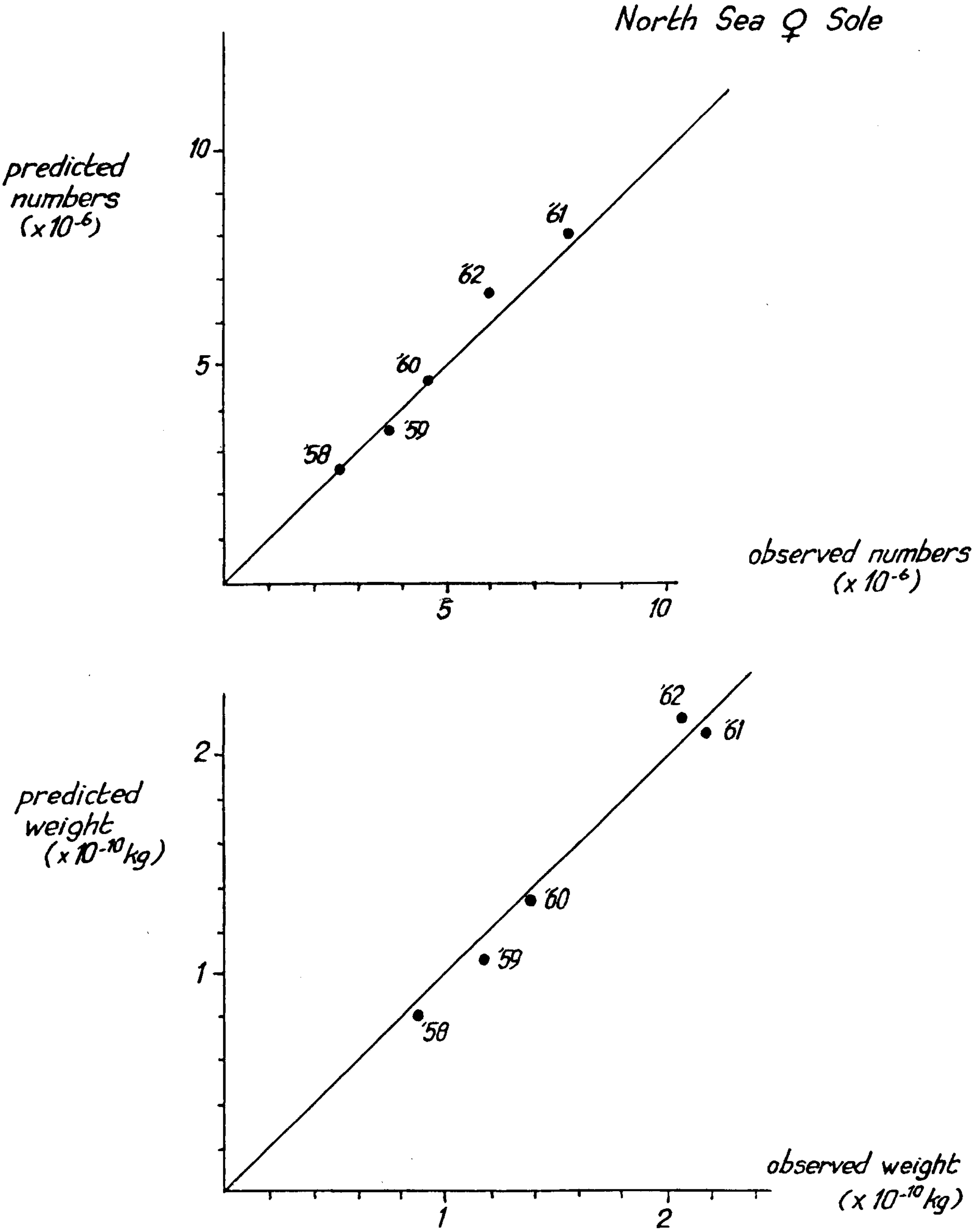


Fig. 3

ratio between total number of fishing hours in ottertrawl-units in the Dutch sole fishery and total number of fish. hours in the simulated ottertrawl-fishery

Fig. 4



comparison of numbers and weight predicted and observed in North Sea sole starting from the observed 1957 age-distribution of the catch and using observed recruitment and fishingmortality values

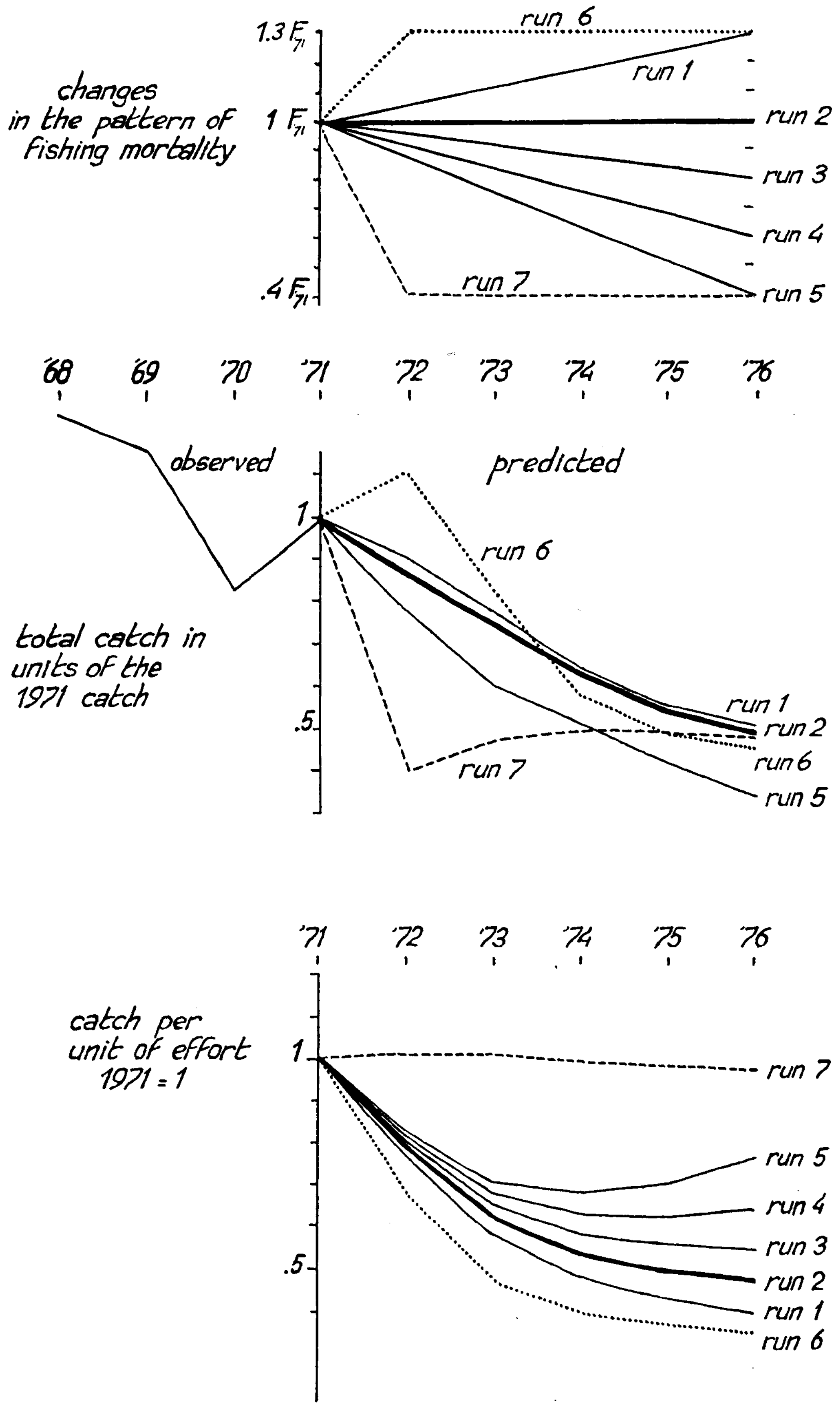
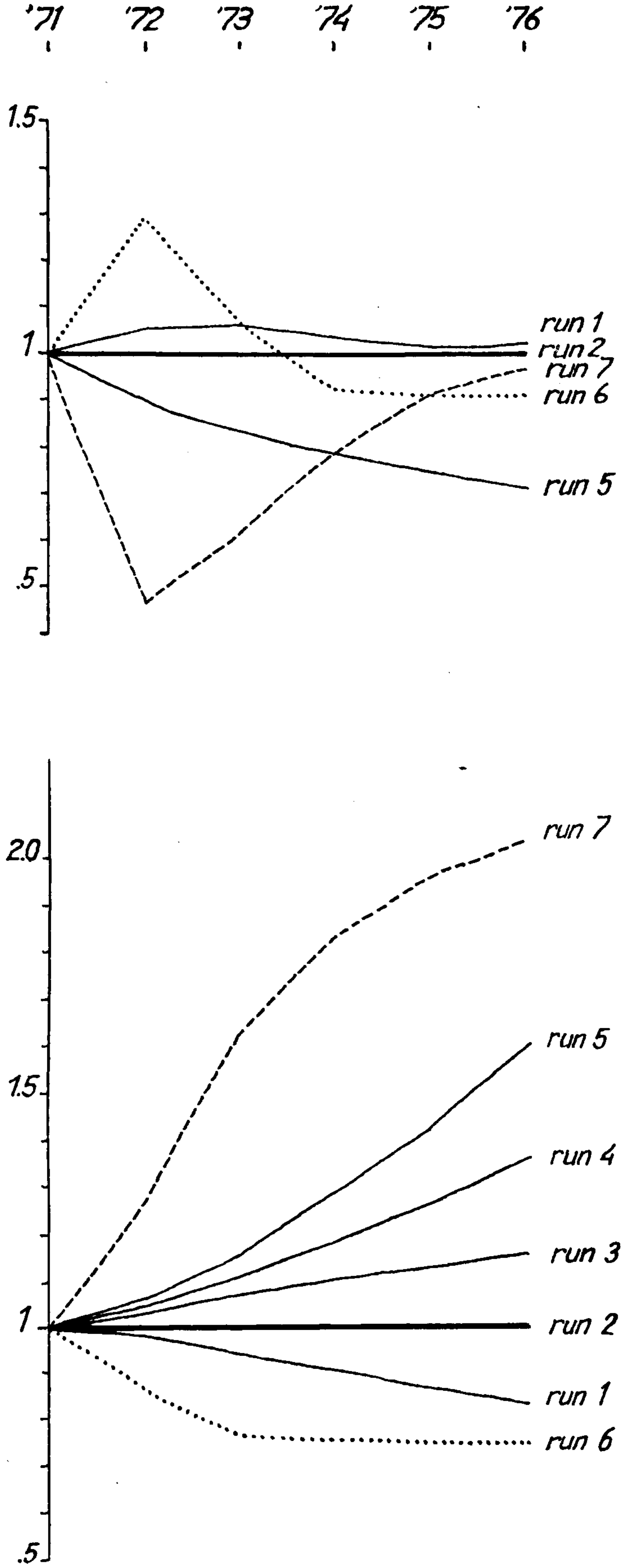


Fig. 5 North Sea Sole



catches under different management strategies compared to the catch in the situation where fishing mortality is stabilized at the 1971 level

the corresponding values for the catch per unit of effort

Fig. 6

North Sea Sole

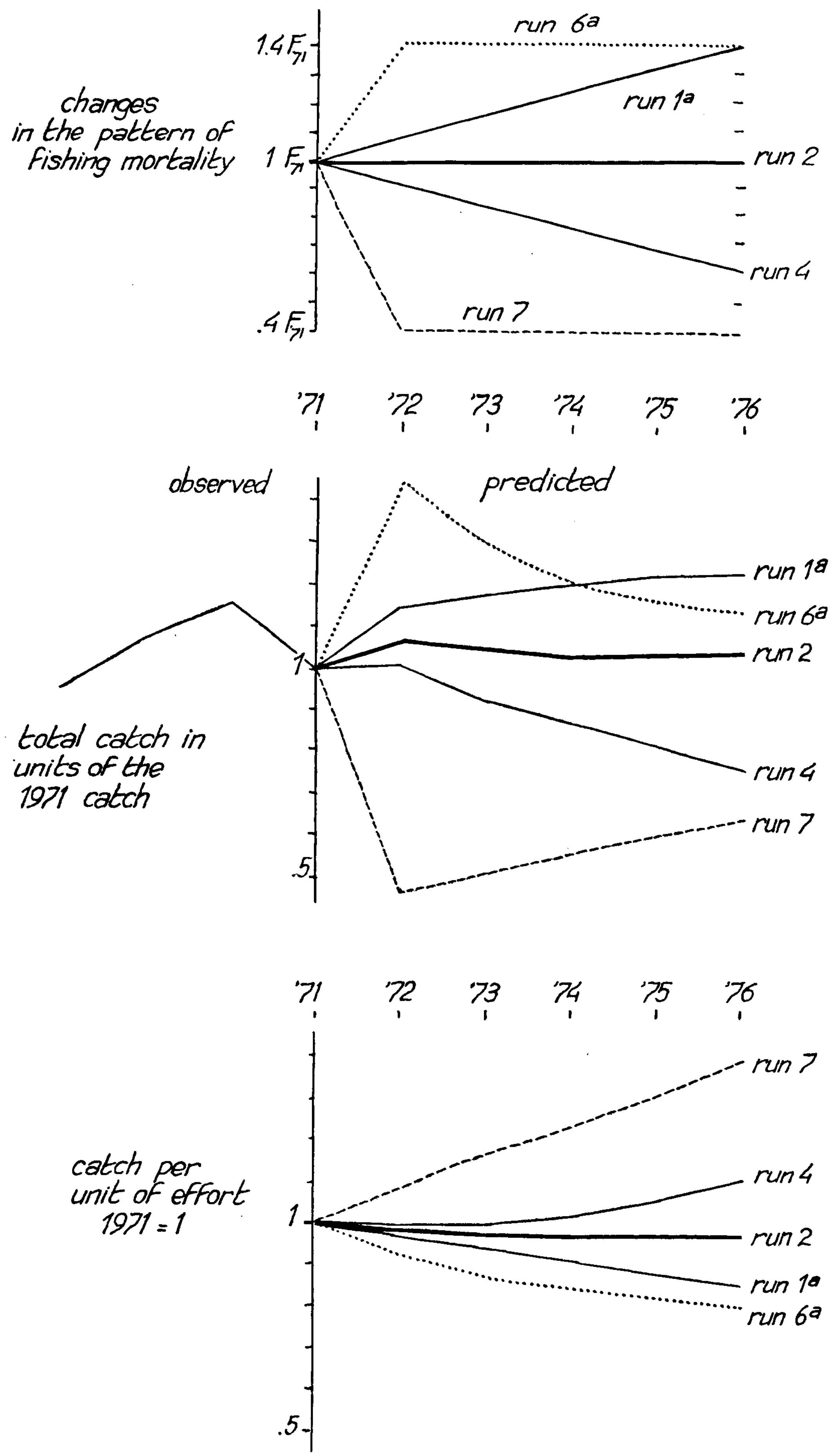


Fig. 7 North Sea Plaice