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The plaice of the English Channel: spawning and migration

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The spawning of plaice in the English Channel was studied by means of plankton surveys carried out during the winters of 1970-71 and 1971-72. Spawning occurred over a wide area of the Channel between the Straits of Dover and 4°W. In 1970-71 the total egg production was at least $4{\cdot}15 \times 10^{12}$ fertilized eggs and equalled the level of egg production in the Southern Bight of the North Sea. Between 75 and 85% of the eggs were spawned in the eastern Channel.

Tagging experiments carried out on the spawning fish showed that approximately 56% of the Channel spawners migrated to the southern North Sea after spawning. The remainder stayed within the English Channel.

The number of female plaice which spawned in the Channel in 1970-71, as estimated from the results of the plankton surveys, the tagging experiments and fecundity data, was between 30·7 and 47·3 million fish.

The drift of the spawning products is discussed in relation to the known nursery areas for plaice. It is suggested that, under normal wind conditions, a high proportion of the Channel progeny would be swept through the Straits of Dover to nursery grounds in the Thames estuary and on the coasts of Belgium and the Netherlands.

Introduction

In recent years, plaice (*Pleuronectes platessa* L.) have contributed up to 30% of the English catch of demersal fish from the English Channel in ICES Divisions VII d and e (MAFF, 1967). Between 1960 and 1971 international landings of plaice from the Channel averaged 2851 metric tons annually, of which 39% went to England, 59% to France and 2% to Belgium (ICES, 1960–1971). Although the plaice catch in the Channel has been only 1·8% of the annual catch of plaice in the Northeast Atlantic region since 1960, its local importance dictates that it should be considered in assessments of the Channel demersal fisheries.

A necessary preliminary to this work is to determine the areas where the plaice can be or are being exploited. This problem can be approached through tagging and the study of spawning grounds, since plaice, in common with other fish species, are thought to have a constant migration pattern which is linked to one spawning ground (see Harden Jones, 1968).

As a result of the work of Simpson (1959 a & b), plaice spawning grounds are well known both in the North Sea and the Irish Sea. These are shown in Figure 1, together with the place-names used in this paper. Tagging experiments on spawning plaice carried out in both the North and Irish Seas (de Veen, 1961, 1962; Macer, 1972) have shown that individual plaice tend to return to the same spawning ground in successive years and that each spawning group has a well-defined summer feeding area. There was no evidence of interchange of fish between the Irish and North Seas, nor any indication that fish which had spawned in either area moved into the English Channel after spawning. Immature plaice, however, do move from the Irish Sea to the English Channel.

Studies on the English Channel plaice themselves have been few. Evidence that plaice spawn in the Channel was produced by Simpson (1959a) who found patches of plaice eggs on several occasions at the eastern end of the Channel. These he interpreted as the progeny of fish which had 'spilled over' into the English Channel from the Southern Bight spawning ground. Wimpenny (1947, 1953), who studied the plaice population of the Kent coast in the eastern Channel, concluded from tagging experiments that they were part of the large plaice stock of the southern North Sea, a view which is the parallel of Simpson's interpretation of the distribution of plaice eggs in the eastern Channel. Simpson did suggest, on the basis of slight evidence, that a separate and probably regular spawning took place in the Bay of the Seine.

In addition to the fishery off the Kent coast studied by Wimpenny, plaice are also caught by English trawlers near the Devon coast in the western Channel.

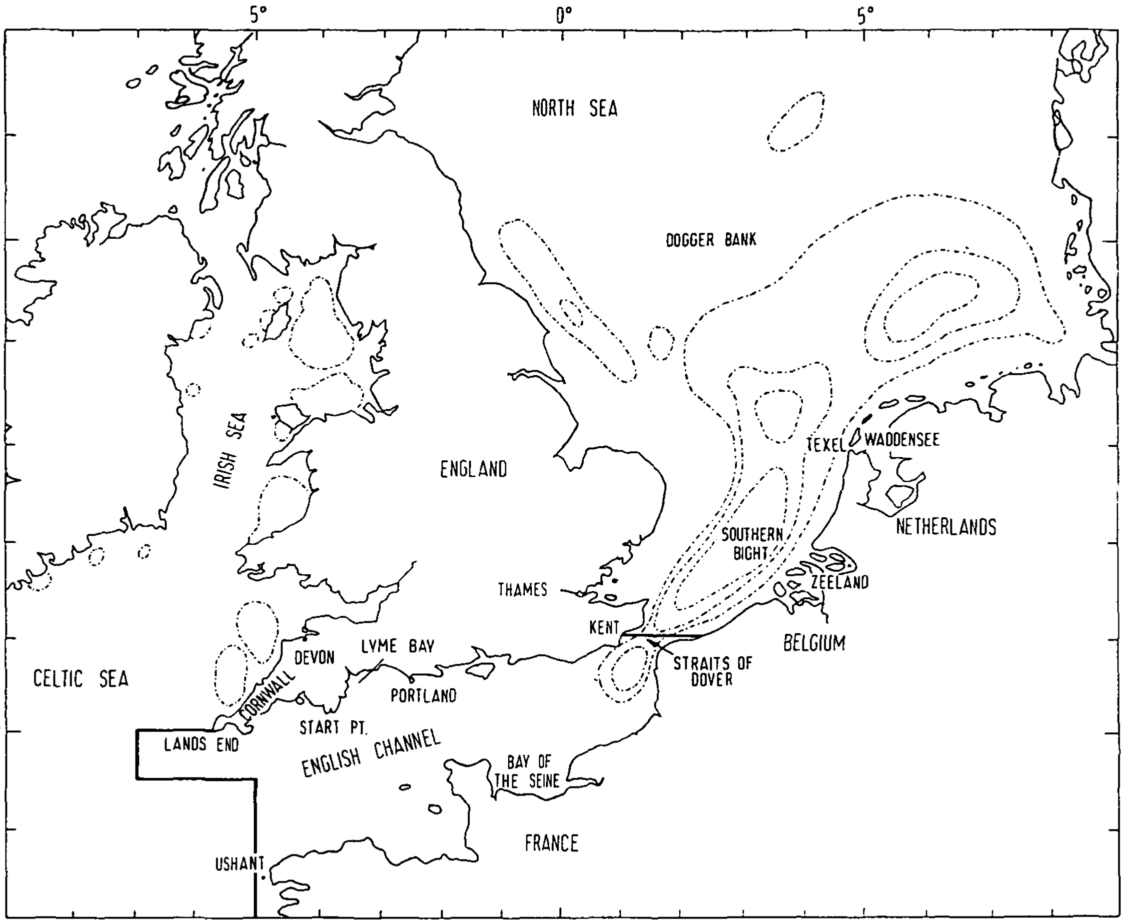

Figure 1. Plaice spawning grounds in the Southern North Sea, English Channel and Irish Sea, according to Simpson (1959a, b). The place names used in this paper are shown and the western and eastern boundaries of the English Channel - (ICES Divisions VII d and e) are illustrated by the bold lines between Lands End and Ushant and across the Straits of Dover.

This population was the subject of work by Kyle (Garstang, 1903) who deduced, from the evidence of tag recaptures and the distribution of plaice in different reproductive stages, that "the largest plaice spawn in 30 fathoms, 20 to 25 *miles offshore*" (from Devon) "whilst medium-sized spawn in 25 to 30 fathoms along the line from Start Point to Portland".

These studies indicated that plaice do spawn in the Channel, a fact which is supported by the experience of fishermen who catch ripe and recently spent plaice there every year; but exactly where spawning occurs, with what intensity and by which group of plaice is not known. The present paper defines the time, position and intensity of plaice spawning in the Channel as established by means of plankton surveys, and it also defines the distribution of Channel spawners outside the spawning season as determined by means of tagging experiments. The results have an important bearing upon the biology of the North Sea and Channel populations as a whole; the discussion of the specific status of the Channel plaice fisheries, which was the impetus for this study, is left for a later paper.

Materials and Methods

Plankton sampling

Samples were taken at sea using the standard 70·2 cm Lowestoft multi-purpose high-speed sampler (Beverton and Tungate, 1967). After the net had been washed down, the plankton was transferred to 4%

formalin in sea water and later sorted at the laboratory. Plaice eggs and larvae were staged using Simpson's criteria for eggs (Simpson, 1959a) and Ryland's criteria for larvae (Ryland, 1966). The results of five surveys in the 1970–71 season and three in the 1971–72 season have been considered. They cover the periods from December 1970 to March 1971 and January to March 1972.

The density of an organism at a particular station was calculated as follows:

$$d = (n \cdot s) / (r \cdot k)$$

where d = the density in numbers beneath 1 m of sea surface; n = the number of organisms in the sample; r = the number of revolutions of the internal flowmeter; k = the volume accepted per revolution of the internal flowmeter (m^3); and s = the depth sampled (m).

The value of k was determined from five hauls of the sampler without the net; for these hauls the volume accepted was calculated as the product of nose-cone area and distance travelled. Experiments with a smaller 50·8 cm sampler of similar design have shown that the volume strained calculated by this method exceeds the true value (Harding and Arnold, 1971) and this is also true of the70·2 cm sampler. The densities presented here are therefore underestimates of the true densities. The depth sampled was measured either with a pressure transducer attached to the sampler and linked to a shipboard display or with a Kelvin sounding tube. The sea surface temperature and salinity were also measured at each station.

Knowledge of the relationship between development time and temperature allows us to convert densities to numbers of eggs produced/m^2/day. This relationship for Stage I eggs (Ryland, personal communication) is as follows:

$$y = -9{\cdot}6197x + 11{\cdot}7269$$

where y = the duration between fertilization and the end of the stage, in days,
and x = the $\log_{10}$ of temperature, in °C.

If, for example, the development time between fertilization and the end of Stage I is three days, the density of Stage I eggs at any instant will represent the production of Stage I eggs over 3 days. Daily egg production is therefore calculated by dividing the density of Stage I eggs by the development time at the temperature of the station.

The values of Stage I egg production so obtained were plotted on charts and contoured. The area within each contour was measured with a planimeter and hence the total Stage I egg production on each survey was calculated. Annual egg production (measured as Stage I) was obtained by measuring the area under the curve obtained by plotting daily egg production against the mean sampling date for each cruise.

An estimation of the number of eggs fertilized can be made if the mortality rate and mean stage duration are known. The instantaneous rate of daily mortality between Stage I and II eggs in the Channel in 1970–71 was 0·1819, and the mean duration of Stage I was 2·505 days. Hence the number of fertilized eggs produced was approximately 1·6 times the number of Stage I eggs.

Tagging

Ripe, running and spent plaice were captured by otter trawl in January and February 1972 in two areas of the Channel where egg and larval surveys of the previous year had shown centres of plaice spawning. The plaice were marked with plastic Petersen discs: a yellow and serially numbered disc on the dorsal side and a blank red disc on the ventral side, joined by stainless steel wire. The fish were released as quickly as possible after capture, close to the position at which they were caught. The releases were concentrated in two different areas: 136 fish in the western Channel within 41 km radius of 49°55′N 3°05′W, and 644 fish in the eastern Channel within 37 km of 50°15′N 0°05′W.

Results

The position of spawning

The distributions of eggs in their earliest stage of development may be used to determine the position of spawning. Stage I egg distributions of each survey are shown in Figure 2a–h. No correction has been made for tidal or residual current movements between spawning and sampling.

Spawning occurred throughout the Channel (Fig. 2c) and tended to be concentrated offshore, approximately midway between the coasts of France and England. The peaks of the distribution occurred consistently at the same positions in each survey and it is suggested that these represent the positions at which plaice concentrate to spawn. Five such centres can be recognized and these are labelled A to E in Figure 3. Trawling near centres B and E in January 1972 yielded large numbers of ripe, running and spent plaice, with a sex ratio of 8·5 to 1 in favour of males at centre B and 3·3 to 1 at centre E.[1] Trawling a short

[1] The maximum catch-rate with a 23·8 m headline Granton trawl was 195 fish per hour at B and 52 fish per hour at E.

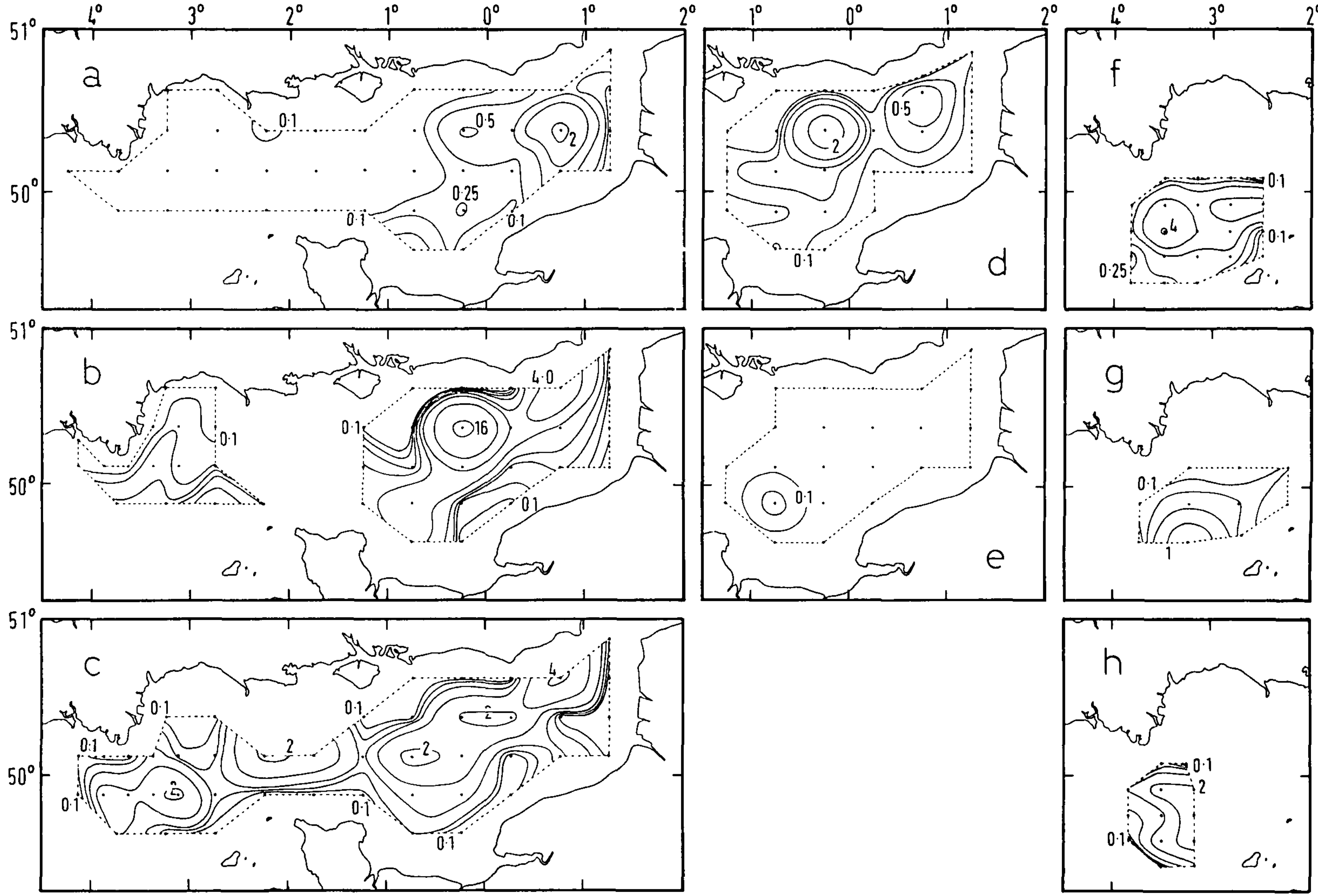

Figure 2. Distribution of Stage I plaice eggs in the English Channel in 1970-71 and 1971-72. Full lines, contours of the distribution; dashed lines, boundaries of the survey grid; dots, sampling positions. Contours are drawn at 0·1, 0·25, 0·5, 1·0, 2·0, 4·0, 8·0 and 16·0 eggs produced/m²/day intervals.
a) 7-14 December, 1970; b) 6-9 January, 1971; c) 6-10 February, 1971; d) 23-25 February, 1971; e) 10-11 March, 1971; f) 19-21 January, 1972; g) 3-5 February, 1972; h) 8-9 March, 1972.

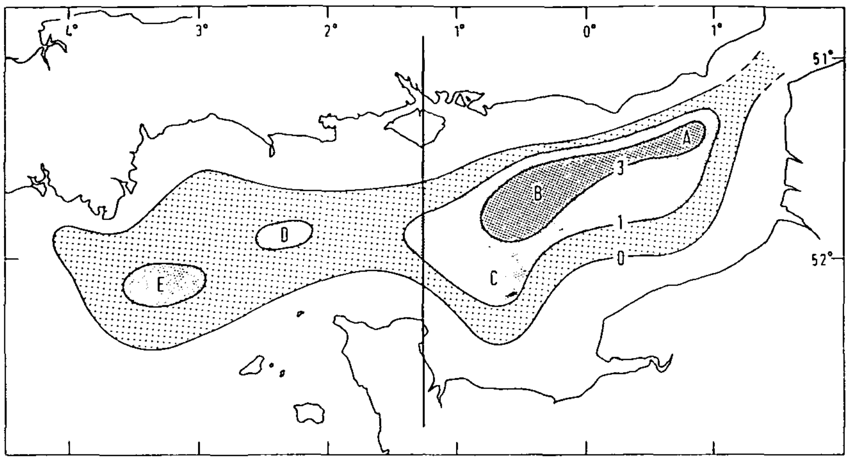

Figure 3. Diagrammatic representation of the distribution of Stage I plaice eggs in the English Channel at the peak of the spawning, contoured at 0·1 and 3 eggs/m²/day intervals. The letters A to E denote the centres of egg production referred to in the text and the bold line at 1°15′W indicates the boundary between the east and west Channel spawnings.

distance away (15 km) produced fewer plaice. This finding, together with the sex ratio observed, confirms the view that fish aggregate to spawn at these positions.

Neither depth nor type of bottom sediment appears to be a common factor in the position of the spawning grounds, since the depth varies from 67 m at centre E to 38 m at A, and the bottom sediment from fine sand at centre E to stones and gravel at D (Pratje, 1950). The positions of spawning do however lie within the tongue of high-salinity water which pushes into the Channel from the Atlantic (Lumby, 1935).

Even though samples were not taken west of 4°15′ W or south of 49°25′N in the western basin it is unlikely that other centres of egg production exist, in view of the proximity of the 100 m contour which is recognized as a boundary to the distribution of plaice (Wimpenny, 1953).

Time of spawning and annual egg production

For the following analysis it is convenient to divide the Channel spawning grounds into two groups by longitude 1°15′W, the eastern group consisting of centres A, B and C and the western group of centres D and E. Five good estimates of daily egg production are available for the eastern Channel in 1970–71 and three estimates for the western Channel for each of the 1970–71 and 1971–72 seasons.

In Figure 4a the eastern Channel estimates have been plotted against the mean sampling date. Spawning began at the end of November, rose to a peak between late December and the end of January, and ended in the middle of March. The total Stage 1 egg production in 1970–71 in the eastern Channel was at least $2{\cdot}21 \times 10^{12}$ eggs (from the area under the curve in Fig. 4a). It is unlikely that Stage I egg production exceeded $3{\cdot}0 \times 10^{12}$, if one makes the extreme assumption that the sampler underestimated the density to the extent of 30%. The total egg production in the eastern Channel, expressed as fertilized eggs (i.e. Stage I abundance $\times$ 1·6), was therefore at least $3{\cdot}54 \times 10^{12}$ and certainly not greater than $4{\cdot}80 \times 10^{12}$ eggs.

In Figures 4b and c daily Stage I egg production in the western Channel has been plotted against mean sampling date for the 1970–71 and 1971–72 seasons respectively. The limits of the distributions were defined well on three occasions (7–14 December 1970, Fig. 2a; 6–10 February 1971, Fig. 2c; 19–21 January 1972, Fig. 2f) and less well on the other surveys. It is certain however that spawning had only just begun in the western Channel by 7–14 December 1970 and it has been assumed that the same was true of the following season. The end of spawning was not defined in either year but a reasonable estimate is the middle of March. The solid lines in Figures 4b and c were drawn with these assumptions in mind, and the total annual Stage I production that was sampled was estimated to be 0·38 and $0{\cdot}43 \times 10^{12}$ eggs in successive seasons. If, as seems likely from extrapolation of contours, the broken lines in Figures

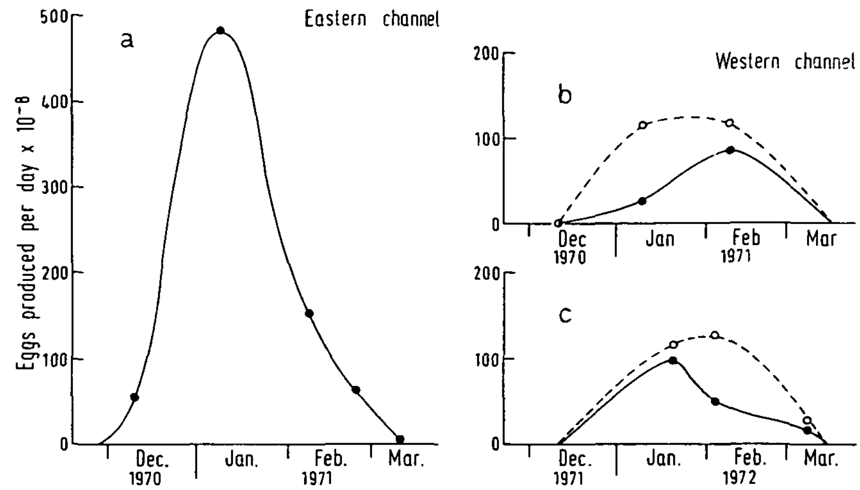

Figure 4. Daily egg production plotted against mean sampling date. (a) 1970–71, east of 1°15′W; annual egg production (AEP) 2·21 × 10^{12}; (b) 1970–71, west of 1°15′W; AEP 0·38 × 10^{12}; (c) 1971–72, west of 1°15′W, AEP 0·43 × 10^{12}. Solid line, sampled values; dashed line, extrapolated values. For further explanation see text.

4b and c represent the curves of true egg production, the annual Stage I egg production in the western Channel did not exceed 1·0 × 10^{12} eggs in either year. Expressed as numbers of fertilized eggs, egg production in the west was at least 0·61 and 0·69 × 10^{12} in successive seasons, and did not exceed 1·6 × 10^{12} eggs.

To summarize, fertilized plaice egg production in the English Channel in 1970–71 was at least 4·15 × 10^{12} eggs and probably did not exceed 6·4 × 10^{12} eggs. These estimates can be used with fecundity data and the results of tagging experiments to determine the numbers of female plaice which spawned in the Channel.

The movements of tagged fish

Ripe, running and spent plaice were tagged at centres B and E in the English Channel during January and February 1972. The recaptures in the first year have been grouped by season and their positions plotted in Figures 5 and 6 for each release.

The pattern of recaptures is similar for both the westerly and easterly releases and is remarkable in that it reveals a strong movement of plaice away from the Channel into the southern North Sea after spawning. A portion of the tagged population from each release remained in the Channel during the summer and an insignificant proportion moved west past Land's End into the Celtic and Irish Seas.

Since the number of recaptures is determined by the number of tagged fish present and the level of fishing effort, the proportions of the tagged population which occurred in each area can be estimated if the distribution and intensity of fishing is known for at least one fleet which operates in each area. Following Gulland (1969), but considering only a single time interval,

$$q\bar{N} = \sum n_i \cdot a_i / f_i$$

where $\bar{N}$ is the total mean number of tagged fish present in a sea-area; n_i, a_i and f_i are the number of recaptures, the surface area and the fishing effort in the ith subdivision of the sea-area, and q is the probability of capture on encountering fishing gear. The relative proportions of tagged fish present in the Channel and North Sea, for example, may be obtained by estimating $q\bar{N}$ for each area.

Since the tagging was carried out on the spawning grounds, mixing with the untagged population will have been rapid and the results can be legitimately extended to the total population of mature plaice which spawned at centres B and E in January and February 1972. The analysis was restricted to recaptures in the second and third quarters of 1972 and the results therefore relate to the distribution of fish on the summer feeding grounds.

Almost all of the North Sea recaptures were due to the Dutch twin-beam trawl fleet, and the majority of the Channel recaptures in these two quarters were made by English inshore trawlers. Effort data were

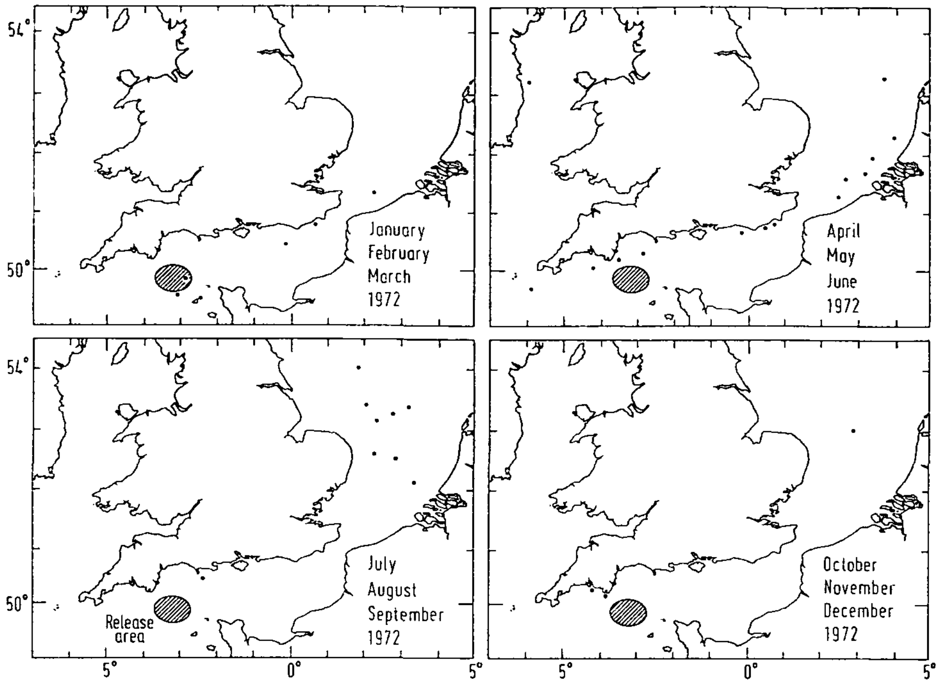

Figure 5. Distributions of recaptured plaice in successive quarters of 1972 from fish released on spawning grounds in the western English Channel in January/February 1972.

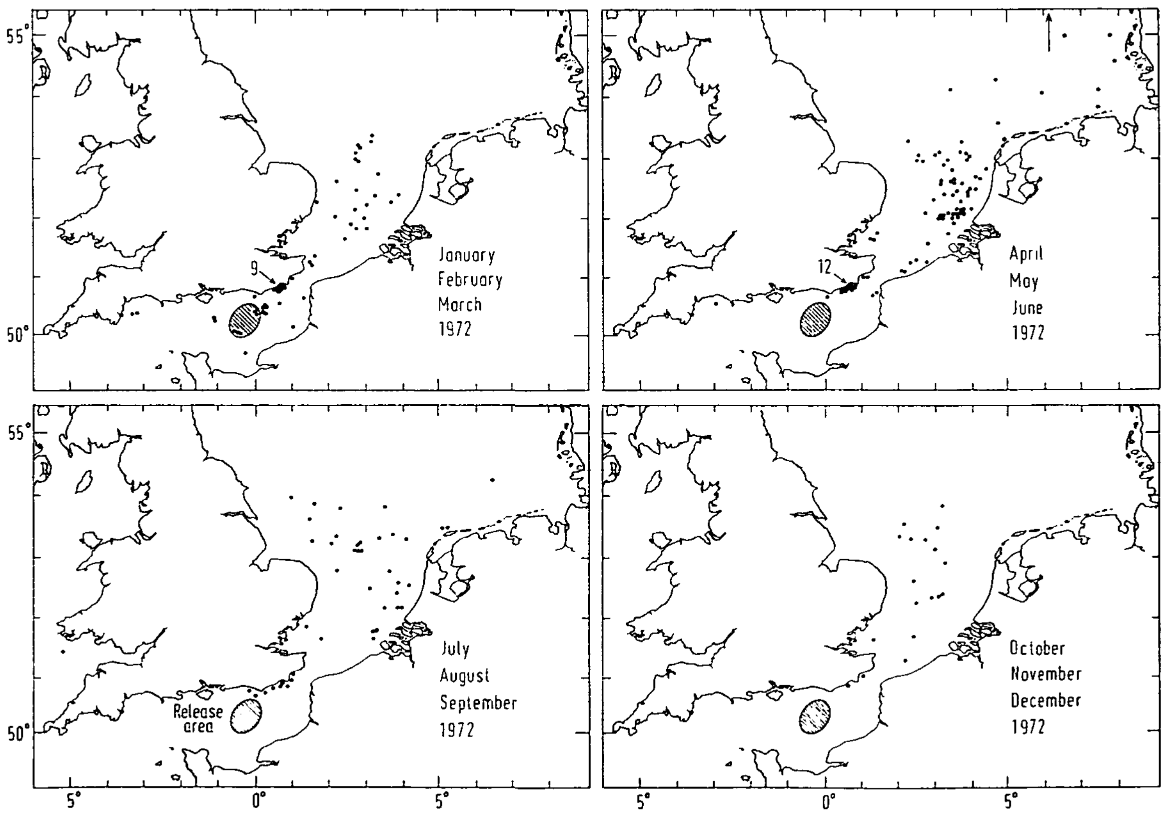

Figure 6. Distributions of recaptured plaice in successive quarters of 1972 from fish released on the spawning grounds in the eastern English Channel in January/February 1972.

Table 1. Estimates of $q\bar{N}$ (constant × average number of tagged fish present) for the 2nd and 3rd quarters 1972 from two releases of plaice in the English Channel in January 1972

Recapture position (ICES Divisions)		Release position: Western spawning ground (centre E) $q\bar{N} \times 10^{-4}$	%		Eastern spawning ground (centre B) $q\bar{N} \times 10^{-4}$	%	
IV B Central N. Sea		6·65	12·2	37·5	31·35	16·3	61·3
IV C Southern N. Sea		13·89	25·3		86·40	45·0	
VII D Eastern Channel:	Eng.	7·21	13·2	22·0	42·95	22·4	24·3
	Fr.	(4·80)	8·8		(3·73)	1·9	
VII E Western Channel:	Eng.	22·01	40·4	40·4	27·59	14·4	14·4
	Fr.	(0)	0		(0)	0	
Total		54.56			192.03		

available for both these fleets and it was possible to relate them by comparison of catch rates in the southern North Sea where the area of operation of the two fleets overlaps. We are indebted to Mr J. F. de Veen of the Rijksinstituut voor Visserijonderzoek of Ijmuiden for the Dutch data. The combined effort of these two fleets was expressed in Dutch beam trawl units, using a ratio of 3 to 1 north of 53°30′N and 6 to 1 elsewhere and $q\bar{N}$ estimated for each area (Table 1).

It is certain from the distribution of English and Dutch fishing effort that no major component of the tagged population evaded capture in the North Sea. One cannot be certain that the same is true of the fish in the Channel because of the lack of French fishing effort information. Assuming that plaice are exploited wherever they occur in the Channel, an indication of the relative abundance of plaice between the areas fished by English and French trawlers (which essentially do not overlap) may be made from the ratio of recaptures by each country in both the east and west Channel in the second and third quarters of 1972. The overall ratio (4:31, French to English) may be compared with the annual catch figures, which are in the ratio of 60:40. If the discrepancy is real it indicates that most of the French catch is taken during the fourth and first quarters of the year. Table 1 includes estimates of $q\bar{N}$ for the French area of the Channel from the tag ratios and summarizes the results of the analysis.

The accuracy of these results is difficult to evaluate but they are probably of the right order for the major components of the dispersal. Of those plaice which spawned in the eastern Channel at centre B, about 60% moved into the North Sea. A minority of those which did not travel through the Straits of Dover migrated to the western Channel. The estimates for the western spawning group are less reliable because fewer fish were released but the analysis shows that about 40% migrated into the North Sea after spawning.

Recaptures from the westerly release in the first quarters of 1973 and 1974 (approximating to the next two spawning seasons) were low; in 1973 2 fish were caught in the eastern Channel close to the English coast and, in 1974, one fish was caught near the release position on the spawning ground in the west. Of the fish released in the eastern Channel, 19 were recaptured between January and March 1973; 7 in the eastern Channel, 2 in the western Channel, 8 in the central and southern North Sea and 2 at unknown positions. In 1974 five fish from the easterly release were caught in the first quarter; 3 in the central North Sea and 2 in the eastern Channel. The evidence for a general return to the same spawning ground each year is therefore doubtful. It could be, of course, that the recaptures in the North Sea were of fish on their way to or from the Channel spawning grounds, especially since the movement away from the Channel in 1972 was rapid enough for fish to be taken in the North Sea during February, the month of release. With these data, however, it is not possible to determine which alternative is correct.

Estimates of spawning stock size

If the average fecundity is known, estimates of egg production may be used to determine the numbers of mature females in the spawning population. Difficulties may arise in evaluating fecundity for a particular spawning area if spatial variations in fecundity occur between adjacent populations, and if the contribution by each group to the spawning ground is unknown, since female plaice with gonads in a suitable stage of development for egg-counting have to be captured some distance away from the spawning ground, typically between November and January. Such a situation exists in the case of the Channel spawning, since the three populations (west Channel, east Channel and North Sea) which are likely to spawn in the Channel have different fecundities. However, the results of the tagging experiments and the published data on fecundity are a basis from which the average fecundity of Channel-spawning plaice can be determined.

Bagenal (1957) suggested that fecundity could be described as a power function of fish length in the form:

$$\ln F = \ln a + b \cdot \ln L$$

where F = fecundity (number of eggs), L = fish length (cm) and a, and b are constants.

Data on the fecundity of Southern Bight plaice have been given by Simpson (1951) and on that of eastern and western Channel plaice by Bagenal (1960). Additional samples from the western population were collected from Brixham market in 1970. These data were subjected to regression analysis for the three areas separately and the constants determined (Table 2). The length composition of mature female plaice at centres B and E was determined from research vessel catches in January 1972 and used with the fecundity/length relationships to evaluate the average fecundity of North Sea, eastern Channel and western Channel plaice on each spawning ground. The average fecundity for each spawning ground was then determined from these figures and the results of the tagging experiments, and the numbers of the spawning stock were estimated from average fecundity and fertilized egg production for 1970–71 (Table 3).

Table 2. Values of a and b in the relationship between fecundity and length ($F = aL^b$) in three sea areas (n = number of observations, r = correlation coefficient)

	a	b	n	r
Southern North Sea (Simpson 1951)	0·47	3·28	54	+0·85
Eastern English Channel (Bagenal 1960)	34·85	2·53	11	+0·97
Western English Channel (Bagenal 1960; this study)	1·35	3·14	18	+0·90

Table 3. Estimates of the number of spawning female plaice in the western and eastern Channel during the 1970–71 spawning season

	Western Channel	Eastern Channel
Average fecundity	137 322	134 521
Egg production in 1970–71 $\times 10^{-12}$	0·61 to 1·6	3·54 to 4·80
Stock of mature females $\times 10^{-6}$.......	4·43 to 11·63	26·27 to 35·69

The results show that between 30·7 and 47·3 million female plaice spawned in the Channel in 1970–71, of which between 85 and 75% spawned to the east of 1°15′W. Of the total Channel-spawning females, between 5·6 and 9·9 million (about 20%) spent the summer in the western Channel, between 7·3 and 11·2 million (about 24%) spent the summer in the eastern Channel and between 17·8 and 26·2 million (about 56%) moved into the North Sea.

Discussion

It has been shown that in the 1970–71 spawning season in the English Channel, plaice egg production measured as Stage I eggs was at least $2{\cdot}6 \times 10^{12}$ and that production measured as fertilized eggs was at least $4{\cdot}1 \times 10^{12}$. In the same season the corresponding estimates for the Southern Bight of the North Sea were 2·5 and $4{\cdot}1 \times 10^{12}$ (Bannister, Harding and Lockwood, 1973) and therefore one may conclude that egg production in the Channel in 1970–71, at least, was of the same order of magnitude as that in the Southern Bight. It has also been shown by tagging that a large proportion (estimated as 56%) of the Channel spawners are fish which return to the southern North Sea after spawning.

There is some evidence to show that the position and intensity of plaice spawning in the Channel found in 1970–71 relative to that in the North Sea is not a recent feature. Of the surveys which Simpson (1959a) reported, only one (December 27 to 29, 1946) covered adequately the eastern Channel, and it demonstrated a low level of egg production. This distribution is almost exactly the same as that of 7 to 14 December 1970 reported in the present paper. It is therefore probable that Simpson missed the main spawning in the Channel by going there too early. Some unpublished results of a herring larval cruise in 1923 show that in January of that year plaice were spawning over wide areas of the Channel (R. V. "George Bligh", Cruise 57, January 1923).

These results have consequences for the plaice fisheries in the North Sea, if only for the reason that a component of the North Sea population is vulnerable to exploitation in the English Channel between December and March. The North Sea and Channel Stage I egg production in 1971 was approximately 12×10^{12} (Harding, unpublished data) of which $2{\cdot}6 \times 10^{12}$ were produced in the Channel. The tagging experiments showed that 56% of plaice which spawned in the Channel returned to the North Sea after spawning and so it is likely that 12% of mature North Sea plaice are present in the Channel at spawning time. The tagging experiments indicated that most of the French catch of plaice in the Channel (about 1770 metric tons/year) is taken in the first and fourth quarters of the year, which implies that the French catch is largely of North Sea fish.

Further consequences of the main result hinge upon the direction in which the eggs and larvae drift and the position at which they metamorphose and take up a demersal life. Do the progeny of the Channel spawnings ultimately recruit to the plaice population which lives throughout the year in the Channel, or do they recruit to the North Sea?

In the centre of the English Channel there is an east-going stream which passes into the North Sea through the Straits of Dover. The local wind distribution accelerates or decelerates the speed of flow and when the local wind has a strong northerly component the flow may be temporarily reversed (Wyrtki, 1952; Lawford and Veley, 1956). The centres of plaice egg production in the Channel occur in or near this stream.

The main body of the Atlantic flow entering the western Channel was thought by Lumby (1935) to turn at longitude 4°W and leave the Channel past Land's End, but according to Dietrich (1950) it leaves past Ushant in the winter. The most westerly centre of egg production, centre E, is situated at the point where the Atlantic flow divides. Sea-bed drifters which were released at centre E in January 1972 demonstrated a clearly defined bottom flow to the north and west towards the Devon and Cornish coasts (Jones, 1974). It seems probable, therefore, that at least some of the eggs produced at centre E do not drift eastwards towards the eastern Channel but travel towards the coasts of Devon and Cornwall.

Both Dietrich and Lumby postulated the existence of a clockwise swirl in the Bay of the Seine. Eggs produced at centre C would be carried into the main stream by this swirl. The strength of the swirl relative to the main stream would determine the proportion of eggs which would be carried from centres A, B and C towards the French coast in the Bay of the Seine. Dietrich also suggested the existence of a west-going counter-current close to the English coast in the winter. It is conceivable that some eggs from centres A and B are carried westwards towards Lyme Bay by this current.

In spite of this it seems likely that, with the exception of those from centre E, the majority of plaice eggs in the Channel drift in the eastgoing central stream towards the Straits of Dover. Preliminary analyses of the strength of water flow in the Straits in 1971 have suggested that a large proportion of the eggs produced in the eastern Channel, did, in fact, enter the North Sea before metamorphosis (Ramster, Wyatt and Houghton, 1973). The larval distribution and salinity patterns tend to confirm this view. It is to be expected that the local wind distribution at the time of egg and larval drift has a major influence on the proportion of eggs which enter the North Sea from the Channel.

The progeny of the Southern Bight spawning drift north-eastwards to nursery grounds on the Dutch coast and in the Waddensee. The progeny of the Channel spawning which are swept through the Straights of Dover could also take this route, because the time taken to travel through the Straits may be quite short; the residual drift in the area is between 2 and 10 km per day. On balance, however, this route seems unlikely since, if the Southern Bight progeny reach metamorphosis in the vicinity of Texel Island, Channel progeny would certainly reach metamorphosis even further south. Zijlstra (1972) showed that significant numbers of 0-group plaice occur in the coastal zone and in the southern inlets of Zeeland to the south of the Waddensee. It is probable that at least some of these are derived from the Channel spawning.

Our colleague John Riley found 0-group plaice at surprisingly high densities (6·6 per 1000 m^2) during September 1970 and September 1973 on the English east coast from the Humber southwards to the Thames. He has estimated the population in the Thames Estuary in September 1970 to have been at least 12·5 million. For the Dutch Waddensee in September 1969 Zijlstra (1972) estimated the population to have been 18·6 million. Neither of these figures takes into account gear efficiency and they are therefore minimum estimates, and, since the gears used and years sampled were different, they are not strictly comparable. The figures do, however, illustrate that the 0-group population of plaice in the Thames Estuary in 1970 was of the same order as that in the Dutch Waddensee in 1969. Such hydrographic information as exists (Riley and Ramster, 1969) does not exclude the possibility that the 0-group plaice of the Thames Estuary are derived from spawning grounds in the Channel. Thus the high level of plaice egg production in the Channel, which is perhaps incompatible with the currently accepted view of the distribution of 0-group plaice in the North Sea, is more readily explained.

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