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THE EXPLOITATION OF GREY MULLET *CHELON LABROSUS* (RISSO) IN THE SOUTH EAST OF IRELAND.

The exploitation of Grey Mullet *Chelon labrosus* (Risso) in the south east of Ireland.

by

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ABSTRACT

Fisheries for grey mullet are widespread on the south coast of Ireland, the majority being small and irregularly operated. The largest, at Wexford in the south-east, is a summer fishery where recent catches are well documented. At Wexford nets of mesh perimeter 18.4 cm are fished as fixed engines by two methods known locally as *stake* and *ring* nets. The fish are captured by wedging in a single mesh. Data from the stake nets give an indication of catch per unit effort and this has shown no significant variation from 1969 to 1977.

From June to September 1977 fork length and girth measurements were made from 2,121 net-captured grey mullet; age and weight were determined for 528 of these. Gonads from 341 fish were weighed and 154 ovaries were sectioned. The majority of net-caught fish were between 31 and 45 cm fork length and 8 to 12 years of age. As the season progressed the gonads of maturing males expanded by up to 700% by weight. Growth of the ovary was variable and smaller in degree. Ovary weight in autumn correlated well with mean oocyte diameter.

On the basis of previously reported growth data for grey mullet in British and Irish waters and on the length of fish retained by the nets a mean age of catch of 9.6 years is expected. This figure was approached only at the beginning of the season; thereafter the mean age of capture was lower.

INTRODUCTION

Relatively little attention has been given to the ecology of grey mullet in British and Irish waters. Hickling (1970) examined various aspects of the biology of several mullet species in British waters and Kennedy and Fitzmaurice (1969) described the growth of thick lipped grey mullet in Ireland where they found it to be slow growing, long lived and late maturing. Though common fish in the shallow waters of all tropical and temperate seas (Wheeler, 1969) grey mullets are typically fish of warmer waters, at the limit of their range around the coasts of Britain and Ireland (Hickling, 1970). Thus their exploitation has not been the basis for any major fishery in Ireland although small local fisheries, widely distributed around the coast, have been operative for periods during the last 200 years (Parochial survey 1814-'19; Fraser, 1807, Maxwell, 1832, Brabazon, 1847).

Like a number of other marine fish grey mullet have come under increasing commercial pressure during the last decade. Precise statistics for most fisheries are not available but what information there is suggests that the catch of grey mullet has grown considerably on several parts of the coast. At the same time the effects of greater catches of another long-lived and slow maturing species, bass, *Dicentrarchus labrax* (L.) have been a cause for concern (Kennedy and Fitzmaurice, 1972). Thus, an enhanced commercial interest in mullet, together with a decline of another, in some respects similar species, prompted an investigation of the conduct of mullet fisheries.

THE FISHERY

DISTRIBUTION OF FISHERIES

The heaviest reported mullet landings in 1977 came from the south coast. To ascertain the distribution of these fisheries and to see something of their organisation a brief survey was undertaken in that year. Local fish buyers were consulted and through them contact with individual fishermen was made. It is probable, from the information received during the survey, that all inlets and estuaries on the south coast have supported however briefly a mullet fishery at one time or another. Emerging from this enquiry is an irregularly distributed and casually organised fishery (Fig. 1) which, though widespread, is best developed in the estuary of the River Slaney, Wexford Harbour. Methods of capture varied considerably: drift and draft (seine) nets and even rod and line made some contribution to total landings. The majority of the catch was taken in "mullet netting"—monofilament webbing, 40 meshes in depth with a mesh size of 18.4 cm in the round.

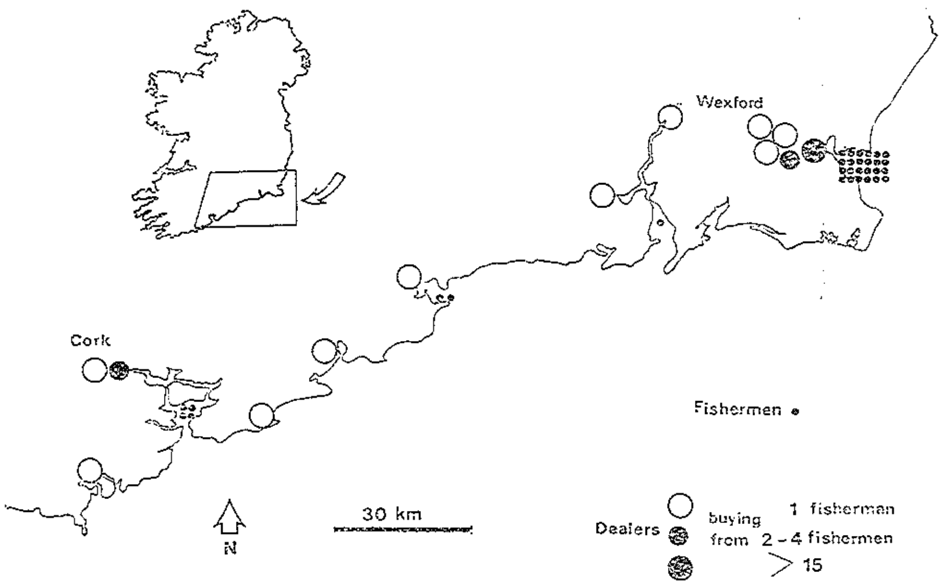

Figure 1. The mullet fishery on the south coast in 1977.

The Wexford fishery

In any recent year more than 20 fishermen have participated in the fishery situated in Wexford Harbour. According to local accounts the methods employed by these fishermen are similar to those practised by their predecessors in the early years of the century. Nets currently in use in the Wexford fishery are of two kinds locally referred to as "stake nets" and "ring nets" both of them composed of similar webbing. (For a description of these local terms see under *Catch per effort*). The meshing is at present monofilament nylon in meshes of 18.4 cm. in the round. The nets are of variable length and 40 meshes deep. Stake nets are not staked but anchored and the ring nets are more accurately referred to as enclosing meshing nets. The operation of both types is as fixed engines so they belong to class I, Division F of Davis's classification (1936).

Sources of data

A principal reason for selection of Wexford for a case study was the existence of documentation on the fishery. When a major fish exporting firm commenced dealing with mullet there in the 1950s some were purchased from the fishermen, although for a time local hotels and shops provided a larger market for these fish. In the early 1960s however the firm, hereinafter referred to as the Company, began to export mullet to the U.K. and this stimulus provided the main boost for the expansion of the fishery. Export books from the early years are still extant, giving details of each consignment on a daily basis and from these Fig. 2 has been drawn. It should be pointed out that not only Wexford fish were included in these accounts since there were

occasional inputs from the smaller estuaries on the south coast and from as far north as Wicklow on the east. However mullet from sources other than Wexford were relatively few and they were consistently bought-in from the same agents. As there was no indication as to the origin of every batch of fish it was considered as well at this stage to treat all the exports together without further elaboration.

Trends in landings

Since local consumption never accounted for large quantities, the amount of mullet exported was taken to be equivalent to total landings of the fish. Copies of dockets describing daily consignments to the U.K. and going back to 1961 were examined. Fig. 2 shows three phases in the landings. Before 1968 when multifilament nets were used the catch was relatively low. The introduction of monofilament webbing in 1968 was accompanied by an increase in landings which persisted for four years. The average annual exports from the Company during phase 1 was 9,348 kg and during phase 2, 27,336 kg (a three fold increase). Phase 3 of the graph describes the years succeeding 1971 when the landings have shown a decline. In addition to an annual trend in catches the figures reveal a seasonal pattern. For each of the three phases identified the percentage distribution of landings through each month of the year is set out in Fig. 3, from which it will be clear that although the total catch changed the percentage distribution of landings throughout the year was very similar for each phase. Some mullet were exported in every month but the fishery had a distinct high season from May to September, both inclusive. This area has thus been a summer fishery at least since 1961.

Catch per effort

Mullet gear can be fished in two ways, both of which have been described as fixed engines. The netting for these is identical and interchangeable, but their operation and yield are quite different:

Stake nets: are lengths of meshing 300-400m. long, set from dusk to dawn, into which the fish stray.

Ring nets: are set deliberately round a shoal. Beginning at the seaward side of the fish the net is paid out rapidly, the boat moving in a circle all the while. Once the circle has been closed the boat crosses into it and the crew beat the water with sticks stampeding the fish into the meshes. The two kinds of fishing have particular advantages and make certain demands on the size of the crew and its expertise. In general ringing is the more skilled method and catches taken are thus larger than by stake net.

To examine variation in the catches of Wexford fishermen another source of statistics was consulted. Every fisherman after a day's work puts his catch into cold storage. At the Company each batch of fish is weighed in and a credit docket written before the fish are put in the cold room: the chit is later exchanged by the fishermen for cash. Copies of these credit dockets go back to 1969 and, while they cover a shorter period than the export books, there is for the years between 1969 to 1977 inclusive, a record of all consignments of mullet bought-in by the Company. The interpretation of these figures provided some problems. In all more than 120 fishermen were listed in the Company's records as contributing to the mullet catch. The majority of these men were part-time fishermen and the type of gear they used was at the time of writing uncertain: some fishermen switch from one kind of engine to another, particularly during the later months of the year, so that consideration of all catches would give little indication of yield by a particular engine. A list of the fishermen was therefore compiled and those who had used one or other type of net for the duration of the buying-in books were identified: there are 10 stake netters and 10 ring netters. While these men formed a minority of those fishing they accounted for a very high proportion of the landings (*c* 60%) from Wexford Harbour, being largely full-time fishermen. Further, to minimise any distortion of the figures that might have occurred because of the inclusion of low season landings, the following account is confined to the months of the high season, May to September inclusive.

Daily catches from ring and stake nets differed in mean weight but there was considerable overlap in the percentage weight frequencies of their catches in a season. In Fig. 4 the percentage weight distribution of daily catches from each type of gear is set out. The data came from the 1973 high season returns of 20 fishermen using known gear.

In Fig. 5 the mean high season daily catches of three types of fishermen from 1969 to 1977 are presented: known stake netters, known ring netters and users of all engines. From Fig. 4 it will be obvious that there is considerable variation about these mean values. For the stake net fishermen the standard deviations of the mean values are included. An error is introduced by the fact that a fisherman who caught nothing and therefore did not send any fish to the factory is not included in the calculation of effort. Against this, effort is calculated in the same way for the duration of the records so that relative, if not absolute, changes in the catch per effort should be identifiable.

THE FISH

Observations on the netting mechanism

More than 2,000 grey mullet captured by mullet meshing throughout the 1977 high season, were measured (to the nearest mm), the following being recorded: fork length, girth of the fish at the eyes and at the anterior end of the first dorsal fin. In addition some 15 ring and 9 stake net shots were observed. These yielded 320 fish all but one of which were wedged in a single mesh. The single exception was enmeshed by the lips. Another method of freak capture reported to the writer was entanglement of mullet in the float line.

The mechanism of capture is the same for both kinds of net employed in Wexford; the fish are wedged in the webbing, invariably in a single mesh as described by Baranov (1948). Meshing usually occurs in the region of the gills but the meshing zone is not confined to the gill area but commences at the eyes and extends back to the anterior end of the first dorsal fin. Regressions of girth at the centre of the eye and at the anterior end of the first dorsal fin on fork length are shown in Fig. 6. The size of the head can apparently obstruct meshing at a smaller dimension than might be expected. At a fork length of 54cm the girth of the fish at the eyes (read from Fig. 6) exceeds the mesh perimeter. Only 0.5% of the fish captured by net were longer than 47cm. Moderately large head dimensions therefore discourage meshing.

Length frequencies of the catch are shown in Fig. 7. The bulked sample comprises 12 sub-samples each containing a minimum of 108 and a maximum of 284 individuals. A sub-sample consisted either of a large ring net catch (which may, however, be an accumulation of fish from several ring shots) or smaller consignments from stake and ring nets delivered to the factory over brief periods (one or two days). In Fig. 7 the mean percentage length frequencies of the sub-samples are also set out, the vertical bars being a coefficient of variation (standard deviation/mean) expressed in an arbitrary but standard way (i.e. its scale is not the same as that of the distribution curve). As examples the coefficient of variation for the 38cm fork length fish is 0.34, and for fish of 50cm is 2.34.

The curve in Fig. 7 is a fairly smooth, unimodal distribution, with arms descending to zero. The mode is clearly recognisable and consistent for the two arrangements of the data. The mean point at 38cm coincides with it. As Fig. 7 demonstrates, there is a clear modal point in the catch curve, obvious in both arrangements of the data. Furthermore, variations in the composition of the sub-samples is least in the vicinity of the peak, increasing greatly as the arms of the curve descend.

BIOLOGICAL CHARACTERISTICS OF THE CATCH

Materials and Methods

From June to September of the 1977 fishing high season samples of the mullet catch were examined and a number of biological data recorded. As far as possible the fish were handled immediately after landing and each sample batch was a unit of effort by one crew (as defined earlier).

The fish were aged by reference to otoliths and scales. Scale formation and the labelling of circuli have been described by Kennedy and Fitzmaurice (1969) whose observations were used to interpret the otoliths. A number of structures have been used to age mullet, fin rays and opercular bones in addition to scales and otoliths. Otoliths can be difficult to work with and in this instance were found to be too brittle for the Christensen method (1964) of burning. Kennedy and Fitzmaurice (1969) used the entire otolith, identifying the growth rings by judicious manipulation of light. In this study the otoliths were broken across the nucleus, smeared with terpineol and set in plasticine. By directing a light beam at the otolith (at right angles to the line of observation) the dark and light bands were easily visible (Gambell & Messtorff, 1964).

Ovaries were stored in Gilson's fluid when the catches were censused. Small sections were removed from the central part of the organs (the extremities were avoided to minimise distortion) and gently macerated in glycerol after which approximately 25 of the oocytes from each ovary were measured by micrometer eyepiece. In addition, the diameter the largest oocyte in the section was recorded.

Age and growth

The age composition of the Wexford catches throughout the high season is shown in Table 1. The predicted composition of the catch is derived by estimating the percentage age composition of the curve in Fig. 7 on the basis of the mean length at age data assembled by Kennedy and Fitzmaurice (1969). The observed and expected catch compositions are closely alike but there were more younger fish in the Wexford samples than would have been considered catchable from the length at age data of Kennedy and Fitzmaurice. Length at age measurements for the Wexford fish are set out in Fig. 8 together with Kennedy and Fitzmaurice's (1969) calculations for the species.

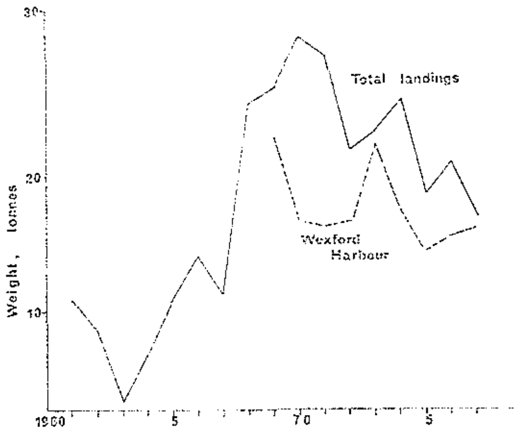

Figure 2. Mullet exports from Wexford since 1961, and the catch originating in Wexford Harbour during the high season since 1969 (from buying in figures).

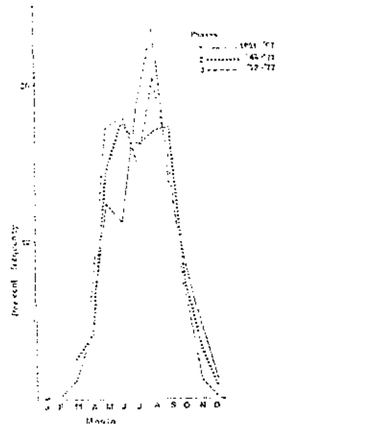

Figure 3. Percentage frequency distribution of the catch throughout the year during the three phases of the fishery.

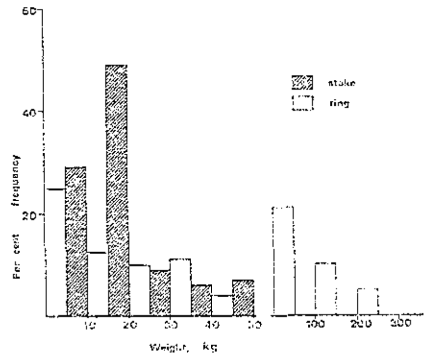

Figure 4. Percentage frequency distribution of daily catch weights from stake and ring nets during high season, 1973.

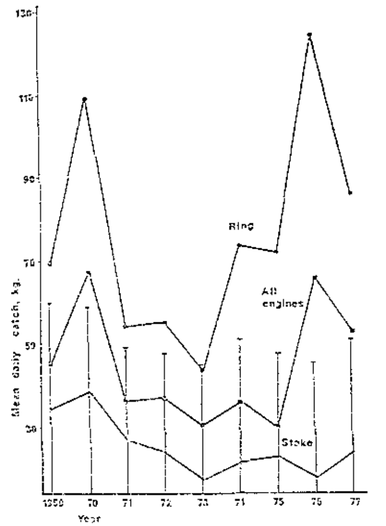

Figure 5. Mean daily catch by operators of ring nets, stake nets and all engines, high seasons 1969-1977 inclusive. The standard deviations of the stake net catches are indicated by the vertical lines.

Table 1. Age composition of high season mullet samples.

Age groups	June	July	Aug.	Sept.	Totals	%	Predicted percentage
4			2	5	13	2.5	0.4
5	2		6	1	3	0.6	—
6	2	5	24	18	49	9.3	1.6
7	5	18	50	34	107	20.3	6.8
8	20	27	30	46	123	23.3	19.7
9	16	29	19	26	90	17.0	24.9
10	14	25	16	18	73	13.8	20.0
11	12	8	8	7	35	6.6	12.5
12	6	9	5	3	23	4.4	6.8
13	3	1		2	6	1.1	5.4
14					—	—	0.6
15	2		1		3	0.6	0.6
16	1				1	0.2	0.7
17					—	—	—
18	1				1	0.2	—
19				1	1	0.2	—
Totals	84	122	161	161	528		
Mean age	9.5	9.0	7.9	8.2		8.5	9.6

Sex ratio and maturation

The sex ratio $\left(\frac{♀♀}{♂♂}\right)$ of the Wexford high season samples varied from 0.9 to 1.0 with a mean value of 0.95 (n=630). Chi-square tests indicated that neither sex was significantly (at 5%) dominant in any of the high season months.

The gonadal cycle was considered very important in the Wexford work but there were a number of difficulties to be overcome in assessing the reproductive status of the fish. Hickling's (1970) account of British mullet reveals that the gonads are smallest during the summer months; in the autumn they expand and spawning takes place from January to April. The most convenient indication of reproductive conditions was the weight of the gonad, expressed as a percentage of the total body weight (gonadosomatic index). Mean values for this parameter in two months, July and September, are shown in Fig. 9. The testes expand more dramatically than the ovaries, a feature also reported by Hickling (1970) and, if this expansion is interpreted as an indication that spawning will commence the following Spring, the 7-year olds would appear to have some spawners.

Data on female maturation presented in Fig. 9 do not show any clear age at which the expansion of the gonads commences. Another technique was employed to clarify the position. Shehadeh, Kuo and Milisen (1973) described an *in vivo* method of interpreting ovarian development in grey mullet (*Mugil cephalus*) in the course of which they gave directions for monitoring ovarian condition. Oocytes of the grey mullet develop in approximate synchrony but there are large extremes in their size in any ovary. When plotted together the log weight of the gonad and the log mean diameter of its oocytes correlate so that the development of the oocytes can be regarded as a factor contributing to the swelling of the ovary, although how important it is in relation to the multiplication of oocytes cannot be stated with certainty. Four correlations, (by geometric mean functional regression, Ricker, 1973), for the four high season months of the fishery, are set out in Fig. 10 and these indicate that some oocyte growth is taking place throughout the summer. However it is in the autumn that the process displays marked development. The correlation coefficient is not significant at the 5% level in June but thereafter for the other three high season months it is highly significant ($P > 0.001$), the level of significance increasing as the sampling period progresses. It is therefore from the September sample that most information is drawn.

Among the smallest gonads all oocytes were fairly uniform in size, averaging less than 0.1mm. Any diameter greater than this was identified as "expanding" and two levels of expansion were recorded: oocytes with a maximum width of greater than 0.1mm but less than 0.2mm and oocytes of greater than 0.2mm. While both are taken to be an indication of spawning their precise relevance to maturation is unknown.

The September sample contained 61 females and the distribution of the largest oocytes among them is recorded in Fig. 11. If the mean age of maturation is interpreted as the average age at which any oocyte expansion occurs it will be 9.5 years; mullet having smaller expanding oocytes average 9.2 years and those with the larger 9.9, so that the three estimates differ from one another by less than a year. At spawning (one winter later) these figures would be 10.2 to 10.9 years. However, if the mean age at maturation is as high as 11 years, then the age at first maturation must be lower.

CONDITION

Correlations (by geometric mean functional regression, Ricker, 1973) were calculated of log weight against log length for the sexes separately and together in each of the high season months. With the exception of the calculation for females in July which was significant at the 0.01 level the value of P of all the other regressions was less than 0.001. The results presented in Table 2 suggest that there is very little variation in the samples, that any change from one month to another is not in the same direction and that there is no consistent difference between the condition of males and females. More probable is the explanation that the netting in question selects for condition just as it does for length (see *Age and Growth* above) and that the results for condition presented here do not truly represent the fish available. Some other information collected in the course of these investigations supports this theory. As remarked in the preceding section (*Sex ratio and maturation*) the expansion of the testes is more dramatic than the growth of the ovaries in mullet and one would therefore expect the condition of males to be higher during the summer. Again, in Table 1, the mean age of the fish examined has been shown to decline during the sampling period (in more detail, males averaged 8.9, 7.9 and 8.0 years of age in July, August and September and females 9.3, 8.2 and 8.8 years in those months).

As there is some evidence of a decline in the age of catch as the season at Wexford progresses it is appropriate to comment on the length of fish captured. Table 3 contains details of the length at age of grey mullet in July and September and the average length of the majority of year classes was shorter at the end of the sampling period. The greatest reduction occurred in fish of probably spawning age.

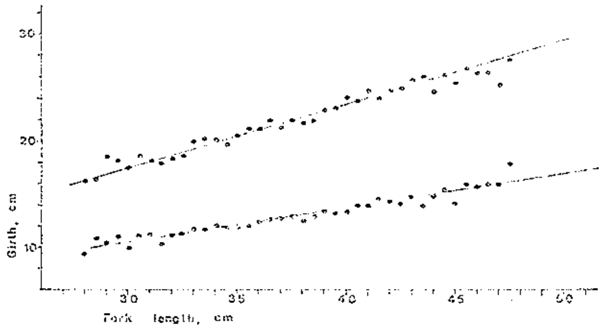

Figure 6. Regressions of the girth of the fish at the anterior end of the first dorsal fin (above) and the girth at the eyes (below) on the fork length. The mesh size is 18.4 cm in the round. The lines are fitted by predictive regression.

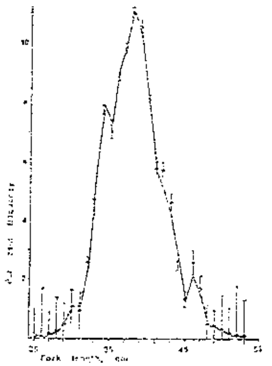

Figure 7. Percentage length frequency of the catch from mullet gear. The thin line is the total catch (N = 2,121) and the dots the average of 12 sub-samples. Vertical lines indicate coefficients of variation (S.D./Mean) on a different scale.

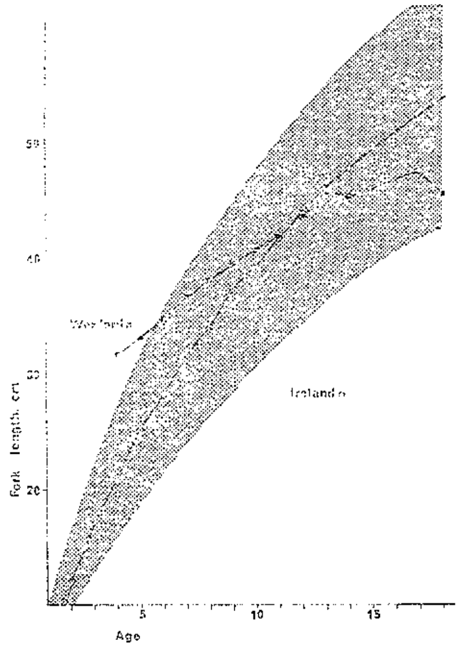

Figure 8. Length at age data for Irish and Wexford mullet. The stippled area represents the limits within which the majority of Irish fish are thought to occur and the central line the mean length at age for these (from Kennedy and Fitzmaurice, 1969). The oblique line illustrates the mean length at age of mullet from the Wexford nets.

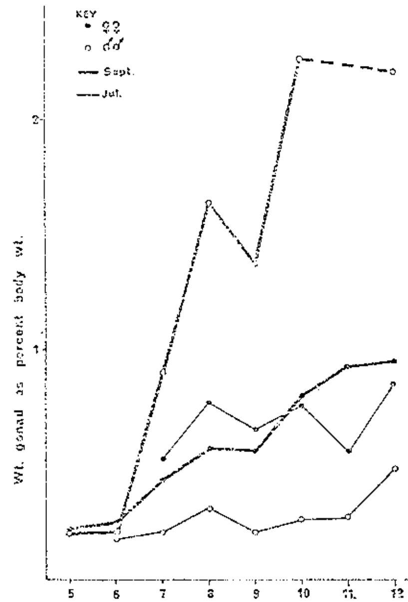

Figure 9. The gonadosomatic index in male and female mullet of different ages in two high season months.

Table 2. Condition of grey mullet in the Wexford fishery—as indicated by the relationship between log weight and log length—during the four high season months:
log wt. (gm) = b log fork length (cm) + a: r = correlation coefficient.

		b	a	r	N
June	Males and Females	3.86	3.26	0.76	107
July	Males	4.47	—4.11	0.58	63
	Females	5.34	—5.49	0.41	46
	Males and Females	4.73	—4.58	0.55	133
August	Males	4.75	—4.53	0.51	45
	Females	4.78	—4.62	0.52	46
	Males and Females	4.23	—3.72	0.57	167
September	Males	3.11	—1.99	0.89	85
	Females	3.07	—1.92	0.83	63
	Males and Females	3.08	—1.94	0.87	165

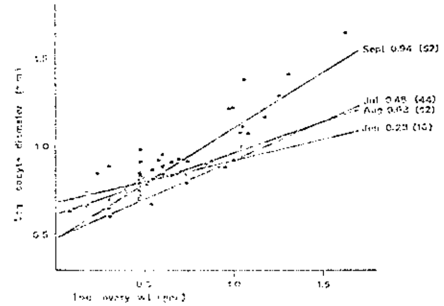

Figure 10. Calculated correlations of log mean oocyte diameter on log weight of the ovary throughout the high fishing season. All the data for September are set out. Correlation coefficients follow each monthly symbol; sample numbers are in brackets.

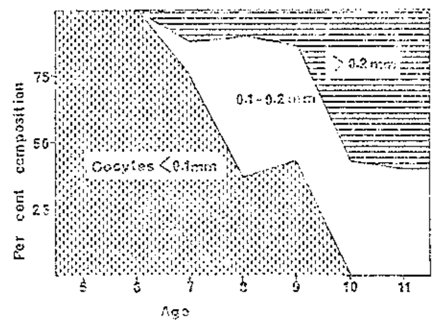

Figure 11. September female mullet sample according to the size of the largest oocyte recorded.

DISCUSSION

Bass (*Dicentrarchus labrax*), widely distributed around the coasts of England, Ireland and Wales, is more abundant in the Celtic Sea (Holden and Williams, 1974) and grey mullet, also more heavily concentrated in the southern parts of Britain (Hickling, 1970) may have a similar distribution pattern. If so, Wexford Harbour is close to the region in which the species would be most heavily concentrated and, being shallow and hence warm and productive during the summer months, provides a suitable environment for a relatively large fishery.

Landings of mullet in the Wexford area have been declining in the 1970s but the downward trend for high season catches in Wexford Harbour has not been steep if indeed there has been any reduction (Fig. 2). The high yield of ring nets is obvious in Fig. 5 but the operation of this type of gear requires a number of environmental conditions such as calm weather and the absence of algal blooms. Successful ring netting also owes much to skill and perseverence, as many as 9 or even 11 shots being made by a crew in a day. In short, ring netting as a unit of effort is not a good indicator of stock abundance. Stake nets on the other hand are passive engines, of particular dimensions, set for a certain period and hence this method of capture is regarded as a better indicator of the abundance of the fish. Catch per effort for stake nets (Fig. 5) showed initially a decline in mean value although the wide standard deviations indicate that there is no significant difference in the mean daily catch in any recent year.

The indication must therefore be that stocks are not displaying signs of depletion and that ring netters, perhaps for environmental reasons, have become more successful in recent years. Effort has also fluctuated considerably: in the high season of 1976 for example only 235 journeys to factory were made as against 637 in the high season of 1973 so that the lower catches of recent times probably owe as much to a decline in fishing effort as to a reduction in stock size. The effect of the introduction of monofilament webbing, apart from dramatically increasing the catch (Fig. 2) is unlikely to have had other consequences, such as on the dimensions of fish selected. Several authors refer to the increase in catch of fish, under most environmental conditions, resulting from a change to synthetic netting. Molin (1952) maintained that a change in material could alter the length distribution of the catch but that is contradicted by the observations of other workers (Ridenhour and diConstanzo, 1956; Hewson, 1951; Scidmore and Scheftel, 1958 and McCombie and Fry, 1960) who have demonstrated that although the use of manmade fibres greatly increases a catch, the length frequency of the catch remains unchanged.

The biology of grey mullet at Wexford displays close similarity with the species in other British and Irish studies but the method of capture of the fish complicates interpretation of the information. This is particularly true of the growth rate.

Several accounts of growth rate are available for comparison in Hickling (1970). Where feasible these have been subjected to Walford plot and two of the resulting parameters, the L_∞ and K values are arranged in Table 3. From this it will be seen that there is good agreement between the several assessments of the growth of *Chelon labrosus* in Britain and Ireland: Hickling's (1970) estimate from his work with opercular structures is fairly similar to Kennedy and Fitzmaurice's results (1969). Material collected during the present investigation corresponded closely with growth data for certain age-groups of Irish mullet. For example Kennedy and Fitzmaurice (1969) gave mean lengths of mullet captured in various kinds of gear at 11-13 years as 42.0, 44.0 and 46.2cm respectively, compared with 41.9, 43.8 and 45.9cm in the Wexford fish. Thus, it can be said that Wexford mullet achieve the same length at age for these three ages as other Irish fish. Wexford fish of younger than 11 years apparently exceed the national mean length and those fish of greater than 13 years do not attain the average lengths. The data are presented in Fig. 8. One explanation for these readings is selection by the nets. Mullet are distributed within wide extremes in length at any age and the size distribution in the catch may simply demonstrate the selection pattern of the gear. The interaction of fish and gear in Wexford is shown in Fig. 7. Catch curves of the kind shown in Fig. 7 obtain their shape from the interplay of two factors, the selective characteristics of the net and the availability of fish of certain dimensions. Because nothing is known of the structure of the mullet population in Wexford Harbour and the catch from only one mesh size has been observed, Fig. 7 cannot be interpreted as a true mesh selection curve. Regier and Robson (1966) proposed three methods of estimating gill net selectivity but all require either a knowledge of the population structures of the fish or catch data from several nets of different mesh sizes. In spite of these limitations certain conclusions can be drawn for Fig. 7. At 38cm the modal point corresponds with the length of fish at 9-10 years (on Kennedy and Fitzmaurice's figures) and the 8 year olds at Wexford (Fig. 8).

Table 3. Growth characteristics of grey mullet populations. Hickling and Kennedy and Fitzmaurice's data are for *Chelon labrosus;* Erman and Morovic's data refer to *Mugil cephalus* L.

Author		Place	L_∞ (cm)	K
Hickling (1970)—scales	...	England	52.0	0.248
Hickling (1970)—opercular bones	...	England	62.5	0.142
Kennedy and Fitzmaurice (1969)	...	Ireland	63.0 (total length)	0.116
Kennedy and Fitzmaurice (1969)	...	Ireland	61.5 (fork length)	0.119
Erman (1959)	...	Mediterranean	82.5	0.113
Morovic (1963)	...	Mediterranean	101.5	0.106

The figures showing the composition of the catch in Table 1 are used to further clarify the selection of the catch by the nets. First, a series of population structures were established on the basis of coefficients of Total Mortality (Z) 0.05 to 0.45. Relatively low values for the C.T.M.s were used for the reasons given by Gulland (1969) that a species which has a low value of K is likely to have a low natural mortality. In each structure the various age groups were expressed as percentages. Next, taking the observed percentage catch

in Table 1 and assuming that it remained constant, the selection curves in Fig. 12 were generated. The most heavily exploited age groups are the 7 to 10 year olds. If the lower values of C.T.M. obtain the greatest pressure is on the 8 year olds whereas if the C.T.M. is high the 10 year old fish are the most heavily exploited.

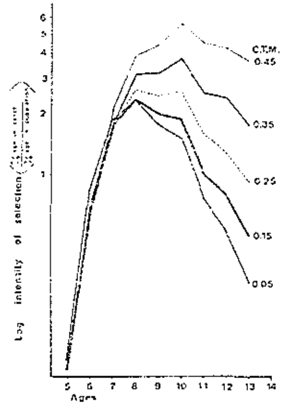

Figure 12. Gill net selection curves, generated from the known composition of the catches at Wexford (Table 1) and a series of assumed Coefficients of Total Mortality.

Some of Baranov's earlier observations (as discussed by McCombie and Fry, 1960) are relevant to the interpretation of data on selectivity. Baranov first observed the relationship:

$$\Phi = KLm$$

where Φ is the bar measure $(\frac{\text{perimeter}}{4})$ of the mesh, Lm the modal length of the fish taken and K a constant. For mullet a K value of 0.121 is in general agreement with readings obtained elsewhere for fish of similar shape (see McCombie and Fry, 1960).

Mullet mesh in the same way as other species of simple shape and another observation of Barazov's is apposite: fish mesh in maximum numbers when their girth exceeds the mesh perimeter by 25%. For mullet the modal point at 38cm can be related to an average girth of 22.4cm (Fig. 6) which is 21.7% greater than the mesh size.

Any species which improves in condition during a fishing season can, even if under-sized at the beginning, become vulnerable to capture by gill net as the body increases in girth. Farran (1936) demonstrated that the catching power of a herring net is dependent on the condition of the fish as well as on their length. Kennedy and Fitzmaurice (1969) described mullet as extremely variable in shape, due to the large size of the gonads, and Hickling (1970), to obviate error from this source, estimated the weight of fish without gut or gonads. With the expansion of the gonads during the summer mullet increase in girth and some of the smaller individuals become more vulnerable to capture. Thus the mean age of the catch decreases (Table 1) and the mean length of those year classes that are retained falls (Table 4) as the season progresses. Those numbers of the younger year classes which are preferentially retained by the nets are more likely to be maturing individuals. This fact emerges from a consideration of the likely age at which maturation takes place.

Table 4. Change in length (cm) of net caught mullet of different age groups between July and September. Sample numbers in brackets.

	Age							
	6	7	8	9	10	11	12	13
Females								
Mean length in July		37.2 (5)	38.1 (10)	38.7 (12)	40.9 (8)	40.9 (4)	42.3 (4)	37.2 (1)
Mean length in September		36.8 (8)	37.0 (20)	38.4 (8)	41.8 (8)	39.7 (5)	38.8 (2)	46.8 (1)
% change		−1.2	−2.8	−0.8	+0.2	3.5	−8.5	+25.8
Males								
Mean length in July	34.2 (4)	36.5 (9)	39.4 (11)	40.6 (13)	41.0 (12)	46.6 (2)	41.7 (4)	44.1 (1)
Mean length in September	34.2 (11)	35.5 (26)	38.6 (27)	39.2 (18)	40.0 (8)	37.0 (3)	42.0 (1)	37.9 (1)
% change	—	−0.1	−1.9	−3.5	−2.4	−20.7	+0.7	14.1

Results from Wexford suggest that some fish may be mature at 8 years of age while Kennedy and Fitzmaurice (1969) and Hickling (1970) give 11 years old as more general. Kennedy and Fitzmaurice (1969) described females of 11 and 12 years and 40-42cm long as the youngest mature fish they encountered and, once more, it is appropriate to refer to the large fish of the younger age-classes taken by gill net as the reason for the low mean age at maturation in the Wexford samples. Indeed when mean oocyte diameter was correlated with the age, length and weight of these fish the correlation coefficient was highest for the last characteristic (age, 0.388; length, 0.676; weight, 0.707 $P < 0.001$). Kennedy and Fitzmaurice (1969) found their smallest mature male to be 38.8cm (total length) and Hickling (1970) reported the smallest he encountered to be 35cm. Those individuals showed that maturation of males occurred at the age of 9 years; the 7 years olds in Wexford (8 at spawning) had a mean fork length of 36.8cm (Fig. 8). (As total length is approximately 1.10 times the fork length the length at which maturation occurs in Wexford is in close agreement with findings elsewhere).

In conclusion, current fishing effort at Wexford is not having a demonstrably adverse effect on mullet stocks there. However the Wexford fishery is for several reasons unusual in the Irish context: in size it is exceptionally large while its proximity to the likely heavy concentration of the species in the Celtic Sea might mean, should the fish migrate in a westerly direction, that Wexford is adequately stocked even when fisheries further west are not. It should not therefore be assumed that other small and more isolated fisheries for mullet could, over the longer term, bear exploitation by similar methods or indeed that the Wexford stocks would sustain greater fishing effort.

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