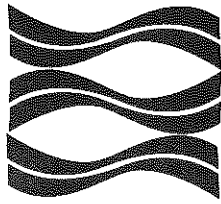


SERIES B (Marine) No. 35

1990



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INVESTIGATIONS**

Edward Fahy and Paul Gleeson

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The post-peak-yield gill-net fishery for spurdog *Squalus acanthias* L. in Western Ireland

BY

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ABSTRACT

A gill net fishery, directed on Spurdog, expanded rapidly on the western coast of Ireland in the 1980s and quickly collapsed, the fishermen moving offshore in pursuit of smaller individuals. Catch per effort and landing data in the gill net fishery are used to estimate the size of the mature and maturing component of the south western "stock" which is within a range of 3,700 tonnes (landed) and 5,700 (calculated). An appraisal of the post-peak-yield landings reveals that the average individual weight declined from those of peak landings, in males by 9.5% and females 32.0%, and the percentage of females in them declined from 75 to 19%. The majority of the later catches were immatures whereas the peak-yield catches were mainly mature and maturing females. The average age of females was reduced from 19 to 16 years — 18 to 17 years in the case of males — and later captures were a shorter length at age. The fate of the depleted stock is not known and the possibility of its locus having moved elsewhere cannot be discounted.

INTRODUCTION

The Irish Fishery for spurdog expanded rapidly in the early 1980s, initially in Co. Donegal and then, following a sharp reduction in catches there in 1986, in southwest Ireland the following year (Fig 1). An investigation of the southwest fishery in 1987 and early 1988 which incorporated a catch curve, and data on the age, growth rate and fecundity of the female broodstock, concluded that the species was under heavy fishing pressure (Fahy, 1988; 1989). The trend in landings of the earlier developing Donegal fishery is shown in Fig 1; the southwest fishery, to which the Donegal vessels subsequently turned their attention, is known to have reached a peak in 1987 and to have subsequently declined, presumably by much the same order.

The northern part of the southwest spurdog fishery is fished from Carrigaholt (on the line separating ICES areas VIIb and VIIj). The West Clare Co-operative was founded on the spurdog fishery whose progress is documented in sales records, abstracted to provide an account of the fishery between January 1987 and January 1989 (Fig 2).

The purpose of this account is twofold: to estimate the size of the exploited mature and maturing component of the stock in the southwest fishery from catch effort and landings data, and to describe the characteristics of the landings.

The Carrigaholt fishery

The spurdog fishery in Carrigaholt is conducted using gill nets. Although the standard 5 inch (12.7 cm, 2 bar) monofilament mesh is used throughout the year, a proportion of the vessels based there change to other gear during the summer months, either because spurdogs are less abundant at that time or because other species become temporarily more attractive. The Carrigaholt landings, in common with those from gill nets in other parts of the south-west, are characterised by a large component of pregnant females (Fahy, 1988; 1989) and it has been supposed that these fish move into the vicinity during the autumn and winter months.

The expansion of the Carrigaholt fishery has been accompanied by an increase in the quantity of gillnet used: specifically, by the entry into the fishery of some larger vessels capable of carrying greater lengths of meshing. The diagram showing the mean length of gill net per trip (Fig 2) is an indication of the rate of expansion of fishing effort, the majority of boats fishing at the same time; the occasional reduction in effort taking place when some of the larger vessels move to other grounds. Overall, the diagram suggests there has been an increase of 50% fishing ability per vessel and something of that order is proposed by the fishermen themselves.

Catch per effort has fluctuated considerably over the period covered by the data but there has been a marked reduction in the winter c.p.u.e. which went down by something of the order of 80-90% between January 1987 and January 1989. The earlier account of the southwest fishery described the catch at its

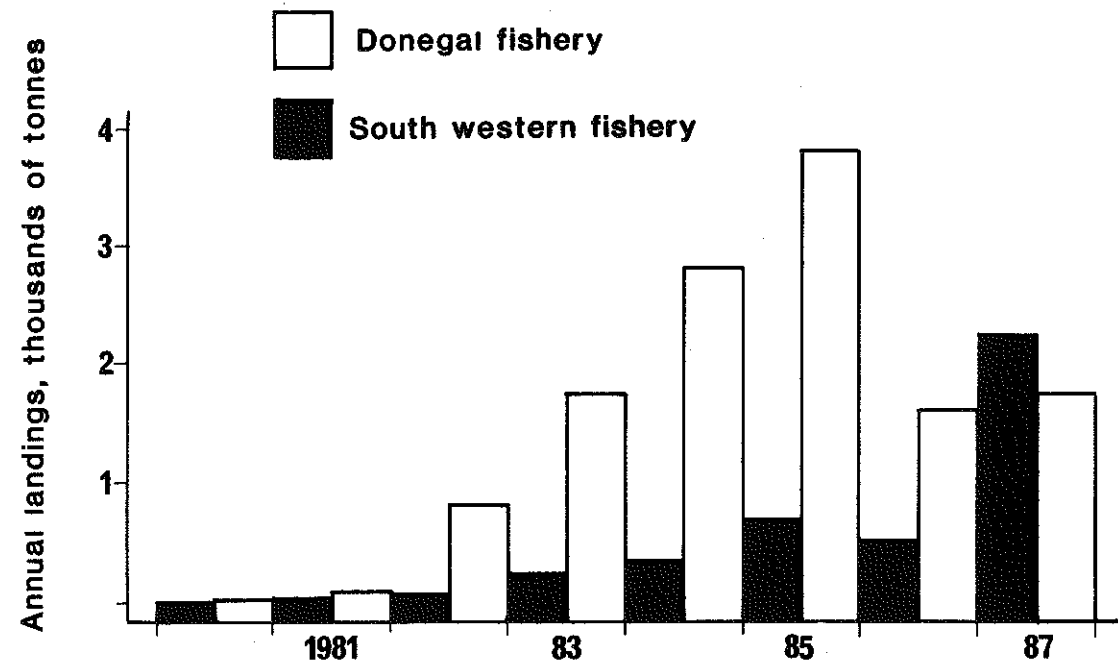


Figure 1 Landings of spurdog from the northwest (Donegal) and southwest fisheries, 1980-1987.

Table 1. Calculation of female spawning stock biomass in the southwestern spurdog fishery

Year(s)	Month	Catch (tonnes) by gillnet	Percentage mature + maturing female	Tonnage mature + maturing female	Cumulative tonnage mature + maturing female	Catch/unit effort at Carrigaholt (kg/100m gillnet)
1980-1986	—	1675	75	1256	1256	—
1987	January	61	70	43	1299	40
	February	51	70	36	1334	35
	March	61	70	43	1377	50
	April	275	70	193	1570	36
	May	63	70	44	1614	8
	June	38	70	27	1640	13
	July	9	70	6	1647	8
	August	87	70	61	1708	16
	September	504	70	353	2060	16
	October	526	70	368	2429	18
	November	470	70	329	2758	12
	December	329	70	230	2988	37
1988	January	64	70	45	3033	36
	February	159	70	111	3144	30
	March	168	70	118	3262	22
	April	278	70	195	3456	14
	May	83	62	51	3508	18
	June	68	54	37	3544	7
	July	80	45	36	3580	3
	August	82	37	30	3611	7
	September	55	30	17	3627	9
	October	124	22	27	3654	10
	November	99	13	13	3667	9
	December	114	5	6	3673	17

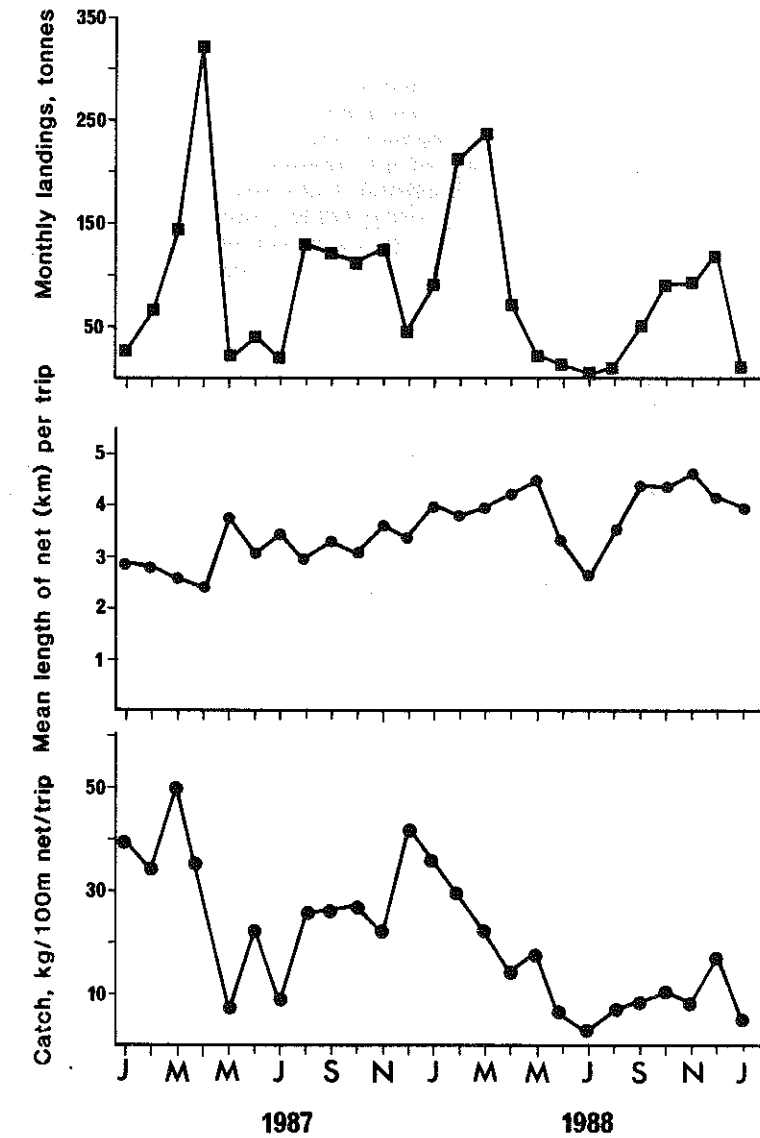


Figure 2 Spurdog landings, length of net fished per vessel and catch per unit effort, in the Carrigaholt fishery, monthly, January 1987 to January 1989.

inception; what follows is an account of the landings after heavy gill-netting. Following the depletion in inshore concentrations of large pregnant females in 1988, the Carrigaholt vessels moved offshore to exploit spurdogs in deeper water, periodically ascertaining the state of the fishery close inshore. Samples from the landings from Burtonport, in Co Donegal, whose fishery declined before pressure on the southwest spurdog fishery increased, are included in the appraisal.

Biomass of the mature and maturing female component of the southwest fishery

Whether the fish exploited by the southwest fishery constitute a separate stock or belong to a much larger complex remains open. However, the working hypothesis assumed that the southwest fishery is a separate stock. Efforts to estimate the size of its maturing and mature female component are made using the technique of Seber and Le Cren (1967): regressing the monthly catch per effort at the Carrigaholt fishery (taken to be representative of the entire southwest fishery) on the sum of previous catches (estimated, taken by gill net) from the entire southwest region and extrapolating to the horizontal axis the line best fitting the points.

The data used are set out in Table 1. From the first records of the fishery until December 1987, approximately 2500 tonnes of dogfish were landed. This figure must be an understatement because an unquantifiable tonnage of this species had always been taken as a by-catch of other methods but, because those fish were not sold, they were not recorded either. Of the 2500 tonnes, 67% approximately were gill

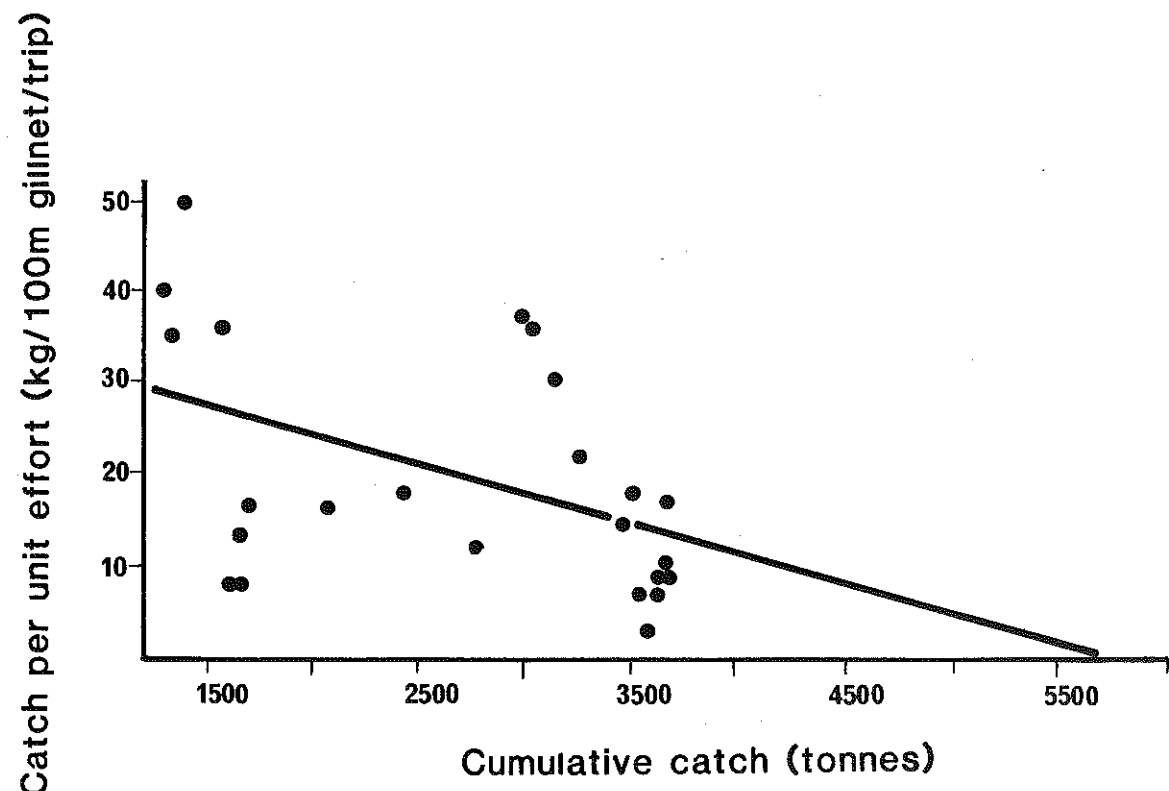


Figure 3 Regression of catch per effort at Carrigaholt on cumulative catch in the southwest spurdog fishery (N = 22; d.f. = 20; r = -0.4657; intercept = 37.10; slope = -0.0065; P < 0.025).

netted and about 75% of these were mature and maturing females with an average weight of 2.2 kg, the remainder were males with an average weight of 1.5 kg. In total then 1256 tonnes of mature and maturing females would have been taken by this method (Fahy, 1989).

From January to December 1987, the percentage of the catch taken by drift nets increased and an estimated 70% of that weight was accounted for by mature and maturing females. Exactly what occurred after this is not certain as sampling was discontinued; there was however a decline in the representation of females which may have come about very suddenly. For computational purposes, a gradual (linear) decline from January 1988 is assumed. The estimate of total female "spawning" biomass, at 5700 tonnes is therefore an optimistic one (Fig 3).

The small size of this stock, together with the comparatively high rate of capture, emphasises the vulnerability of the local fishery.

MATERIALS AND METHODS

Because of the reduced state of spurdog stocks, material from a wide area was amalgamated in the assessment of the post-peak yield fishery. All of the sampled material came from gill nets.

The census of the landings was carried out along the lines of the earlier investigation (Fahy, 1988; 1989), fish being examined opportunistically. When time permitted spines were removed for ageing; an effort was made to repeat estimates of fecundity but insufficient mature females were encountered.

Sampling commenced in August 1988 and continued until the end of February 1989. The following samples were collected:

Landing places	Dates	No. fish sampled
Burtonport, Killybegs	16 August 1988 to 2 February 1989	1424
Dingle	1 — 3 September 1988	33
Carrigaholt	3 November 1988	528
Total		1985

Ageing

The majority of the ages were determined by Gleeson but 10% of spines were read by both authors, the outcome of the dual reader exercise being summarised in Table 2.

As in a previous exercise of this kind, there was little unanimity between readers on the ages of specific spines; Gleeson tended to over-estimate the younger ages and under-estimate the older, relative to Fahy. Overall, there was good agreement between the two, the cumulative age totals within the range of 9 to 22 years inclusive being 217.0 (Fahy) and 213.4 (Gleeson).

Spurdogs are aged on the banding of the spines, an annual phenomenon. As the fish grow however the spines erode, chip and occasionally break. Enamel wears off. Ageing the oldest fish involves assumptions about the degree of loss. Holden and Meadows (1962) attempted to ascertain rates of erosion and thus, by regressing corrected spine length on body length, to estimate loss as the fish grew.

In the course of investigating the southwest Ireland fishery Fahy (1988; 1989) used only readings from undamaged or mildly eroded spines. The ages of fish bearing the latter were estimated by placing them alongside spines of young fish of the same sex from the same sample to "restore" the eroded portion.

Ketchen (1975) addressed the question in Pacific spurdogs by regressing the ages of a series of easily read spines on the dimension of the structure at the base (i.e. at the limit of the enamel). The technique would permit a spine which had been broken off low down to be aged and the missing years of a structure which had sustained tip damage to be reassembled. Spurdogs display highly variable growth rates however and the regression technique provides a limited interpretation of a particular spine dimension. Further, the reading of older spines is, to some extent based on circular premises, there being no objective means of establishing ages.

The following observations were made to examine the application of Ketchen's principles to the southwest Ireland fishery.

The posterior spine was interpreted using the convention

$$x + y = \text{Total Age}$$

where x was the observed number of annual phenomena (rings, bands, notches on the trailing edge of the spine) and y the number estimated on spines which were not seriously worn or broken (i.e. the spines of young fish placed alongside those of older specimens).

Using the approach of Ketchen (1975) regressions of age on spine base "diameter" (as defined by him) were prepared. The observed ages which were selected for computation were for spines which had been read by the two workers whose readings were within ±2 years; the additional estimated ages were those of one (E.F.) only.

Table 2: Summary of a dual reader exercise to standardise interpretations of spurdog spines: Reader 1 was E. Fahy, Reader 2 P. Gleeson

Number of spines read	Age determined by Reader 1	Percentage of readings coinciding exactly	Mean ages of spines Reader 2
3	9	33	10.0
7	10	14	10.7
12	11	8	13.5
25	12	36	11.8
16	13	31	13.9
20	14	25	14.6
19	15	11	16.1
18	16	11	17.1
18	17	0	16.8
25	18	8	16.4
13	19	0	16.1
13	20	15	18.2
7	21	0	18.2
9	22	0	20.0
Total 205			
Cumulative age		217.0	213.4

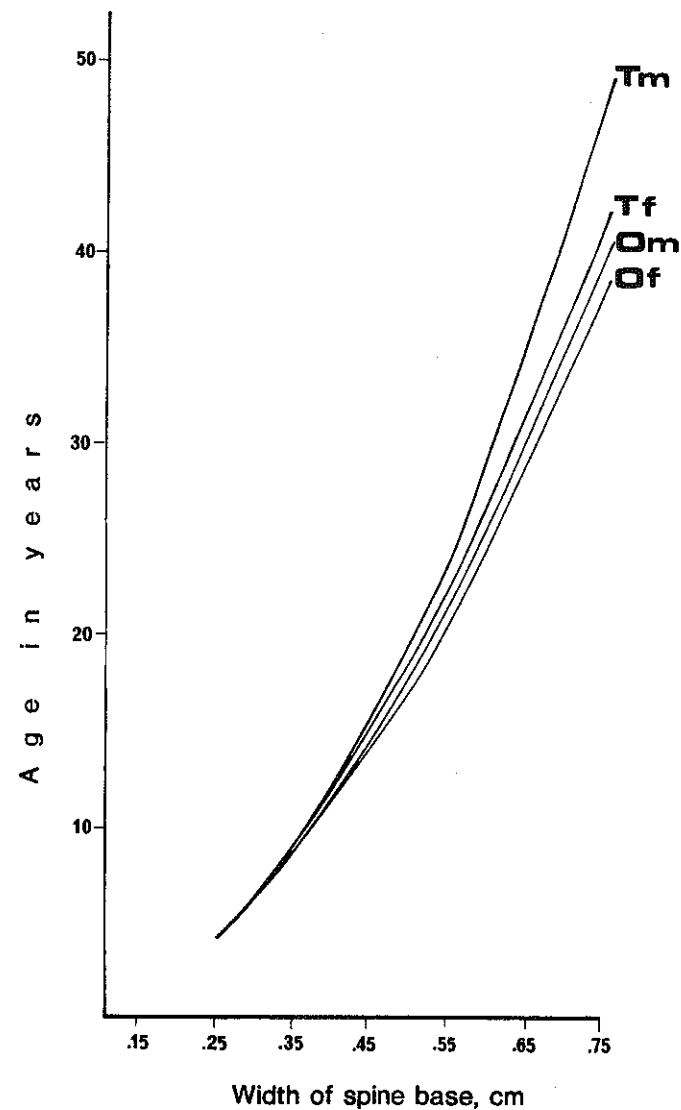


Figure 4 Variation in the width of the posterior dorsal spine of south western spurdogs with age: O = observed; T = total; m = male; f = female.

There is considerable variation in spine width at any age. The regressions are summarised in tabular form below and in Fig 4. Spine widths are given in cm; the regressions are geometric mean functional (Ricker, 1973).

	Females		Males	
	Observed	Total	Observed	Total
Degrees of freedom		120		125
a (functional)	1.8349	1.8963	1.8582	1.9710
b (functional)	1.9649	2.0972	1.9869	2.2361
r	0.8042	0.8283	0.6468	0.6588

The four regressions are set out in arithmetic form in Fig 4 which suggests that, up to age 14, there is very little erosion, minimum and maximum values differing by approximately 1 year. The effects of spine erosion become progressively more marked as the fish age, and more pronounced in the males.

While these regressions provide a base for estimating the age of fish whose spines have been seriously damaged, it should be remembered that the actual readings of age are very variable and that the regressions provide an approximate age only. Spine base diameters for the southwest Ireland fishery would appear to be slightly larger (by about 11%) at a particular age than those of Pacific spurdogs from Hecate Strait. Compared with dogfish from the Strait of Georgia (Ketchen, 1975) the spine base of the southwest Ireland material was even larger, by between 15% at 10 years and 40% at 25.

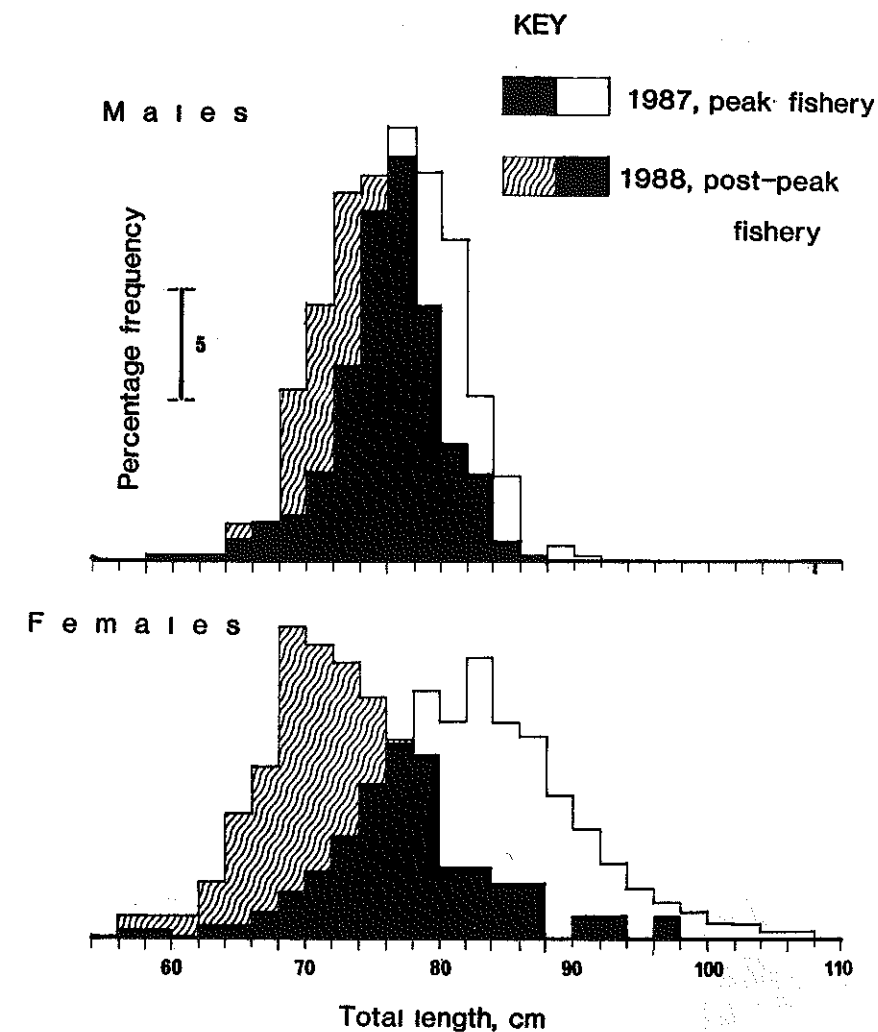


Figure 5 Length frequency distributions of male and female spurdog from the landings of the peak and post-peak gill net fisheries.

RESULTS

Characteristics of the samples

Length frequency distributions of males and females from the peak and post-peak fisheries are set out in Fig 5 from which the reduction in size of individuals will be obvious. In the peak fishery males averaged 1.48 kg, post-peak 1.34 kg, a fall of 9.5%. Females however declined from 2.17 to 1.47 kg, a fall of 32.3%.

The distribution of the sexes among the samples at the various collecting places was as follows:

	Males	Females	% Female
Burtonport	1177	247	
Carrigaholt	10	23	
Dingle	429	99	
Totals	1616	369	18.6

Comparison with assessment of 1987/88

74.7

Age distribution

Amalgamating all material, the ages of the spurdogs sampled in the latter part of 1988 and compared with fish examined during the previous year in the southwest fishery were as follows:

Sex (year)	Number	Mean	Std dev
Female (1987)	1321	19.1	4.67
(1988)	342	15.8	3.88
Male (1987)	315	18.4	5.83
(1988)	1607	17.3	3.74

Comparison of the samples between years had the following outcome: for females $P < 0.001$ ($t = 15.499$; d.f. = 1661); for males $0.001 < P < 0.005$ ($t = 3.22$; d.f. = 1605).

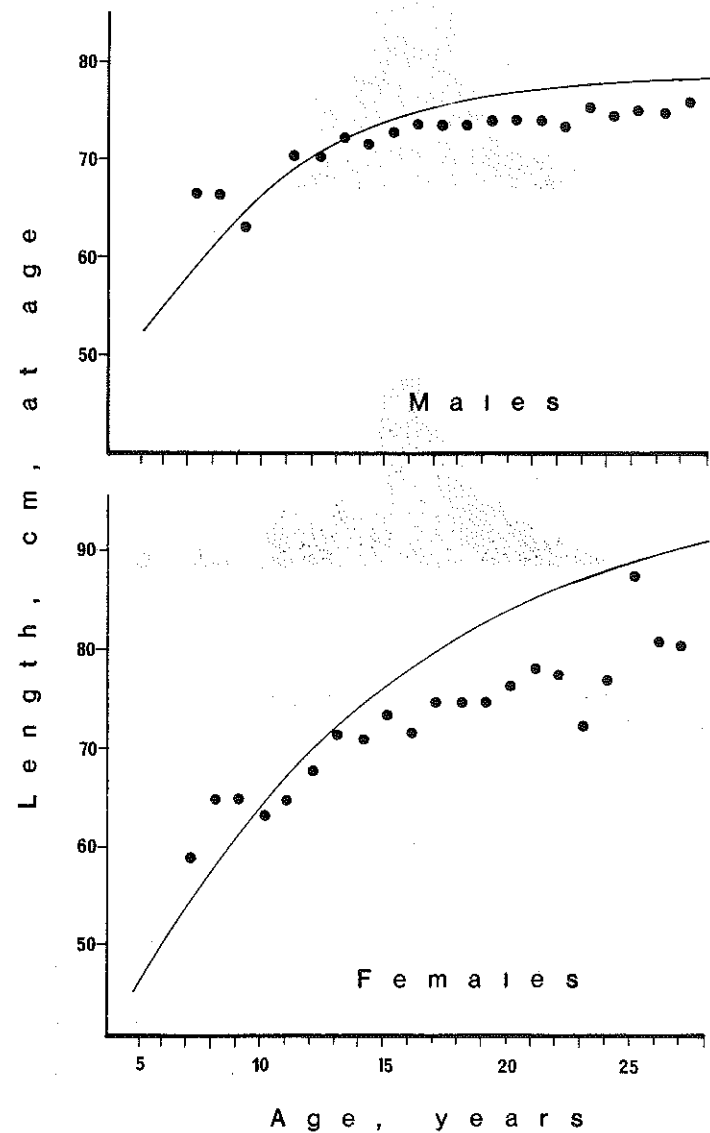


Figure 6 Growth data for spurdogs in landings from the southwest post-peak fishery; growth curves from the peak fishery are included for comparison.

Length at age

Length at age data for the fish landed in late 1988 are set out in Fig 6 together with calculated growth curves devised from data collected in 1987/1988. There is a great variation in length at age of spurdogs and some characteristics of what appeared to be a distinctive growth curve were calculated for the later data:

Sex (year)	P (Walford Plot)	L-inf	K	t ₀
Males (1987)		79.9	0.16	-1.69
Males (1988)	0.8906	75.5	0.15	
Females (1987)		98.8	0.09	-1.57
Females (1988)	0.8115	76.9	0.28	

Noteworthy is the fact that Linf in the later Ford Walford plots is considerably less than in the earlier appraisal. Attempts to proceed further with the calculation of growth curves on the later data were not fruitful.

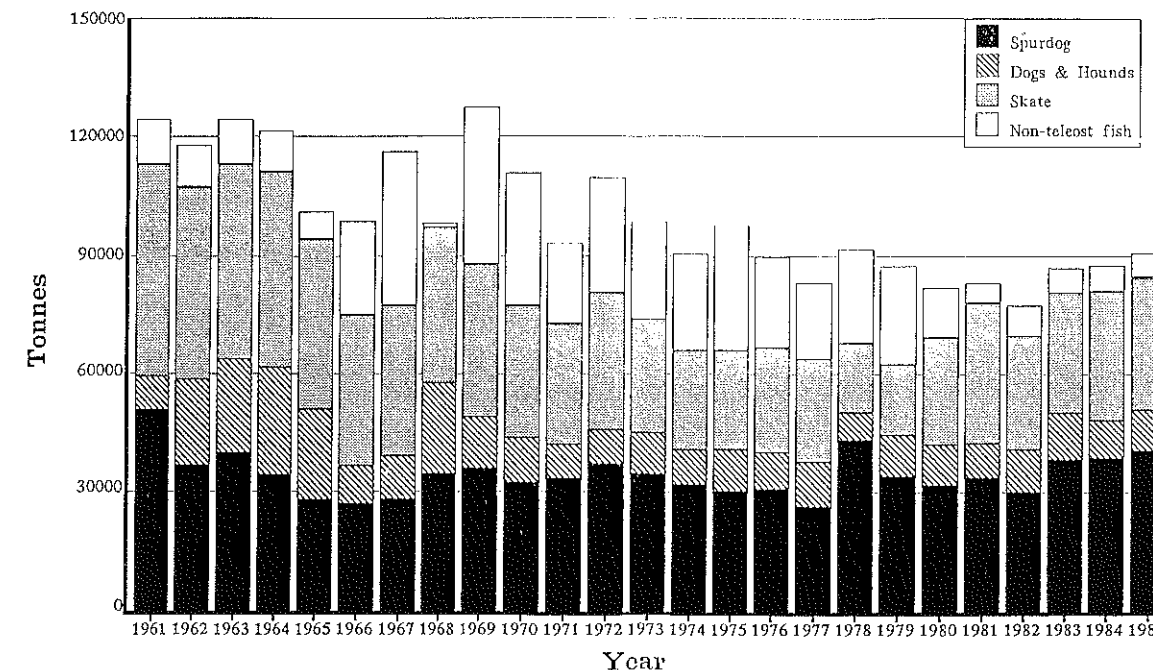


Figure 7 Elasmobranch landings in the northeast Atlantic as reported by ICES, 1961-1985 (Figure prepared by J. Gauld, DAFS, Aberdeen).

DISCUSSION

The most obvious change in the Carrigaholt fishery between January 1987 and January 1989, was the reduction in catch per unit effort which fell by 80-90%. This could be explained as exhausting the numbers of gravid females which, in the samples taken in 1987-1988, accounted for 80% of gill net landings by weight and by partially depleting the numbers of males. However an explanation of the characteristics of the later catches is required: while the age distributions of males in the two samples were very close, though significantly different, the samples of females, which also differed significantly, had a greater difference in their mean ages.

The lengths at age in the two samples also differed. It has been noted that, although they appeared to have distinctive growth characteristics, the spurdogs of southwest Ireland, have growth curves which are almost identical with fish from the North Sea (Fahy, 1988; 1989; Holden and Meadows, 1962). The growth curves suggested by the later data — but not pursued because of unsatisfactory Ford-Walford plots — comprised lengths at age which are within the range of the 1987-1988 data.

An explanation for the change in age and growth characteristics of the samples of the western fish is that different sectors of the population were exploited and, in at least some parts of the coast, fishermen moved ground, as far as 30 km offshore. The association of spurdogs of different sex, maturation and size with waters of various depths has been noted (Hickling, 1930; Fahy, 1989). Maturation is associated with both size and age and males and immature females tend to occur at greater depths than aggregations of gravid females close inshore. Hence, it would appear that the spurdogs exploited in the post-peak fishery are the more dispersed and more inaccessible shoals of males and immature females.

It might be deduced from this that local aggregations of mature females have been depleted. However, the stock divisions of spurdogs along the western seaboard are not understood and that point is crucial to interpreting these results. Spurdog in the northeast Atlantic have been described as belonging to several stocks (Holden, 1965) or just one (Aasen, 1964) having complex seasonal and maturational migrations (Gauld and MacDonald, 1982, Hjertenes, 1980, Vince, undated). Ketchen (1986) observed of Pacific spurdogs that although some individuals made extensive migrations the fishable stocks appeared to move only short distances with changes in water temperature. On the other hand, Wood, Ketchen and Beamish (1979) reported that an increase in spurdog numbers off the Canadian coast in the 1950s might have resulted from an immigration from less exploited populations. C.p.u.e. data, which might provide indications of the movements of a locus — or loci — of population in the northeast Atlantic, are not available but fisheries for spurdog there have been known to periodically collapse in places and, simultaneously, to develop elsewhere. The collection of landings data on this species has not been consistent but, overall, the yield from spurdog fisheries in the northeast Atlantic is probably reasonably represented in Fig 7 which suggests it has remained stable over the period 1961–1985.

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