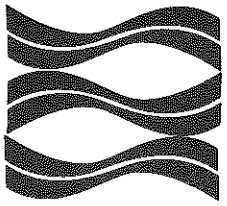
SERIES B (MARINE) No. 37 1991



IRISH FISHERIES INVESTIGATIONS

Edward Fahy

The south eastern ray *Raja* spp. fishery, with observations on the growth of rays in Irish waters and their commercial grading.

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Roinn na Mara

(Department of the Marine)

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by
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ABSTRACT

Five species contribute to the landings of the south eastern ray fishery, *Raja microocellata* being additional to the four more generally encountered in the Irish Sea. Fishing logs from 17 vessels were examined; they described more than 26,000 hours of fishing effort, most of it in division VIIg. Auction records contained a higher than expected proportion of small grades. The fishery is assessed as being more heavily exploited than the ray fisheries of division VIIa.

As far as possible, growth curves of rays in Irish waters were calculated on the fully recruited age groups. Values for L_{∞} were greater for females than males of all species; those for *R. montagui* and *R. naevus* are less than in other published accounts. Values of K range between 0.19 and 0.33 while values of t_0 are between –3.009 and +0.49. In general, there is more variability in the values of t_0 than is warranted by life cycles which are basically similar.

Fishermen sort rays primarily on their size and secondarily on their external appearance, certain species having greater values than others. The supply of fish influences the outcome, insufficient quantities requiring that fish which would normally be segregated are bulked. Another influence is the local occurrence of certain species.

Statistical associations among species differ with grade, the smaller growing species rarely gaining access to the larger grades; when they do they are usually associated with species of lesser value.

Rays are probably most effectively sampled by working on size grades within which samples are chosen at random.

GENERAL INTRODUCTION

This paper is a description and assessment of the south eastern ray fishery which includes data on the growth of rays in Irish waters and a statistical assessment of the commercial grading of ray species, both of the latter topics being relevant to the assessment of ray populations.

Part 1, on the south eastern fishery, is based on auction records, fishery logs and a brief examination of ray landings.

Part 2 presents data on the growth of rays in Irish waters; occasional observation on three species, *R. microocellata, R. batis* and *R. fullonica,* the latter for the first time. Data on four common species, *R. clavata, R. brachyura, R. montagui* and *R. naevus,* are sufficient to make separate calculations of growth parameters by sex and by ICES statistical division.

Part 3 concerns the statistical association of ray species within commercially graded landings to Ireland which is examined with the objective of devising a stratified sampling method for population assessment purposes.

Landings of rays to Ireland by the Irish demersal fleet rarely exceeded 500 tonnes annually until 1940 when they began to rise steadily until the mid 1970s after which the increase became steeper; a decade later more than 3000 tonnes had been landed in a single year (Fig. 1).

Throughout the period in which statistics have been collected, the Irish Sea has provided the greatest proportion of ray landings, although between 1940 and 1970 the south coast frequently contributed 30% of the annual total. (Between 1903 and 1960 Irish waters were described in local terminology; in 1961 ICES sub-divisions were adopted in the reporting of national catch statistics. The two systems, pre and post 1961, are fairly similar (Fig. 2)).

A previous account of the ray fisheries in the Irish Sea suggested that the four species contributing to the landings are heavily fished. Their abundance increased, moving offshore and in a southerly direction (Fahy, 1989). Kilmore Quay was chosen as a landing place closest to the supposed centre of abundance for a more detailed investigation of the south eastern fishery.

Ray species are not distinguished in the landings, a fact which has inhibited investigations of fisheries for them in the past. This account of the south eastern fishery is undertaken along similar lines to an earlier investigation of the ray fisheries of division VIIa (Fahy, 1989). Some matters relevant to these investigations are examined in greater detail here: one concerns the growth of ray species which has a major influence on the way they are graded; information on the growth of rays in Irish waters is presented in Part 2 of this work. The second is the method of grading rays landed to the Irish coast which Part 3 of this paper sets out to clarify.

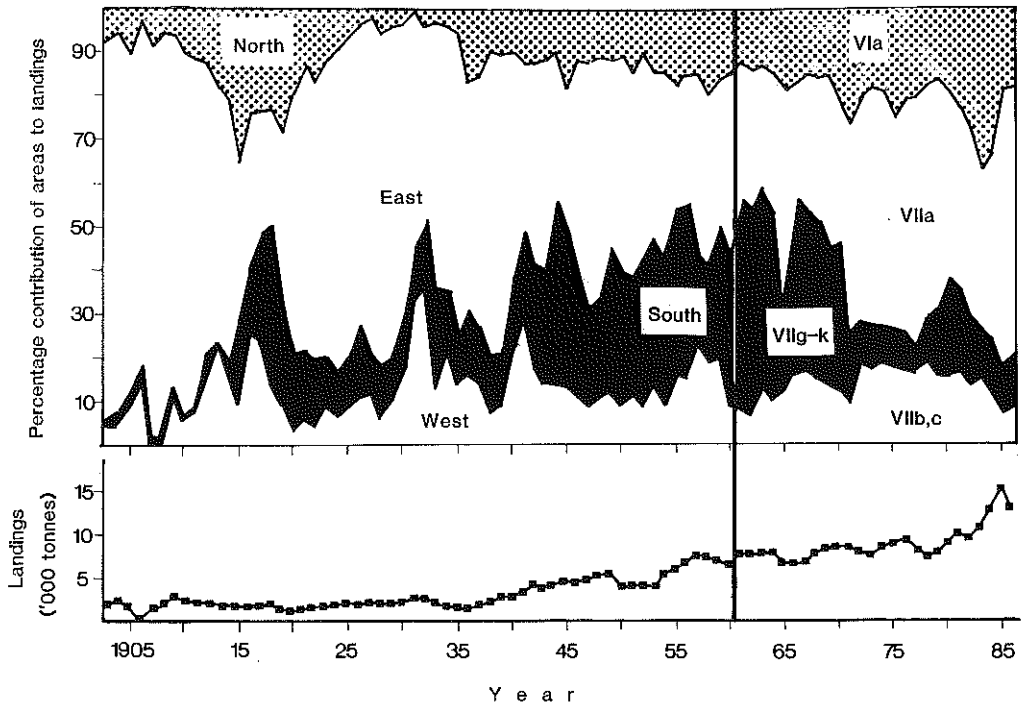

Fig 1. Ray Landings, 1903 - 1986 inclusive; *above,* percentage contribution of sea area to the total *below,* national total, tonnes. The year 1961 in which the sea areas were first described as ICES divisions is indicated.

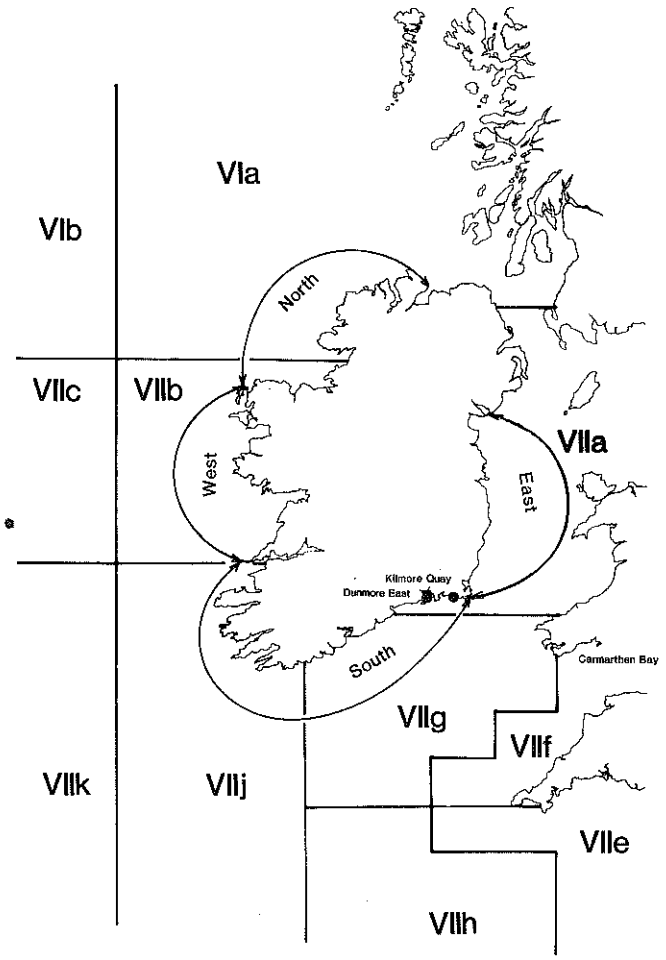

Fig 2. Irish waters, divided according to the pre-1961 and post-1961 (ICES) terminology. The locations of places referred to in the text are shown.

PART 1: THE SOUTH EASTERN RAY FISHERY

Introduction

This analysis of the south eastern ray fishery is based on three sources of data:

1, Auction records of the Co-operative in Kilmore Quay.

2, Fishery logs from selected vessels based in the vicinity.

3, An examination of rays landed into Kilmore Quay in July and August 1990.

Whole rays are graded predominantly by size into three categories: up to 60 cm in length are small; from 60 to 70 cm are medium and those greater than 70 cm are large. An additional category of rays less than 50 cm, labelled very small, is rare. A more exhaustive account of grading is given in Part 3.

The fishery

Fisheries data for ray and other demersal species in south-east Ireland were extracted from log-book returns. The Communities Logbook proforma provides for data on certain quota species; many fishermen supply additional information. An initial scrutiny identified 13 vessels using bottom otter trawl and four beam trawlers, based in Kilmore Quay and Dunmore East, which regularly reported additional species, including ray. All logbook data for these in the period from 1 January 1985 to 31 December 1987, were used in the calculations. In all, 12,447 hours of otter trawling and 14,062 hours of beam trawling are the basis of calculations used here.

The fishing grounds for these vessels are located close to their home ports (Fig. 3), the trawlers having a more extended range than the beamers.

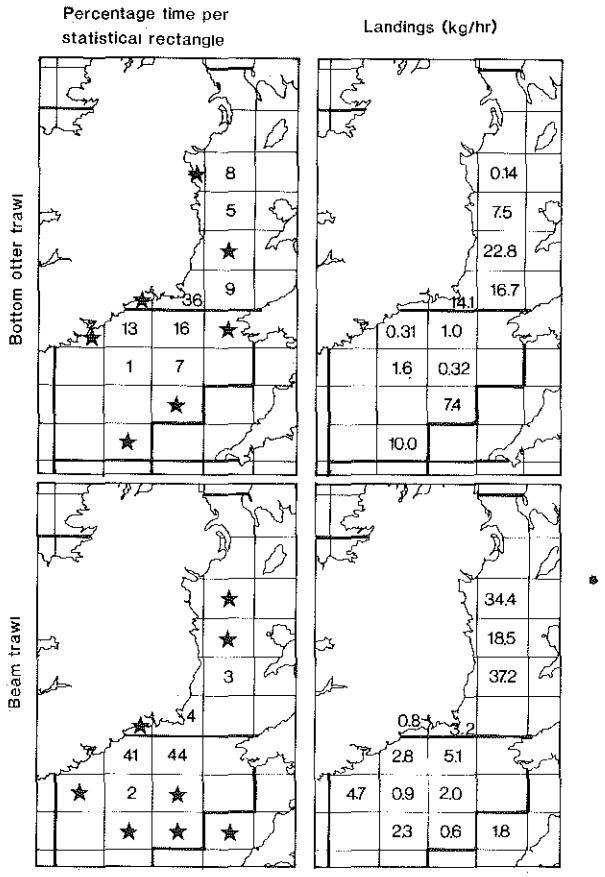

Fig 3. Summary of ray landings by statistical rectangle as reported on the Communities' Logbook proforma by selected vessels from Dunmore East and Kilmore Quay: *above*, by bottom otter trawlers and *below*, by beam trawlers. *Left*, percentage of reported time per statistical rectangle and *right*, ray captures per statistical rectangle. Stars indicate less than 1%.

Weights of capture of various species (kg) per 100 hours fishing are set out in Table 1 which shows dramatic differences between landings of round and flat demersal species by the two types of trawl. Both fishing methods capture ray which, contrary to expectation, is taken to a greater extent by otter trawl. This may be due either to the greater susceptibility of ray species to that method or to the fact that rays are more abundant on substrata which are not accessible by or insufficiently profitable to beam trawl.

Landings per hour by each fishing method per fishing rectangle are set out in Fig. 3. The reward for effort follows a pattern previously described (Fahy, 1989) for bottom trawling in division VIIa: landings increase moving in a southerly and offshore directions. The yield to beam trawling is related to factors other than abundance, and probably owes more to the suitability of the substratum for the method.

Ray landings

Ray fisheries have been characterised by their landings at Howth and Arklow, two ports in division VIIa (Fahy, 1989); the landings were described in terms of the percentage representation of size grades they contained.

In Arklow the landings have a clear seasonal pattern, the large grades reaching their maximum proportion in the summer, younger fish being recruited in the autumn. In Howth the pattern is more complex, without a clear seasonal influence, a fact which was thought to be related to the longer range of the vessels there and, thus, to their ability to exploit various ages and conditions of the fish.

Records of landings from the south east come from the Kilmore Quay Fishermen's Co-operative. They are less complete than in either of the other two fisheries, and provide an unbroken account for nine consecutive months only; in the year 1985 however, eleven months are documented. On the other hand, the sporadic records from 1984 and 1986 are consistent with those of 1985 and the actual tonnages on which the landings have been described are large.

The seasonal variations in the ray landings to Howth and Arklow are barely discernible in the Kilmore records: in 1985 the proportion of large grades rises during the spring and summer months and the young fish are recruited in the autumn; even this weak trend is not supported by data from the other two years. Distinctive features of the Kilmore records include the relatively small overall contribution of large grades (which exceeds 50% in the cases of Arklow and Howth and averages less than 40% at Kilmore Quay) and the relatively large contribution by both small and medium ones (Fig. 4).

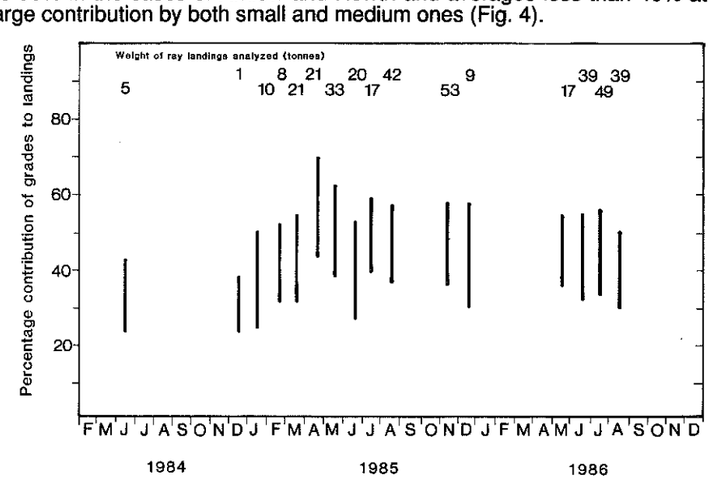

Fig 4. The percentage grading of rays auctioned at the Kilmore Quay Fishermen's Co-operative in selected months (those for which data have been entered). Vertical lines represent the percentage medium grade, the percentage large grade being the space below. The sample size (the quantity of rays involved in the monthly analysis) is reported above.

Species composition

Five species make up the landings of ray in south east Ireland: *R. clavata, R. montagui, R. brachyura, R. naevus* and *R. microocellata.* Four of these species are widely distributed around the coast but *R. microocellata* tends to be more local. It also occurs as a sizeable component of the ray fishery in Carmarthen Bay, at approximately the same latitude (Ryland and Ajayi, 1984).

The species composition of the landings auctioned by the Kilmore Quay Co-operative was examined in July and August 1990. The same procedure was adopted as in the investigation of the ray fisheries of VIIa (Fahy,

1989). Boxes were taken at random, their entire contents identified to species and each individual measured - from the tip of the snout to the end of the tail - to the nearest cm below.

In all, 5,210 rays made up the sample. Percentage species composition at 1 cm intervals is set out in Fig. 5 whose outcome is similar to that of the Irish Sea investigation. On Fig. 5 is superimposed the approximate limits of the grading system used (all of those termed very small, small (these together), medium and large - see Part 3 - are amalgamated under these headings). *Raja naevus* and *R. montagui* can be described as small growing species, the other three achieve greater dimensions - see Part 2 - and their representation in the grades reflects their size.

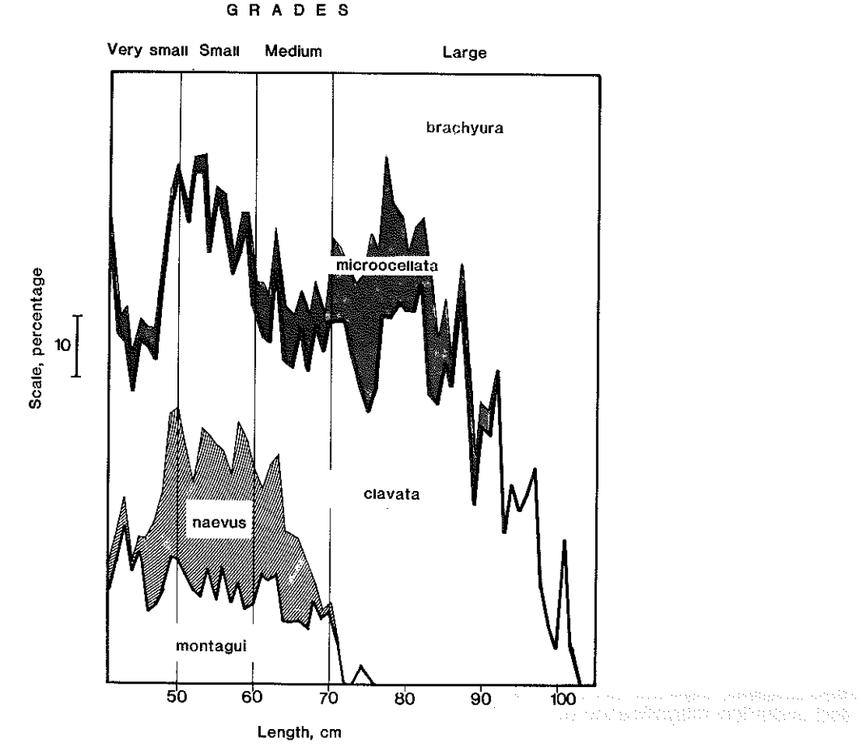

Fig 5. Percentage length frequency distributions of five ray species sampled in the Kilmore Quay Fishermen's Co-Operative in July and August 1990. The approximate size limits of the grades are marked by the vertical lines.

In Table 2 the percentage composition of the grades by species, in the Howth and Arklow and the Kilmore samples is set out; to facilitate comparison, *R. microocellata* has not been included in the calculations. While the fish from Howth and Arklow were collected over a longer period of the year than those from Kilmore, the proportions of the grades they contain are stable over the longer term and these samples are considered comparable with the material from Kilmore.

The small-growing species, *R. naevus* and *R. montagui* make up a smaller percentage of the landings to Kilmore Quay than in the fisheries further north.

Discussion

The south eastern ray fisheries differ from those in VIIa by having an extra species, *R. microocellata,* which reaches moderately large dimensions (see Part 2). In spite of this and the relatively low representation of small growers, the south eastern fishery appears to consist of large proportions of small and medium grades.

Although no aged analysis of these samples was undertaken and it is thus not feasible to provide a catch curve, as was done for the fisheries of VIIa, a general appraisal of fishing pressures is possible, on the limited materials analyzed.

An investigation, based on other collections, of the occurrence of ray species in the commercial catches and their comparison with the occurrence of large, rod-caught (known as "specimen") rays recorded by the Irish Specimen Fish Committee, suggested that the latter had a more localized distribution than the species to which they belonged (Fahy and O'Reilly, 1990). The inference drawn from this was that rays, having a low reproductive rate, were susceptible to high fishing pressures and reached their maximum weight only on ground which is not accessible by fishing vessels. This observation has also been made by Ryland and Ajayi (1984).

Ryland and Ajayi (1984) also remarked that the more usual effect of intensive fishing is to reduce the size of rays landed. Brander (1988) suggested that the size of rays captured might be used as an indicator to the fishing pressures in an area. Compared with the fisheries of division VIIa, whose landings contained a higher proportion of large grades, the south eastern fishery is likely to be more heavily exploited. A more precise assessment is not possible on the information presented here. On the other hand, data from Lowestoft indicate that although catch/effort of rays in division VIIa decreased in the 1960s it subsequently stabilized (Horwood, pers.comm.). In spite of being well fished, the south eastern fishery remains a good producer of rays.

Part 2: Growth data on rays from Irish waters

Introduction

There are comparatively few studies of the growth of rays in British and Irish waters but observations have been recorded on six species. Holden (1972) collected data from tagged and recaptured individuals. Otherwise, the majority of observations come from fish taken in demersal fishing gear and aged on the concentric growth rings in the vertebrae, a technique validated by Holden and Vince (1973). A paper by Brander and Palmer (1985) combines an intuitive recognition of the youngest year classes with the traditional ageing technique for older *R. clavata,* the species on which most information is available. Brander and Palmer identified problems in deciding the mid-year growth point of the youngest year classes which are likely to be accentuated in the commercial catches which select only the largest of the younger, pre-fully recruited, age groups.

This presentation considers seven species, one for the first time, giving what length at age data were gathered during a survey of the commercial catches and attempting to fit von Bertalanffy curves for the most common ones.

Materials and methods

Between March 1987 and the end of February 1988 commercial catches of rays from major ports were sampled. Of those fish examined, total lengths were recorded from all and the sex noted, weights from about sixty percent and sections of backbone were removed from approximately one half.

The vertebrae were removed to the laboratory where they were boiled, cleaned up and dried before being read under low magnification (x10 - x20).

Results

Where there are sufficient data, growth rates are reported for species by ICES statistical division and by sex. Least data were collected for three species, *R. batis, R. fullonica* and *R. microocellata* and these are set out in Table 3. The area from which most material was sampled was the Irish Sea, ICES division VIIa (for some species this was divided into Northern and Southern sectors, indicated as n and s). Growth data for the four common ray species (*R. montagui, R. naevus, R. clavata* and *R. brachyura*) are shown in Fig. 6, the sexes combined.

There is considerable variation in length at age throughout the sampling period, obscuring regional differences: whatever the origin of the fish, all measurement are within the range in Fig. 6 and the average lengths at age in all ICES statistical divisions also display close agreement. Von Bertalanffy curves are fitted for the four species (Table 4).

Fitting growth curves requires a sequence of mean lengths at age on which Ford-Walford plots can be calculated. The retention of rays for market purposes commences at a total length of 35 cm so the earlier year classes are largely discarded, only their largest individuals appearing in the landings. Age analyses of the catch in the Irish Sea (Fahy, 1989) suggest that recruitment to the fishery is complete at two years for the wider winged species (*R. montagui, R. clavata* and *R. brachyura*) and one year later for the narrow winged *R. naevus*.

While it would be desirable to consider length at age data from one year following full recruitment, this has not always proved feasible. The smaller rays, *R. montagui* and *R. naevus* tend to be shorter lived; the later years of these species are poorly represented providing little information on which to make calculations

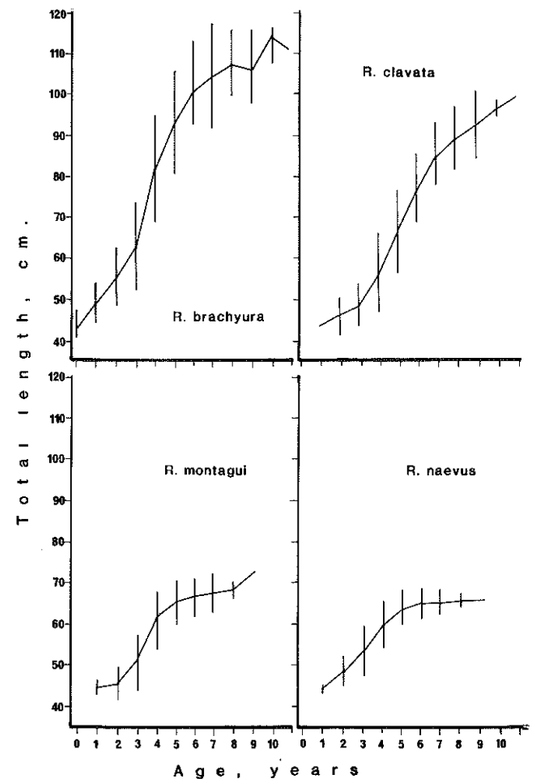

Fig 6. Growth curves of four common ray species (sexes combined); vertical lines indicate the range of length at age.

(Table 4). Growth calculations for *R. brachyura* are made from the second year, this being the largest of the common species (Table 4).

In view of the work of Brander and Palmer (1985) on *R. clavata,* particular emphasis was devoted to this species which was also one of the most abundant, as well as the second largest of the four most common (Table 4).

For comparison, the growth data are summarised and set out with growth parameters for other British and Irish species in Table 5.

Discussion

Some aspects of the results are emphasised here: L_∞ values for females tend to be greater than for males and, in general, are in keeping with what has already been ascertained by other workers. Exceptions are:

R. naevus of which the largest encountered by du Buit, who gives a value of 91.64 cm, was 69 cm total length. In the experience of this writer the species rarely exceeds 70 cm.

R. montagui for which Ryland and Ajayi give an L_∞ value of 97.8 cm, almost 25 cm longer than the largest specimen they aged. In the experience of this writer, *R. montagui* is much the same length as *R. naevus*, rarely exceeding 70 cm.

Values for k range between 0.06 and 0.33 but most lie between 0.19 and 0.25. Estimates of t_0 vary between -3.009 and +0.49, a wide range considering the basic similarity of life cycles of the various species. However, t_0 is sensitive to selection and, while it contributes to estimates of length in the catch, it may not be primarily a biological parameter.

Brander and Palmer (1985) considered the work of others on *R. clavata* in the context of their own novel approach to devising a growth curve for the species. Juveniles were collected over several years in an experimental trawl, the year classes being distinguished as the modes in length frequency distributions. Because the exercise was carried out three times annually, it was possible to follow the modes through successive samplings. This approach was applied to the first four years of life after which the modes could not be confidently separated. The combination of modal analysis of the younger fish with vertebral ageing of the larger age groups produced a growth curve quite unlike any other presented hitherto and seriously questions the representativeness of the youngest length at age data used in most of these studies. Growth data gathered from material in the commercial landings are likely to be biased by the larger of the pre-fully recruited age groups; they are unlikely to represent true growth curves.

PART 3: SEGREGATION OF RAYS IN COMMERCIAL CATCHES

Introduction

Population work on rays has been inhibited by the fact that species are not separated in the commercial catches. Instead, a grading system operates, grouping rays by size and by value (more accurately, by appearance, species of approximately similar appearance being boxed together). The supply of material may pose practical problems, small catches obliging fishermen to amalgamate and mix species and sizes. Thus, the grading system tends to operate in a casual rather than a strict way.

Grading systems in operation vary slightly from one part of the country to another. In the Dublin market there is, for practical purposes, a three grade system based on size (a fourth, very small, grade being rare). The larger of these grades may be further distinguished by the species they contain, blonde ray (*R. brachyura*) being of greater value than roker (*R. clavata*). An attempt to reconstruct the populations from which the landings came was undertaken by randomly sampling the graded catches (Fahy, 1989).The exercise was however conducted on landings from the Irish Sea whose ray stocks are composed of only four species,

Nine ray species have been recorded in the commercial catches from other parts of the Irish coast, seven are frequently encountered, and the grading system can be more complex. In the Kilmore fishery (Co. Wexford), thought to be one of the largest for ray in Ireland, sixteen grades are commonly used. A similar number, otherwise defined, are in operation in France although they would appear not to effectively segregate species either (IFREMER, 1984).

A critical examination of the actual separation of ray species in the commercial landings on criteria actually perceived by fishermen is the purpose of this analysis. A practical grading system which can be used for both marketing and population assessment is the objective.

Materials and methods

Between January 1987 and August 1988, 728 boxes of ray, each one 50 kg in weight, were examined at various ports around the Irish coast and in the Dublin fish market. The species content of each box was noted as was its grade, according to the conventions:

Large — The majority of fish exceeded 70 cm total length. There might be as few as 4 rays to a box in this grade.

Medium — Containing fish of between 60 and 70 cm. Alternatively, medium could be regarded as a mixed grade of unsorted sizes. A medium grade box would contain approximately 30 rays.

Small: — Fish of mostly less than 60 cm. As many as 60 were recorded in a single box of this grade.

Very small: — Fish of mostly less than 50 cm. In excess of 80 were recorded in a box of this grading.

The co-occurrence of species was measured on the number of species, not individuals, in the samples on the assumption that all had an equal opportunity to occur in all samples within a grade. Hence the degree of association of a pair of species was measured by comparing the difference between the actual and the expected number of joint occurrences. This approach was chosen rather than an index of affinity because it was considered important to measure negative as well as positive associations, something an index of affinity does not do (Southwood, 1966). Separate calculations were made for pair associations within each size grading, initially for all samples and then for samples which came from ICES statistical divisions other than the Irish Sea which, producing 413 samples and a limited range of species, dominated other sources of materials.

The number of samples in which species occurred is set out in Table 6.

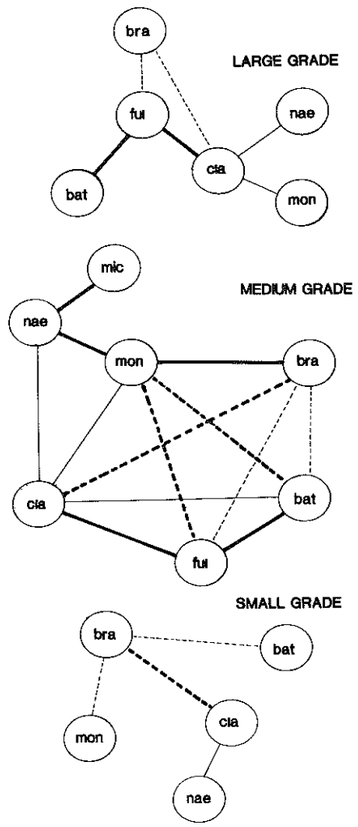

Fig 7. Significant associations among ray species in three commercial size grades: positive values are indicated by solid lines, negative values by broken ones. Thick lines indicate that an association applied in both ICES areas (i.e. in all divisions adjoining Ireland and in divisions other than VIIa); thin lines indicate an association occurred in only one of them. Species are referred to by the first three letters of the species name.

Results

The separate, joint and non-occurrences of a pair of species within a grade was set out as recommended by Southwood (1966) in a 2 x 2 contingency table; χ^2 was estimated and, where significant, the value of the coefficient of interspecific association and its standard error were calculated according to the methods of Cole (1949).The values of significant associations for the two statistical areas are set out in Tables 7 and 8. The two are substantially similar, the larger sample numbers providing lower standard errors. In Fig. 7 the associations between species pairs are summarised diagramatically from Tables 7 and 8. Positive associations are shown as solid lines and negative associations as dashed ones; where the values in Tables 7 and 8 were similar a thick line was used to indicate the association, otherwise the line was a thin one. In no case was a positive and a negative association recorded for the same species pair in a particular grade.

Discussion

There were relatively few associations among species in the small grade, presumably because of the relatively large sample size, or in the large grade from which a number of the smaller ray species would be excluded except when grading is very casual.

A consistent feature of all grades is the tendency for *R. brachyura*, recognised as the most valuable and sought after species, to be negatively associated with a number of others. In the medium grade*R. brachyura* is positively associated with *R. montagui* to which it bears a close superficial resemblance but this

relationship is lost in the large grade to which the small *montagui* rarely gains access and, when it does, is likely to be grouped with *R. clavata,* a species of lesser value. Female *R. brachyura* has an L_∞ of 130 cm, as opposed to female *R. clavata* which has an L_∞ of 115 cm, a size anomaly which accentuates differences and results in *R. montagui* with a female L_∞ value of 74 cm being included, when it is occasionally placed in the large grade, with species of secondary value, *R. clavata* being less favoured because of its rough exterior, than *R. brachyura.*

The higher value of *R. brachyura*, a fleshier and more easily handled ray than other species, is recognised (Holden, 1977, Fahy, 1989). In the large grade it averaged 1.7 times heavier than *R. clavata* in that grade, in samples taken in the Irish Sea (Fahy, 1989).

R. batis and *R. fullonica* also tend to be positively associated, an important contributory factor being their co-occurrence in catches off the south-west coast which may have influenced the outcome of the association analysis to a greater extent than the grading exercise.

R. naevus has ambivalent associations; usually boxed with *R. clavata,* this small species can be positively associated with *R. montagui* in the medium grade.

Some of the ray terminology in use throughout Ireland is set out in Table 9. It reflects the observed associations well, with the single exception of *R. microocellata* which is often boxed with *R. brachyura.* Prices for ray fluctuate considerably but grades which include "roker" are invariably cheaper than "blonde" or even "ray" of the same size.

A proposed procedure for ray census purposes, utilising rays from the commercial catches, would involve examining material at random within the size grades, The number of samples within grades should be determined in order to provide adequate representation, in view of the number of individuals per box of different grades. The practice of grading is sufficiently haphazard to encourage consideration of a wide range of grades in preparing a population assessment of any species.

REFERENCES

Brander, K (1988) Multispecies fisheries of the Irish Sea. In J.A Gulland (ed) *Fish population dynamics* London, J. Wiley & Sons Ltd.

Brander, K & D. Palmer, (1985) Growth rate of *Raia clavata* in Northeast Irish Sea. *J. Cons. int. Explor. Mer* 42: 125-128

du Buit (1975) Age et croissance de *Raja batis* et de *Raja naevus* en Mer Celtique *J. Cons. int. Explor. Mer* 37: 261-265.

Cole, L.C. (1949) The measurement of interspecific association. *Ecology* 30: 411-424.

Fahy, E. (1989) Fisheries for ray (Batoidei) in western statistical area VIIa, investigated through the commercial catches. *Irish Fisheries Investigations* B, No. 34: 14 pp.

Fahy, E. & R. O'Reilly (1990) Distribution patterns of rays (Rajidae: Batoidei) in Irish waters. *Ir. Nat. J.* 23 (8): 316-320.

Holden, M.J. (1972) The growth rates of *Raja brachyura, R. clavata* and *R. montagui* as determined from tagging data. *J. Cons. int. Explor. Mer* 41: 111-120.

Holden, M. J. (1977) Elasmobranchs. in J.A. Gulland (ed) *Fish pcpulation dynamics.*London, J. Wiley & Sons Ltd.

Holden, M.J. & M.R. Vince (1973) Age validation on the centra of *Raja clavata* using tetracycline *J. Cons. int. Explor. Mer* 35 (1): 13-17.

IFREMER (1984) Etude d'une gestion optimale des pecheries de Langoustines et de poissons demerseaux en Mer Celtique.

Ryland, J.S. & T.O. Ajayi (1984) Growth and population dynamics of three *Raja* species (Batoidei) in Carmarthen Bay, British Isles. *J. Cons. int. Explor. Mer* 41: 161-168.

Southwood, T.R.E. (1966) *Ecological methods* London, Methuen & Co.

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Table 1. Capture of various species per 100 hours fishing by two methods.

Species	Bottom otter trawl kg	Beam trawl kg
cod	1021	307
whiting	1428	44
plaice	921	998
sole	250	467
hake	205	71
megrim	168	266
monk	420	1552
ray	723	490
nephrops	1455	9

Table 2. Percentage frequency distribution of four ray species among three commercial grades in landings to Howth and Arklow (division VIIa, Fahy, 1989) and in the south eastern fishery

Species	GRADES Large	Medium	Small
Howth/Arklow			
montagui	5	23	5
naevus	1	39	39
clavata	45	29	39
brachyura	50	10	17
Kilmore			
montagui	0	10	17
naevus	0	1	25
clavata	40	51	34
brachyura	60	38	24

Table 3 Length at age data, sexes combined, for three infrequently observed ray species.

Age	Range (cm)	Mean	Number
R. batis			75
0+	47 - 62	54.5	8
1+	42 - 67	55.7	20
2+	47 - 82	71.3	26
3+	57 - 92	74.6	13
4+	72 - 92	82.6	5
5+	-	99.5	1
6+	-	104.5	1
7+	-	124.5	1
R. fullonica			99
2+	48 - 70	62.0	18
3+	56 - 89	77.8	23
4+	64 - 93	82.9	28
5+	71 - 99	85.2	15
6+	64 - 98	83.5	10
7+	70 - 96	86.0	2
8+	89 - 93	92.0	3
R. microocellata			63
2+	47 - 79	58.6	21
3+	58 - 85	73.1	26
4+	62 - 86	76.8	11
5+	75 - 82	78.8	4
6+	-	73.0	1

Table 4 Von Bertalanffy growth parameters for the four common species.

ICES Division	Age range	Number	r	L_∞ (cm)	K	t_0
R. montagui males						
All	1 - 7	555	0.94	68.2	0.33	–1.87
R. montagui females						
All	1 - 8	634	0.95	74.0	0.24	–2.72
R. naevus males						
All	1 - 7	670	0.98	69.9	0.33	–1.12
R. naevus females						
All	1 - 8	759	0.99	73.1	0.23	–2.47
R. brachyura males						
VIIa n	2 - 9	372	0.97	119.4	0.26	+1.15
VIIa s	2 - 8	201	0.97	116.7	0.24	–0.31
VIIg	2 - 7	141	0.88			
VIa	2 - 6	63				
R. brachyura females						
VIIa n	2 -10	450	0.97	120.6	0.29	+0.49
VIIa s	2 - 8	250	0.98	120.6	0.24	–0.27
VIIg	2 - 8	149	0.99	134.4	0.19	–0.45
VIa	2 - 8	61	0.96	144.3	0.19	+0.07
R. clavata males						
VIIa s	3 - 8	128	0.94	100.1	0.23	–0.35
VIIg, j	3 - 7	216	0.94	101.9	0.24	–0.34
VIIb	3 - 8	233	0.94	96.8	0.24	–0.32
VIa	3 - 8	206	0.99	104.3	0.19	–1.36
R. clavata females						
VIIa n	3 -10	697	0.97	118.8	0.15	–0.83
VIIg, j	3 - 8	247	0.98	107.8	0.26	+0.05
VIIb	3 - 8	297	0.96	114.4	0.17	–1.01
VIa	3 - 9	263	0.98	120.0	0.16	–0.80

Table 5 **Von Bertalanffy growth parameters for several British and Irish ray species. The range* of values is given for some species examined in the course of this work.**

Species	L_∞	k	t_0	Reference
R. batis, both sexes	253.73	0.057	–1.629	du Buit, 1972
R. brachyura, females	118.4	0.19	–0.8	Holden, 1972
R. brachyura, females	120.0 144.3	0.19 0.29	–0.45 +0.49	This work*
R. brachyura, males	115.0	0.19	–0.18	Holden, 1972
R. brachyura, males	116.7 119.4	0.24 0.26	–0.31 +0.15	This work*
R. clavata, both sexes	139.2	0.09	–2.626	Ryland and Ajayi, 1984
R. clavata, both sexes	105.0	0.215	+0.45	Brander and Palmer, 1985
R. clavata, females	107.0	0.13	–0.6	Holden, 1972
R. clavata, females	107.8 120.0	0.15 0.26	–1.01 +0.05	This work*
R. clavata, males	85.6	0.21	–0.6	Holden, 1972
R. clavata, males	96.8 104.3	0.19 0.24	–1.36 –0.32	This work*
R. microocellata, both sexes	137.0	0.074	–3.009	Ryland and Ajayi, 1984
R. montagui, both sexes	97.8	0.148	–1.719	Ryland and Ajayi, 1984
R. montagui, females	72.8	0.18	–0.37	Holden, 1972
R. montagui, females	74.0	0.24	–2.72	This work
R. montagui, males	68.7	0.19	–0.56	Holden, 1972
R. montagui, males	68.2	0.33	–1.87	This work
R. naevus, both sexes	91.64	0.1085	–0.0465	du Buit, 1972
R. naevus, females	73.1	0.23	–2.47	This work
R. naevus, males	69.9	0.33	–1.12	This work

Table 6 **The occurrence of nine ray species in commercial samples of three grades, from all parts of the Irish coast and in divisions other than ICES VIIa.**

	All divisions			Divisions other than VIIa		
	Small	Medium	Large	Small	Medium	Large
R. brachyura,	119	168	171	37	67	57
R. batis,	3	19	8	3	19	8
R. naevus,	145	185	15	26	64	6
R. microocellata,	2	28	8	1	19	6
R. clavata,	139	240	128	36	107	54
R. montagui,	158	218	42	45	90	15
R. fullonica	1	18	11	1	18	11
R. undulata	0	1	1	0	1	1
R. alba	0	1	0	0	1	0
Total number of samples	175	315	238	57	159	105

Table 7 **Pair associations of ray species in commercial landings from various parts of the Irish coast, excluding the Irish Sea (VIIa), using Cole's coefficient of association. Species names abbreviated to first three letters.**

Species	χ^2	Association values	SE of association
Large grade			
bra-ful	5.04	–0.75	0.48
bat-ful	21.10	+0.54	0.12
nae-cla	4.68	+0.75	0.35
cla-ful	19.90	+1.00	0.26
Medium Grade			
bra-bat	9.51	–0.74	0.26
bra-cla	8.64	–0.27	0.07
bra-mon	18.63	+0.45	0.10
bra-ful	11.99	–0.86	0.27
bat-cla	5.48	+0.83	0.32
bat-mon	5.61	–0.41	0.19
ful-bat	20.40	+0.69	0.08
nae-mic	4.30	–0.48	0.26
nae-mon	7.29	+0.32	0.11
cla-mon	4.10	+0.22	0.10
cla-ful	7.34	+0.98	0.33
mon-ful	13.60	–0.69	0.20
Small Grade			
bra-bat	5.11	–0.60	0.04
bra-cla	6.21	–0.76	0.28
bra-mon	7.72	+0.77	0.24

Table 8 **Pair associations of ray species in commercial landings from all parts of the Irish coast, using Cole's coefficient of association. Species names abbreviated to first three letters.**

Species	χ^2	Association values	SE of association
Large grade			
bra-cla	48.80	–0.76	0.07
bat-ful	32.17	+0.48	0.07
cla-mon	14.44	+0.55	0.14
cla-ful	4.09	+0.78	0.33
Medium Grade			
bra-cla	32.40	–0.60	0.08
bra-mon	33.60	+0.47	0.06
bat-mon	15.38	–0.53	0.02
bat-ful	92.14	+0.59	0.06
nae-mic	19.37	–0.64	0.05
nae-cla	4.11	+0.18	0.08
nae-mon	12.80	+0.26	0.07
cla-ful	4.66	+1.00	0.41
mon-ful	17.51	–0.60	0.23
Small Grade			
bra-cla	13.08	–0.74	0.18
nae-cla	14.89	–1.00	0.28

Table 9 Terminology and characteristics of ray grading in common usage in Ireland.

Common terminology	Special characteristics of grades	Size Categories (used by Fahy (1989)
Large large ray	*brachyura*, > 90 cm.	
Large blonde	Mainly *brachyura* (plus *microocellatta*?) > 70 cm.	majority greater than 70 cm.
Large ray	Similar to above, some of next category also.	
Large roker	Mainly *clavata*, plus *fullonica, batis, naevus*, and *montagui*	
Medium large ray	*brachyura* mainly	mainly between 60 and 70 cm.
Large medium ray	*brachyura* plus *montagui* mainly possibly *microcellatta* also.	
Large medium roker	Mainly *clavata*, plus other species generally.	
Medium ray	Mixture of species diminated by *brachyura, montagui.*	
Medium roker	Mixture of species associated with *clavata.*	
Mixed ray	Possibly an unsegregated category, wide range of sizes and species.	
Small medium ray	Mixture of species with some *brachyura* and/or *montagui*	
Small ray	Mixture of species with some *brachyura* and/or *montagui*	majority < 60 cm.
Small roker	Mixture of species associated with *clavata*, notably *naevus.*	
Very small small ray	Rays, various species, less than 50 cm.	majority < 50 cm.

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