Rays and Skates of Devon and Cornwall. III. The Proportions of the Sexes in Nature and in Commercial Landings, and their Significance to the Fishery.

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With 1 Figure in the Text.

Introduction.

The belief for long was held by early investigators that among most if not among all Elasmobranch fishes the number of females in the stocks exceeded that of the males. As long ago as 1884 Day (**4**, p. 345) remarked concerning the Thornback Ray, *Raia clavata*, " It has been said that the number of females is in excess of that of the males." Haacke (**9**, p. 246), writing in 1885, says of the Sharks and Rays which he had observed in South Australian waters, " Bei den südaustralischen Haien und Rochen, auf deren Fang ich zu wiederholten Malen ausgezogen bin und von denen mir auch nicht selten Exemplare für das Adelaider Museum zugeschickt wurden, habe ich die Wahrnehmung gemacht, dass Männchen verhältnismässig sehr selten gefangen werden. Ob diese Wahrnehmung auch anderswo gemacht worden ist, weiss ich nicht, jedoch ist es nicht unwahrscheinlich ; in der mir zu Gebote stehenden Litteratur finde ich nichts darüber. Die seltenheit der geschlechtsreifen Männchen, soweit sie sich wenigstens durch die Fangresultate dokumentiert, gilt für sämtliche Species der ziemlich artenreichen südaustralischen Selachierfauna."

In the year 1890 Fulton (**7**, p. 350) made the surprisingly definite statement that " among skates and rays females are in excess ; the ratio being 175 females to 100 males. The observations were mainly made on the thornback ray (*Raia clavata*), but also on the starry ray (*Raia radiata*) and grey skate (*Raia batis*). The females specially preponderate in the latter species." By 1903, however, Fulton had acquired additional data which seem to have caused him to be less certain of the exact numerical ratio of the sexes among these fishes, for in that year, after recording separately his data for each species, he wrote more guardedly as follows : " It will be observed that in no case do the males exceed the females in number, and that with the exception of the shagreen ray,* where the

* Only 8 specimens were examined—4 males and 4 females.

numbers are probably too small to indicate the real proportion, the females are in excess. The amount of excess, however, varies. There is almost equality in the case of the common skate,* while with the thornback, the starry ray, and the sandy ray—although here the figures are small—the excess of females is very considerable."

Lamont (**11**, p. 78) records the proportions of the sexes among Rays and Skates received for dissection at the Zoology Department of Edinburgh University during the four academic years 1921–25. She points out that, so far as she could ascertain, only one source of error might possibly have affected her counts in such a way as to cause them to give an inaccurate picture of the true state of affairs in nature : i.e. that in very immature male specimens the claspers are so small as to be very easily hidden by the pelvic fins, and hence, if they were overlooked, some males might have been recorded as females. It is but little likely, however, that a careful worker would fail to observe the claspers in even the most immature specimens likely to be met with in the dissecting-room.

The numbers† dealt with are small and it seems unnecessary to reproduce them here. It is enough to point out that Lamont found the combined totals for all five species (*R. clavata*, *R. radiata*, *R. fullonica*, *R. circularis*, *R. batis*) which passed through her hands to " show a slight excess of males over females, but this excess was not maintained by each species when considered separately. The excess of males was most marked in *batis*, and was also considerable in *circularis*, but in *clavata* and *fullonica* the condition was reversed and there was a still greater disparity in numbers in favour of the female sex." The results for *R. radiata*, this author points out, call for special remark " because in the last year the occurrence of a great excess of females entirely upset the ratios established for that species during the previous three years." Lamont finally came to the conclusion that while her data " undoubtedly indicate that in the early stages of *batis* males are most numerous, they also appear to provide some justification for the conclusion that in the early stages of *radiata* the opposite is the case and females predominate." She was unable, however, to correlate the great preponderance of females during 1924–25 with any unusual degree of immaturity in the fish of that species dealt with throughout the session. Not only so ; the records obtained for *R. radiata* in that year caused her to modify her " opinion formed at the end of the third year to the effect that in adult *radiata* males come to outnumber the females."

Craigie (**3**, p. 492), from data preserved in the files of the Atlantic Biological Station, St. Andrews, N.B., Canada, found that among four species of Raia represented in the records, all showed a predominance

* Common Skate=Grey Skate already referred to above. Compare the two statements.
† A total of 757 males and 727 females distributed among 5 species.

of females, the percentage of males ranging from 45% in *R. erinacea*, the Tobacco-box Skate, to 35% in *R. lævis*, the Barn-door Skate. This author then proceeds to point out that an abnormal sex ratio having been found in any fish (a 50/50 ratio being considered normal) it is then necessary to find out the cause. This, however—apart from tabulating some highly theoretical possibilities such as differential fertilisation, differential mortality of gametes, differential mortality of zygotes, the conversion of an X- into a Y-chromosome or *vice versa*, etc., he does not himself make any endeavour to do but "attempts merely to make a general survey of available data in order to find out in what cases among Canadian marine fishes there is a problem of abnormal sex-ratio awaiting study."

The above is a brief résumé of all the previous work which the present writer has been able to find on the proportions of the sexes in certain of the Raiidæ. It will serve to show that although there is some evidence which seems to suggest that as a general rule females tend to outnumber the males, such evidence is by no means conclusive, and that there remains yet much to be learned.

Ford (**5**, p. 483), however, in the course of researches on the life-history of the Spur Dogfish (*Acanthias vulgaris*) found that his data concerning the proportions of the sexes in that Elasmobranch also showed a decided preponderance of females in a total of 3022 fish from 13 samples drawn from commercial landings caught over a period of seven months, there being 1947 females and 975 males. At the same time he found that, among large numbers of embryos obtained *ex utero*, males and females were represented in approximately equal numbers, and therefore presumably would have been born in equal numbers, for the embryos in which the sex could be determined must have been all at such a stage of development that differential mortality would be but little likely to supervene before birth.

Now although a differential mortality of gametes or of zygotes is known to occur in some animals and operates to produce an excess of one sex or of the other, that explanation, in view of Ford's results, obviously does not apply to the Spur Dogfish. A differential survival of the young is a factor which might operate after birth to produce an unbalanced sex ratio. Apart from the fact that there is no evidence to suggest that such a factor is operative, it need not seriously be considered because a much more satisfactory explanation has already been put forward. It has been shown by Ford (**5**, p. 484) and confirmed by Hickling (**10**, p. 537) that there is a very definite segregation of these fish according to age and state of sexual development. The latter author has further shown that normally the males are present in shallower water than the females of the same size and that therefore, owing to the strict segregation of both sexes by size

and the smaller size attained by the males, in deeper water females predominate. These large females are mostly pregnant and migrate from deep to shallow water to bear their young. "It is therefore," says Hickling, "hardly possible to speak of the sex ratio among dogfishes as if that were a constant; it will clearly vary with depth and also, almost certainly, with season." It is obvious, too, that such differences of habit exhibited by the male and female fish will render them liable in different degree to capture. As the males, though produced in numbers equal to those of the females, are taken less frequently and in smaller numbers than the latter, it is evident that the habits of the females render them the more accessible and/or vulnerable to the usual fishing implements.

The observations of Haacke (*op. cit.*) in Australian waters point to exactly the same conclusion with regard to the Elasmobranch species observed by him in that region. Of the shark, *Mustelus antarcticus*, though females were common, he had never seen a male specimen. Yet when 22 embryos which he was able to obtain were examined they yielded no less than 13 males. Similarly, nearly every adult specimen of *Trygonorhina fasciata* which Haacke encountered was a female. Nevertheless, out of 26 embryos which he examined 15 were males. Of *Rhinobates vincentianus*, a somewhat rare fish, this author had seen but 6 adults, of which only one was a male. But he was able to obtain from 2 of the 5 females which came into his possession 30 embryos—from the one 5 males and 12 females and from the other 10 males and 3 females.

"Es wird interessant sein," continues Haacke, "noch weitere und genauere auf unseren Gegenstand bezügliche, statistische Angaben auch für andere Arten zu sammeln und womöglich die Ursachen der scheinbaren oder wirklichen Minderzahl der geschlechtsreifen Selachiermännchen aufzuklären. Ob die erwachsenen Männchen nicht so leicht an die Angel gehen wie die Weibchen, oder ob viele davon von anderen Männchen ihrer Art im 'Kampf um die Ehe' getötet werden, oder ob endlich junge Männchen einer grösseren Sterblichkeit ausgesetzt sind, vermag ich nicht zu sagen." The most probable explanation almost certainly is that there is some sort of segregation of the sexes amongst the adult fish and that the shoals of males and females exhibit such differences of habit and/or distribution that the former are very much less exposed to capture than the latter.

Results of Plymouth Investigations.

In order to glean some further information on the vexed question of the proportions of the sexes in the British Raiidæ the writer, in the course of his work among these fishes, recorded whenever possible the numbers of the sexes in the samples examined by him. These samples have been drawn from commercial landings by steam, motor, and sailing trawlers

by long liners, and by small vessels fishing with set nets, in addition to landings by the Marine Biological Association's research steamer *Salpa*.

In Table III (p. 620) are recorded the numbers of the sexes observed in samples of the seven species most commonly taken in smaller or larger numbers in the English Channel and for which the data are therefore most adequate. Both the actual numbers and the percentages of the sexes have been recorded separately for each sample, irrespective of mode of capture. Two records opposite one date mean that the samples examined on that day were drawn from two separate landings by different vessels. In order to facilitate interpretation an additional column is inserted in which an excess of males in a catch is indicated by an M and excess of females by an F, while the symbol = indicates that the sexes were equally represented. It will at once be seen on referring to this table that females are considerably in excess of the males both in actual numbers and in the number of samples in which they predominate. This applies to all the seven species. But further examination of the figures for individual samples reveals that there is absolutely no constancy in the proportions of the sexes in the different catches of any species. The proportions vary within wide limits. If reference now be made to Table II, which records the landings* from a very specialised local fishery, or to Figure 1 in which the results are graphically represented, this variation will be found there to vary from 100% females to 100% males. It should here be noted that all these landings came from exactly the same very restricted fishing ground (*vide* **12**, p. 6), and were taken with exactly the same fishing gear.

It is practically impossible to determine the proportions of the sexes among our British Rays at or shortly before birth in order to find out how they compare with the conditions found in commercial catches of the adults. All the species are oviparous, and it has not yet been found possible to collect Ray eggs in any number after they have been deposited in the sea so that the developing embryos may be examined for sex. But very recently-hatched individuals of *R. clavata* from about 9 cm. upwards in width of disc have been taken not infrequently by the *Salpa* in her trawl. Of 91 such young individuals of 12·5 cm. and under in width of disc, which have been obtained and their sex recorded, 47 were males and 44 were females. Similar observations on reasonably large numbers of equally young specimens of other species† have not been possible. But interesting and strongly confirmatory data‡ were obtained by observing the proportions of the sexes in 20 out of 21 hauls made by a Plymouth steam trawler during a week's fishing at the mouth of the English Channel

* These figures are not included in Table III.

† Thirty-seven *R. montagui* under 15 cm. in width of disc yielded 17 males and 20 females.

‡ I am indebted to Mr. F. G. Walton Smith, B.Sc., for having collected these data.

TABLE I.

PROPORTIONS OF THE SEXES IN SEPARATE TRAWL HAULS* TAKEN BY A STEAM TRAWLER DURING ONE FISHING TRIP.

K = fish kept for sale. D = fish discarded as too small.

Date (August, 1932)			19				20		21				22			23		24	
LOCALITY.			Bishop Light bearing E.×S. 30 miles.				Bishop Light bearing E. 50 miles.		Bishop Light bearing E.×S. 30 miles.				Longships Light bearing S.E.×E. 90 miles.			Longships Light bearing S.E.×E. 90 miles.		Wolf Light bearing N. 20 miles.		Totals for each Species.
Duration of Haul (hours)			3½	3½	3½	3½	3	4	3½	3½	3½	3½	3	4	4	4	4	4	4	
Serial No. of Haul			1	2	3	4	5	6	9	10	11	12	13	15	16	18	20	21		
R. clavata	K	♂♂	–	–	–	1	–	–	–	–	–	–	2	1	4	2	9	5		24
		♀♀	1	–	–	–	1	–	1	–	–	–	–	2	2	1	27	5		40
	D	♂♂	–	1	–	–	1	2	–	–	–	1	–	–	–	–	9	1		15
		♀♀	–	1	–	–	3	–	–	–	–	1	–	–	–	–	6	1		12
R. montagui	K	♂♂	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2		4
		♀♀	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	5		9
	D	♂♂	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1		2
		♀♀	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1		2
R. brachyura	K	♂♂	–	3	–	–	–	2	–	–	–	–	–	4	–	–	17	17		43
		♀♀	–	–	–	–	–	–	–	–	1	–	2	7	–	–	25	18		53
	D	♂♂	–	–	–	–	–	1	–	–	–	–	–	–	6	–	4	5		16
		♀♀	–	3	–	–	–	–	–	–	1	–	–	–	2	–	3	2		11
R. nævus	K	♂♂	–	1	–	–	–	–	–	–	–	1	–	1	20	–	10	12		45
		♀♀	–	–	–	–	–	–	–	–	–	–	–	–	6	–	7	9		22
	D	♂♂	–	–	–	–	–	–	–	–	–	–	–	–	2	–	3	–		5
		♀♀	–	–	–	–	–	–	–	–	–	–	–	–	1	–	4	–		5
R. circularis	K	♂♂	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–
		♀♀	1	–	1	1	–	–	3	–	–	1	–	–	1	–	–	–		8
	D	♂♂	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–
		♀♀	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–
R. fullonica	K	♂♂	3	6	–	4	2	3	12	3	–	11	1	–	–	1	5	2		53
		♀♀	3	3	–	3	1	2	5	3	5	7	2	–	8	2	9	2		55
	D	♂♂	1	1	–	2	–	1	2	–	–	2	–	–	–	–	1	–		10
		♀♀	1	–	–	3	–	–	1	–	–	1	–	–	–	–	1	–		7
R. batis	K	♂♂	1	–	2	1	–	–	–	2	–	–	2	3	6	6	–	–		23
		♀♀	–	1	1	–	–	–	–	–	1	–	–	1	9	4	–	–		17
	D	♂♂	–	1	1	1	–	1	–	1	1	1	1	1	–	2	–	–		11
		♀♀	1	1	1	1	–	–	2	–	–	–	–	–	1	1	–	2		10
R. oxyrhynchus	K	♂♂	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1		1
		♀♀	–	–	1	–	–	–	–	–	–	–	1	–	–	–	–	–		2
	D	♂♂	–	–	–	–	–	1	–	–	–	1	–	–	–	–	–	1		3
		♀♀	–	–	1	–	–	–	1	–	–	–	–	–	1	–	–	–		3

* Haul 8 contained no Rays.
Hauls 7, 14, 19 contained no fish. Trawl torn.
Haul 17 was not recorded.
Haul 3 contained 1 male *R. undulata*—the only specimen taken.

in August, 1932. The data obtained from those fish which were kept for sale and from those which were discarded as being too small to be marketable have been noted separately. All Rays exceeding about 25 cm. in width of disc and Skates of about 35 cm. and over were retained.* The results are summarised in Table I, to which reference should now be made. It will be seen that although in 5 out of the 8 species taken females predominate among the larger retained fish, in not a single instance is this true of the totals for the rejected "smalls." It seems clear, therefore, that in *R. clavata* at any rate, as in *Squalus acanthias*, *Mustelus antarcticus*, *Trygonorhina fasciata*, and *Rhinobates vincentianus*—that is to say, in all the Elasmobranchs in which the embryos or very young fish have been examined for sex—the young are born with the sexes approximately equally represented.† This applies also, almost certainly, to several, if not to all the other Ray species, and possibly to all the Elasmobranchs.

If, then, male and female Rays are born in equal numbers the question arises is there any factor, such as the segregation and shoaling habits found in the Spur Dogfish, which may reasonably be expected to account for the difficulty of obtaining a true picture of the proportions of the sexes in the adults ?

It has already been pointed out briefly by the present writer (**12**, p. 17) that there is ample evidence of sexual segregation among adult Rays of several species and that the same probably is true for all the Channel, if not for all Ray species. Such segregation was first brought forcibly to the writer's notice by the composition of the catches landed on Plymouth market by vessels engaged in fishing for Rays with a kind of fixed net which superficially resembles a trammel but consists of only a single wall and acts simply as a straightforward tangle net. The first of such landings was observed on February 20th, 1930.‡ It will be seen from Table II—in which the entire catches landed by the various boats are recorded separately, each landing opposite one date being the total catch of one vessel—that the earlier landings observed in 1930 consisted almost entirely of female fish. With the approach of March, however, more males appeared and in the last landing recorded there was not a single female present. In the years 1931 and 1932 the landings from the net fishery were examined from the very beginning of the season. It will be

* These sizes are considerably smaller than usual because at the time of this trip fish were very scarce and so nothing was discarded which might add even a little to the total returns for the voyage.

† Clark (**1**, p. 595), however, in the course of investigations on the eggs and young of British Raiidæ, hatched out artificially 23 *R. clavata* of which 15 were females. This is clearly an abnormal ratio (which would probably have been corrected if larger numbers from several fish had been examined—cf. Haacke's results with Rhinobates described on p. 7), for even among the adults a 2 : 1 ratio of females to males does not hold good.

‡ There had been earlier landings but the writer, having had only just taken up the study of the Raiidæ, was until this date quite unaware of the existence of such a fishery.

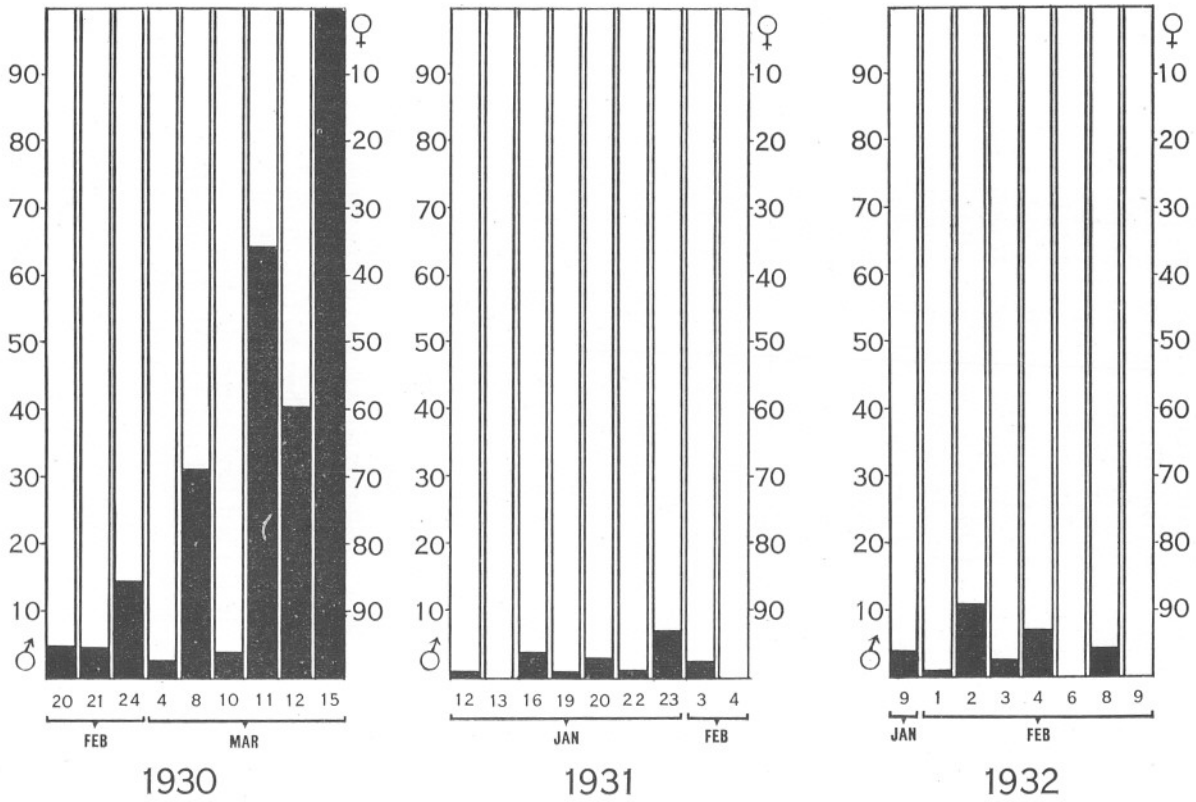

FIG. 1.—Graphical representation of composition of landings of *R. clavata* from Ray Nets in seasons 1930–31–32. Each vertical column represents the *total* landings on one day, the black component being the percentage of male fish and the white component being the percentage of female fish included therein.

TABLE II.

Composition of Landings from Ray Nets—Seasons 1930, 1931, and 1932.

(Not included in Table III, p. 620.)

Date.	Total number of Fish in Landing.	Total ♂♂	Total ♀♀	Percentage ♂♂	Percentage ♀♀
1930.					
February 20	137	7	130	5	95
,, 20	65	3	62	5	95
,, 21	156	7	149	4	96
,, 21	52	3	49	6	94
,, 24	197	21	176	11	89
,, 24	36	13	23	36	64
March 4	34	1	33	3	97
,, 8	26	8	18	31	69
,, 8	38	12	26	32	68
,, 10	35	2	33	6	94
,, 10	14	0	14	0	100
,, 11	104	67	37	64	36
,, 12	69	28	41	41	59
,, 15	38	38	0	100	0
1931.					
January 12	161	2	159	1	99
,, 13	5	0	5	0	100
,, 13	14	0	14	0	100
,, 13	102	0	102	0	100
,, 16	51	2	49	4	96
,, 19	60	0	60	0	100
,, 19	72	0	72	0	100
,, 19	68	2	66	3	97
,, 20	108	3	105	3	97
,, 20	53	2	51	4	96
,, 22	64	1	63	2	98
,, 22	12	0	12	0	100
,, 23	72	9	63	12·5	87·5
,, 23	68	8	60	12	88
February 3	17	1	16	6	94
,, 3	24	0	24	0	100
,, 3	38	1	37	3	97
,, 4	5	0	5	0	100
,, 4	14	0	14	0	100
,, 4	102	0	102	0	100
1932.					
January 9	75	3	72	4	96
February 1	53	1	52	2	98
,, 1	15	0	15	0	100
,, 1	24	0	24	0	100
,, 1	3	0	3	0	100
,, 2	23	0	23	0	100
,, 2	51	8	43	16	84
,, 3	16	0	16	0	100
,, 3	8	0	8	0	100
,, 3	50	2	48	4	96
,, 4	34	4	30	12	88
,, 4	22	1	21	5	95
,, 4	14	0	14	0	100
,, 6	15	0	15	0	100
,, 8	64	8	56	12·5	87·5
,, 8	14	0	14	0	100
,, 8	11	2	9	18	82
,, 8	7	1	6	14	86
,, 9	10	0	10	0	100
,, 9	10	0	10	0	100
,, 9	12	0	12	0	100

TABLE III.

Numbers (with percentages) of Males and Females of seven species of Raia included in Samples from Landings from the English Channel—irrespective of Mode of Capture.

Date.		R. clavata.					R. montagui.					R. brachyura.					R. nævus.					R. circularis.					R. fullonica.					R. batis.				
		Male.		Female.		Sex Predominating.	Male.		Female.		Sex Predominating.	Male.		Female.		Sex Predominating.	Male.		Female.		Sex Predominating.	Male.		Female.		Sex Predominating.	Male.		Female.		Sex Predominating.	Male.		Female.		Sex Predominating.
		No.	%	%	No.		No.	%	%	No.		No.	%	%	No.		No.	%	%	No.		No.	%	%	No.		No.	%	%	No.		No.	%	%	No.	
1930																																				
January	15	33	*52*	*48*	30	M	9	*30*	*70*	21	F	11	*42*	*58*	15	F	–	–	–	–		–	–	–	–		12	*67*	*33*	6	M	–	–	–	–	
,,	16	2	*100*	–	–	M	24	*47*	*53*	27	F	22	*38*	*62*	36	F	25	*51*	*49*	24	M	–	–	–	–		2	*50*	*50*	2	=	–	–	–	–	
,,	17	39	*62*	*38*	24	M	4	*33*	*67*	8	F	5	*50*	*50*	5	=	–	–	–	–		3	*43*	*57*	4	F	2	*33*	*67*	4	F	2	*100*	–	–	M
,,	17	10	*40*	*60*	15	F	7	*47*	*53*	8	F	–	–	–	–		1	*100*	–	–	M	–	–	–	–		5	*42*	*58*	7	F	1	*50*	*50*	1	=
,,	20	3	*60*	*40*	2	M	23	*49*	*51*	22	M	18	*53*	*47*	16	M	13	*54*	*46*	16	M	–	–	–	–		4	*57*	*43*	3	M	–	–	–	–	
,,	20	17	*42·5*	*57·5*	23	F	17	*44*	*56*	22	F	–	–	*100*	1	F	–	–	–	–		–	–	–	–		1	*50*	*50*	1	=	–	–	–	–	
,,	22	12	*22*	*78*	43	F	15	*60*	*40*	10	M	10	*48*	*52*	11	F	–	–	–	–		–	–	–	–		–	–	*100*	3	F	–	–	–	–	
,,	23	11	*32*	*68*	23	F	29	*48*	*52*	31	F	1	*100*	–	–	M	17	*44*	*56*	22	F	–	–	–	–		2	*50*	*50*	2	=	2	*50*	*50*	2	=
,,	24	10	*45*	*55*	12	F	8	*44*	*56*	10	F	10	*32*	*68*	21	F	–	–	–	–		–	–	–	–		1	*100*	–	–	M	–	–	–	–	
,,	25	10	*40*	*60*	15	F	12	*43*	*57*	16	F	–	–	–	–		11	*46*	*54*	13	F	–	–	–	–		2	*25*	*75*	6	F	–	–	*100*	1	F
,,	27	8	*44*	*56*	10	F	23	*59*	*41*	16	M	4	*36*	*64*	7	F	14	*82*	*18*	3	M	–	–	–	–		4	*40*	*60*	6	F	22	*56*	*44*	17	M
,,	31	20	*61*	*39*	13	M	12	*39*	*61*	19	F	–	–	*100*	1	F	13	*30*	*70*	31	F	–	–	–	–		4	*50*	*50*	4	=	1	*50*	*50*	1	=
February	2	23	*62*	*38*	14	M	2	*12*	*88*	14	F	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	3	6	*60*	*40*	4	M	8	*50*	*50*	8	=	10	*40*	*60*	15	F	–	–	*100*	10	F	–	–	–	–		–	–	*100*	3	F	–	–	–	–	
,,	3	19	*56*	*44*	15	M	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	5	33	*43*	*57*	43	F	4	*44*	*56*	5	F	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	11	10	*50*	*50*	10	=	11	*31*	*69*	24	F	17	*30*	*70*	40	F	–	–	–	–		–	–	*100*	1	F	4	*67*	*33*	2	M	–	–	–	–	
,,	11	13	*57*	*43*	10	M	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	17	13	*46*	*54*	15	F	20	*42*	*58*	28	F	15	*43*	*57*	20	F	5	*31*	*69*	11	F	4	*33*	*67*	8	F	3	*33*	*67*	6	F	–	–	–	–	
,,	17	22	*61*	*39*	14	M	13	*42*	*58*	18	F	16	*42*	*58*	22	F	6	*32*	*68*	13	F	–	–	–	–		12	*50*	*50*	12	=	3	*75*	*25*	1	M
,,	17	14	*38*	*62*	23	F	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	27	28	*37*	*63*	47	F	3	*50*	*50*	3	=	–	–	*100*	1	F	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
March	3	17	*42·5*	*57·5*	23	F	1	*33*	*67*	2	F	–	–	–	–		1	*100*	–	–	M	–	–	–	–		–	–	–	–		–	–	–	–	
,,	5	10	*37*	*63*	17	F	11	*44*	*56*	14	F	22	*41*	*59*	32	F	3	*37·5*	*62·5*	5	F	3	*30*	*70*	7	F	6	*60*	*40*	4	M	–	–	–	–	
,,	7	21	*60*	*40*	14	M	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	12	23	*46*	*54*	27	F	19	*46*	*54*	22	F	28	*42*	*58*	39	F	13	*42*	*58*	18	F	–	–	–	–		9	*45*	*55*	11	F	3	*50*	*50*	3	=
,,	16	–	–	*100*	207	F	–	–	–	–		3	*100*	–	–	M	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	19	7	*28*	*72*	18	F	11	*32*	*68*	23	F	16	*40*	*60*	24	F	15	*56*	*44*	12	M	4	*31*	*69*	9	F	4	*36*	*64*	7	F	10	*40*	*60*	15	F
April	4	6	*55*	*45*	5	M	2	*67*	*33*	1	M	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	10	31	*53*	*47*	28	M	1	*50*	*50*	1	=	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	28	6	*24*	*76*	19	F	1	*100*	–	–	M	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
May	6	7	*58*	*42*	5	M	2	*50*	*50*	2	=	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	14	25	*48*	*52*	27	F	13	*39*	*61*	20	F	1	*33*	*67*	2	F	12	*29*	*71*	30	F	–	–	–	–		3	*33*	*67*	6	F	–	–	–	–	
,,	21	14	*37*	*63*	24	F	6	*37·5*	*62·5*	10	F	20	*39*	*61*	31	F	–	–	–	–		–	–	–	–		9	*35*	*65*	17	F	1	*33*	*67*	2	F
,,	28	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		41	*25*	*75*	125	F
,,	29	10	*18*	*82*	46	F	–	–	*100*	2	F	–	–	–	–		2	*100*	–	–	M	1	*14*	*86*	6	F	4	*57*	*43*	3	M	–	–	–	–	
,,	30	24	*44*	*56*	30	F	–	–	–	–		–	–	–	–		1	*100*	–	–	M	1	*14*	*86*	6	F	12	*29*	*71*	29	F	–	–	–	–	
,,	31	54	*39*	*61*	85	F	4	*44*	*56*	5	F	–	–	*100*	2	F	8	*57*	*43*	6	M	4	*25*	*75*	12	F	19	*41*	*59*	27	F	–	–	–	–	
June	2	3	*16*	*84*	16	F	1	*100*	–	–	M	–	–	–	–		2	*40*	*60*	3	F	2	*50*	*50*	2	=	4	*40*	*60*	6	F	–	–	–	–	
,,	3	6	*43*	*57*	8	F	5	*45*	*55*	6	F	–	–	*100*	1	F	5	*42*	*58*	7	F	–	–	–	–		7	*64*	*36*	4	M	–	–	–	–	
,,	3	2	*67*	*33*	1	M	6	*60*	*40*	4	M	152	*83*	*17*	31	M	–	–	*100*	9	F	–	–	–	–		–	–	–	–		–	–	–	–	
,,	4	–	–	–	–		1	*3*	*97*	28	F	469	*57*	*43*	355	M	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	14	99	*40*	*60*	147	F	7	*47*	*53*	8	F	–	–	–	–		13	*28*	*72*	33	F	6	*32*	*68*	13	F	89	*47*	*53*	102	F	–	–	–	–	

July	10	7	*47*	*53*	8	F	6	*29*	*71*	15	F	8	*24*	*76*	25	F	—	—	—	—		1	*50*	*50*	1	=	4	*80*	*20*	1	M	—	—	—	—	
,,	17	13	*43*	*57*	17	F	17	*50*	*50*	17	=	8	*36*	*64*	14	F	9	*64*	*36*	5	M	—	—	—	—		4	*44*	*56*	5	F	10	*48*	*52*	11	F
,,	21	16	*44*	*56*	20	F	16	*39*	*61*	25	F	19	*43*	*57*	25	F	9	*37·5*	*62·5*	15	F	5	*36*	*64*	9	F	4	*36*	*64*	7	F	—	—	—	—	
August	1	26	*47*	*53*	29	F	14	*54*	*46*	12	M	3	*37·5*	*62·5*	5	F	20	*51*	*49*	19	M	4	*40*	*60*	6	F	—	—	—	—		—	—	—	—	
,,	20	15	*36*	*64*	27	F	—	—	—	—		—	—	—	—		33	*35*	*65*	62	F	2	*40*	*60*	3	F	—	—	*100*	3	F	2	*29*	*71*	5	F
,,	20	—	—	—	—		—	—	*100*	1	F	1	*1*	*99*	170	F	2	*100*	—	—	M	—	—	—	—		—	—	—	—		—	—	—	—	
,,	21	12	*29*	*61*	19	F	3	*37·5*	*62·5*	5	F	—	—	—	—		25	*34*	*66*	49	F	—	—	—	—		3	*60*	*40*	2	M	—	—	—	—	
,,	23	—	—	—	—		4	*57*	*43*	3	M	60	*43*	*57*	79	F	—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—	
,,	23	—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—		—	—	*100*	9	F	—	—	—	—	
November	7	6	*43*	*57*	8	F	15	*52*	*48*	14	M	19	*38*	*62*	31	F	—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—	
,,	10	14	*42*	*58*	19	F	4	*33*	*67*	8	F	5	*33*	*67*	10	F	—	—	—	—		1	*3*	*67*	2	F	4	*57*	*43*	3	M	1	*50*	*50*	1	=
,,	18	31	*42*	*58*	42	F	23	*40*	*60*	34	F	32	*46*	*54*	38	F	14	*58*	*42*	10	M	5	*33*	*67*	10	F	6	*40*	*60*	9	F	2	*50*	*50*	2	=
,,	24	17	*39*	*61*	27	F	6	*37·5*	*62·5*	16	F	11	*48*	*52*	12	F	—	—	—	—		—	—	—	—		9	*82*	*18*	2	M	2	*33*	*67*	4	F
,,	28	18	*39*	*61*	28	F	11	*58*	*42*	8	M	—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—	
December	8	24	*50*	*50*	24	=	19	*59*	*41*	13	M	2	*29*	*71*	5	F	15	*44*	*56*	19	F	—	—	—	—		4	*44*	*56*	5	F	—	—	—	—	
,,	11	16	*43*	*57*	21	F	22	*52*	*48*	20	M	—	—	*100*	2	F	18	*50*	*50*	18	=	—	—	—	—		6	*50*	*50*	6	=	—	—	—	—	
,,	16	22	*71*	*21*	9	M	2	*33*	*67*	4	F	5	*36*	*64*	9	F	—	—	*100*	4	F	—	—	—	—		—	—	—	—		—	—	—	—	
,,	22	—	—	*100*	2	F	1	*17*	*83*	5	F	13	*43*	*57*	17	F	—	—	—	—		—	—	—	—		7	*64*	*36*	4	M	—	—	—	—	
1931.																																				
January	8	—	—	*100*	4	F	22	*51*	*49*	21	M	—	—	—	—		11	*37*	*63*	19	F	—	—	*100*	1	F	—	—	—	—		—	—	—	—	
,,	16	27	*37·5*	*62·5*	45	F	2	*25*	*75*	6	F	—	—	—	—		—	—	—	—		—	—	—	—		—	—	*100*	6	F	1	*50*	*50*	1	=
,,	17	14	*48*	*52*	15	F	10	*53*	*47*	9	M	1	*13*	*67*	2	F	—	—	*100*	1	F	—	—	—	—		10	*62·5*	*37·5*	6	M	—	—	—	—	
,,	23	1	*33*	*67*	2	F	23	*55*	*45*	19	M	26	*39*	*61*	40	F	33	*59*	*41*	23	M	—	—	—	—		1	*20*	*80*	4	F	—	—	*100*	2	F
February	3	7	*17*	*83*	35	F	14	*52*	*48*	13	M	31	*60*	*40*	21	M	—	—	—	—		—	—	—	—		4	*27*	*73*	11	F	—	—	*100*	4	F
,,	5	21	*40*	*60*	32	F	26	*51*	*49*	25	M	—	—	*100*	1	F	—	—	—	—		—	—	—	—		1	*50*	*50*	1	=	—	—	—	—	
,,	9	25	*43*	*57*	33	F	30	*49*	*51*	31	F	—	—	—	—		22	*61*	*39*	14	M	—	—	—	—		—	—	—	—		—	—	—	—	
,,	13	11	*44*	*56*	14	F	3	*27*	*73*	8	F	—	—	—	—		—	—	—	—		—	—	—	—		5	*42*	*58*	7	F	12	*44*	*56*	15	F
,,	16	1	*25*	*75*	3	F	14	*34*	*66*	27	F	11	*44*	*56*	14	F	12	*33*	*67*	24	F	—	—	—	—		4	*31*	*69*	9	F	1	*33*	*67*	2	F
,,	21	21	*47*	*53*	24	F	29	*43*	*57*	39	F	1	*100*	—	—	M	29	*66*	*24*	15	M	—	—	—	—		3	*60*	*40*	2	M	—	—	—	—	
,,	24	28	*65*	*35*	15	M	7	*24*	*76*	22	F	23	*50*	*50*	23	=	—	—	—	—		—	—	—	—		5	*38*	*62*	8	F	—	—	—	—	
,,	26	12	*40*	*60*	18	F	11	*61*	*39*	7	M	—	—	—	—		17	*40*	*60*	26	F	—	—	—	—		—	—	*100*	3	F	1	*50*	*50*	1	=
March	3	14	*47*	*53*	16	F	5	*36*	*64*	9	F	—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—	
,,	3	—	—	—	—		17	*50*	*50*	17	=	—	—	—	—		16	*46*	*54*	19	F	5	*29*	*71*	12	F	12	*80*	*20*	3	M	2	*50*	*50*	2	=
,,	5	18	*53*	*47*	16	M	24	*56*	*44*	19	M	14	*31*	*69*	31	F	—	—	—	—		4	*50*	*50*	4	=	6	*60*	*40*	4	M	5	*28*	*72*	13	F
,,	9	2	*40*	*60*	3	F	13	*41*	*59*	19	F	15	*39*	*61*	23	F	7	*24*	*76*	22	F	—	—	—	—		—	—	—	—		2	*33*	*67*	4	F
April	25	16	*43*	*57*	21	F	16	*46*	*54*	19	F	22	*54*	*46*	19	M	—	—	—	—		7	*44*	*56*	9	F	6	*55*	*45*	5	M	—	—	—	—	
,,	29	16	*39*	*61*	25	F	10	*48*	*52*	11	F	26	*39*	*61*	41	F	—	—	—	—		—	—	—	—		—	—	—	—		8	*31*	*69*	18	F
May	4	18	*55*	*45*	15	M	4	*14*	*86*	25	F	12	*32*	*68*	26	F	—	—	—	—		12	*52*	*48*	11	M	—	—	—	—		1	*33*	*67*	2	F
,,	11	20	*43*	*57*	26	F	27	*45*	*55*	33	F	19	*40*	*60*	28	F	—	—	—	—		—	—	—	—		14	*70*	*30*	6	M	1	*33*	*67*	2	F
,,	12	14	*54*	*46*	12	M	3	*50*	*50*	3	=	1	*25*	*75*	3	F	—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—	
,,	22	21	*47*	*53*	24	F	8	*26*	*74*	23	F	14	*40*	*60*	21	F	—	—	—	—		—	—	—	—		3	*37·5*	*62·5*	5	F	2	*33*	*67*	4	F
,,	26	21	*42*	*58*	29	F	15	*48*	*52*	16	F	3	*100*	—	—	M	19	*47·5*	*52·5*	21	F	—	—	—	—		5	*83*	*17*	1	M	—	—	—	—	
June	1	11	*37*	*63*	19	F	2	*40*	*60*	3	F	—	—	—	—		1	*100*	—	—	M	—	—	—	—		9	*69*	*31*	4	M	—	—	—	—	
,,	4	29	*45*	*55*	36	F	29	*48*	*52*	31	F	2	*100*	—	—	M	35	*49*	*51*	36	F	—	—	—	—		3	*33*	*67*	6	F	3	*33*	*67*	6	F
,,	4	6	*40*	*60*	9	F	11	*50*	*50*	11	=	—	—	—	—		—	—	—	—		—	—	—	—		6	*29*	*71*	15	F	2	*40*	*60*	3	F
,,	8	5	*42*	*58*	7	F	10	*62·5*	*37·5*	6	M	11	*34*	*66*	21	F	19	*49*	*51*	20	F	—	—	—	—		15	*47*	*53*	17	F	—	—	—	—	
,,	10	27	*44*	*56*	34	F	29	*41*	*59*	41	F	—	—	—	—		3	*30*	*70*	7	F	—	—	—	—		12	*52*	*48*	11	M	1	*33*	*67*	2	F
,,	15	20	*48*	*52*	22	F	19	*46*	*54*	22	F	18	*51*	*49*	17	M	—	—	—	—		—	—	—	—		7	*39*	*61*	11	F	—	—	*100*	1	F
,,	16	22	*48*	*52*	24	F	26	*50*	*50*	26	=	—	—	*100*	1	F	31	*47*	*53*	35	F	—	—	—	—		10	*48*	*52*	11	F	5	*50*	*50*	5	=
,,	23	29	*63*	*37*	17	M	15	*79*	*21*	4	M	23	*38*	*62*	37	F	—	—	—	—		—	—	—	—		3	*43*	*57*	4	F	3	*43*	*57*	4	F
July	3	17	*49*	*51*	18	F	9	*50*	*50*	9	=	15	*65*	*35*	8	M	—	—	—	—		—	—	—	—		4	*57*	*43*	3	M	—	—	*100*	1	F
,,	3	16	*67*	*33*	8	M	—	—	*100*	1	F	—	—	—	—		8	*62*	*38*	5	M	—	—	—	—		4	*50*	*50*	4	=	—	—	—	—	
,,	13	13	*48*	*52*	14	F	18	*47*	*53*	20	F	27	*47*	*53*	31	F	—	—	—	—		3	*50*	*50*	3	=	3	*43*	*57*	4	F	—	—	—	—	
,,	14	17	*57*	*43*	13	M	8	*62*	*38*	5	M	1	*100*	—	—	M	—	—	*100*	9	F	—	—	—	—		—	—	—	—		—	—	—	—	
,,	29	26	*15*	*85*	149	F	—	—	—	—		—	—	—	—		12	*63*	*37*	7	M	—	—	*100*	1	F	17	*52*	*48*	16	M	—	—	*100*	1	F
October	10	22	*51*	*49*	21	M	1	*50*	*50*	1	=	7	*70*	*30*	3	M	—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—	
,,	28	14	*45*	*55*	17	F	4	*50*	*50*	4	=	—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—	
November	2	—	—	*100*	3	F	2	*50*	*50*	2	=	2	*67*	*33*	1	M	—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—	
,,	27	5	*23*	*77*	17	F	—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—	
December	2	4	*40*	*60*	6	F	—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—	
,,	15	6	*32*	*68*	13	F	2	*50*	*50*	2	=	—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—	
	23	11	*61*	*39*	7	M	4	*57*	*43*	3	M	—	—	*100*	2	F	—	—				—	—				—	—				—	—	—	—	

seen from the table that few males were present in any landing and that not infrequently an entire catch would consist wholly of female fish. This is not explainable by any selective action of the nets as these were the same at the beginning as at the end of the season in 1930. Nor does it appear to be true that the males are not caught because they exhibit some difference (or absence) of movement. When present they are taken quite as successfully as the females.

There is no doubt, therefore, that on this particular fishing ground, during the first three or four months of the year, the Ray population may consist entirely or almost entirely of one sex of a single species. The composition of this population may change rapidly and completely during the brief season of the net fishery, which is simply the time during which fully adult fish are present on the ground in large numbers. The main population consists first, and for the greater part of the season, of mature females with, in some seasons at least, mature males appearing later and for a shorter time towards the end of the season.* Finally, for the greater part of the year, only a residuum of immature individuals of both sexes is present, the adult fish having migrated elsewhere.

Having discovered such very definite segregation of the sexes of *R. clavata* on the Plymouth net fishing ground, coupled with a definite migratory movement of greater or less extent, the question now arises as to whether or not this is an isolated phenomenon or whether there is evidence of similar segregations and migrations elsewhere and for other species. For the purpose of obtaining true samples of fish stocks fixed nets possess a unique superiority over other fishing implements such as trawls and long-lines in that their fishing action is restricted to one very small patch of ground. Unfortunately the writer is not aware of the existence of any other ray-net fishery such as that carried on from Plymouth at any other point on the coast, at any rate within his range of investigation. Nevertheless, a considerable though less complete body of evidence is available from catches obtained by other methods of fishing.

On the night of Saturday–Sunday, March 15th–16th, 1930, between the hours of 7 p.m. and 2 a.m., a steam trawler fishing in shallow water off the Cornish coast caught 210 large Rays, 207 of them being *R. clavata*, every one of which was a female. Obviously this vessel had fallen upon a shoal of female fish similar to that fished by the nets on the Plymouth grounds. It is not to be expected, however, that such a pure landing will occur in trawl or line fishing except at very rare intervals, because even one haul of a trawl or a fleet of lines once shot samples a large area of the sea floor ; and every landing is the product not of one but of many hauls

* Unfortunately, owing to the onset of unfavourable weather conditions, this fishery was brought to a premature close in both 1931 and 1932, so that it is not known whether or not the males appeared towards the end of the season in those years.

of the trawl or a fleet of lines several if not many times shot. That the landings from both trawlers and liners should, in spite of this, not infrequently consist largely and sometimes almost entirely of one sex of a single species points clearly to the occurrence of sexual segregation among species other than *R. clavata* and on grounds other than that fished by the Plymouth nets. Some of the most striking of such landings recorded by the present writer are enumerated below.

On June 3rd, 1930, a small inshore trawler fishing near Newlyn, Cornwall, brought ashore 205 Rays. Of these no less than 183 were *R. brachyura*, all immature, and containing 152 males. Nine *R. nævus* were included in this catch, every one a female. On the following day a small liner fishing on or near the same ground landed 853 Rays, 824 of which were immature specimens of *R. brachyura*. In this catch, however, males and females were present in more nearly equal numbers, there being 469 males and 355 females. *R. montagui* was the only other species included in the catch. Of these 29 individuals, all were adult fish and consisted of 28 females with only a single male included among them. In August of the same year this liner was still fishing on the same ground, but the *R. brachyura* which she was then landing were all mature fish which must have migrated there (*vide* **12**, p. 23). On August 20th this vessel landed 171 adult Rays of this species of which only one was a male. Three days later another but smaller catch was landed in which adult males and females were almost equally represented, there being 60 of the former and 79 of the latter sex. After this date the writer had to leave Newlyn, otherwise it would have been interesting to have noted whether or not the males eventually exceeded the females in number or even completely "replaced" them as happened in the case of *R. clavata* on the Plymouth net grounds in the spring of the year.

There was another interesting landing on August 23rd. A liner which had been fishing in deep water caught only 9 Rays on its full fleet of lines which had been shot once. All these were *R. fullonica* and all adult females.

On July 29th, 1931, a liner from the same port landed 175 *R. clavata* in addition to small numbers of other species. Of these Thornback Rays 149 were adult females; the 26 males were mostly immature. On May 31st, 1932, a liner's catch was observed to contain 19 *R. marginata*, all females over 100 cm. in width of disc, and all containing ripening ova. On June 2nd another landing contained 39 *R. batis* of which 37 were mature or nearly mature males and 2 were immature females.

In no instance was any information available as to how the fish were distributed on the lines. In the hope that an interesting catch similar to one of those mentioned might be taken in his presence the writer went to sea in a liner and recorded the species and sex of every Ray which

came up in the order in which it appeared (*vide* **12**, p. 28). Unfortunately only a very " ordinary " catch rewarded his efforts ; 192 *R. clavata* were taken the majority of which were immature and the two sexes were more or less indiscriminately intermingled all along the line. There was a slight excess of females. The catch of *R. nævus*, the only other species taken in any numbers, was more interesting ; 142 specimens were taken, 104 of which were males, most of them fully adult. The females, of which only an occasional specimen occurred here and there at wide intervals, were found on examination to be mainly immature, only 7 out of the total 38 containing ripe or ripening ova.

Other species were represented by only a very few scattered individuals.

It seems clear, however, from the main body of the evidence brought together in this paper, that the so-called abnormal sex-ratio found among the commercial landings of Rays and Skates is due not to any differential production of males and females at birth, or to a differential mortality after birth, but to differential catches of the sexes owing to segregation of the larger fish into unisexual shoals for at least part of the year. The females, particularly when in a gravid or spawning condition, form more compact schools than do the males, and therefore tend to be captured in greater numbers.

This fact is of much more than theoretical interest ; it has a direct practical bearing on the commercial fishery for these species, which have now become of primary and growing importance as national food fishes. It is well known that for the maintenance of any animal stock the female is, from the numerical point of view, the more important sex. Since, therefore, the females of the Raiidæ as a general rule are captured in considerably greater numbers than the males, it follows that the greatest drain of the fishery upon the fish stock falls upon its most vulnerable part. These Elasmobranch fishes will therefore be much more rapidly and more severely affected by intense fishing in any particular area—such as the English Channel—than species in which there is not an excess of females caught by ordinary fishing methods. Such an effect will tend to be greatly minimised in the case of strongly migratory species—such as the Spur Dogfish, for instance. The stock of such fishes on any particular fishing ground will be exposed to capture only for so long as it remains in that region. Not only so, its numbers will always tend to be sustained or replenished by immigrants from other localities where fishing is less intense or non-existent. It may be highly significant, therefore, that from being a very flourishing concern, the English Channel fishery for Spur Dogfish has, in the course of the last five years, shrunken to almost negligible proportions* owing to the

* The Ministry of Agriculture and Fisheries returns of landings from the English Channel during this period are : 1928, 54,206 cwt. ; 1929, 28,920 cwt. ; 1930, 27,188 cwt. ; 1931, 16,049 cwt. ; 1932, figures not yet available.

scarcity of these fish—*and that in spite of their being a pelagic and migratory species.*

On the other hand, the adverse effect of intensive fishing will be correspondingly increased in the case of species—such as the Raiidæ—whose migrations appear to be very restricted or even quite local in character. Moreover, these very same factors which by their action will assist the commercial forces of depletion will be equally potent in retarding recovery once a decline has been brought about in the stocks.

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Some Records of Parasitic Worms from Marine Fishes at Plymouth.

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Records of parasitic worms from British marine fishes are still rather scanty. A good deal of attention has been paid to the subject of the Trematodes by Nicoll, whose valuable list (1915) is indispensable to anyone working in this field. Nicoll is himself responsible for the records of the majority of the 49 species of Trematodes given in the second edition (1931) of the "Plymouth Marine Fauna." The only work done on the Cestodes of fishes at Plymouth appears to have been that of Woodland (1927, a and b), as a result of which 14 species have been placed on record. Very few data are available as to the Nematodes, and none as to the Acanthocephala, of the Plymouth fauna.

During the latter part of May, 1932, the senior author spent some ten days at the Plymouth Laboratory of the Marine Biological Association, collecting parasitic worms from fishes. Over 100 fish were dissected, including representatives of about 40 species. No attempt was made to collect every parasite, including larval forms, but attention was paid almost exclusively to the adult forms living in the alimentary canal or on the gills and external surfaces. The parasites found were simply preserved at once, and were not determined until after the author's return to London.

The hosts were almost all named by Mr. G. A. Steven, of the Laboratory staff, to whom grateful acknowledgment is due for his kind and unfailing help. Mr. Steven suggested that it might be of some interest to record the sizes of the fish found to be infested with parasites. This had not been done during the first day of collecting, but was done regularly thereafter. For all species except skates the measurement given is the length from snout to tip of tail, to the nearest 5 mm. In the case of skates Mr. Steven's usual practice was followed of measuring across the "wings" from tip to tip.

The names here used for the hosts are those used in the " Plymouth Marine Fauna " (second edition, 1931).

The junior author has, at various times, also visited the Laboratory at Plymouth and collected Trematodes from fishes. His identifications are principally from living specimens. In order to avoid the duplication of records, it has been thought desirable to include them all in one list. Both authors, of course, frequently collected the same species from the same hosts, and where this occurred the records given in the subjoined list, unless otherwise indicated, are the senior author's.

The joint list contains 12 species of Trematodes, 4 of Cestodes, 11 of Nematodes, and 2 of Acanthocephala which have not hitherto been included in the " Plymouth Marine Fauna." These are indicated by an asterisk (*). Hosts which are believed to be new for the species in question are indicated by a dagger (†), while a double dagger (‡) indicates that the record is the junior author's.

Some of the Nematodes, unfortunately, could not be specifically determined owing to the absence of male specimens or to the incompleteness of the material. The occurrence of the little-known form Ascarophis is of particular interest, and a paper on this Nematode will appear elsewhere. *Echinorhynchus leidyi* has hitherto been recorded only from " lake trout " in the Great Lakes region of North America. The determination of the specimens from the rockling is therefore open to question, though they appear to agree very closely with the description of *E. leidyi*.

As regards the nomenclature of the parasites recorded, current usage has generally been followed. Two nomenclatural changes have, however, been introduced among the Trematodes, and these call for some explanation.

(1) We have treated the genus *Paracotyle* Johnstone, 1911, as synonymous with *Microbothrium* Olsson, 1869, because *P. caniculæ*, the genotype of Paracotyle, appears to be almost certainly congeneric with *M. apiculatum*, the genotype of Microbothrium. A paper on this form by the junior author will appear elsewhere.

(2) We have substituted the genus *Mazocraes* Hermann, 1782, for *Octobothrium* F. S. Leuckart, 1827. It appears to be generally admitted that its genotype, *Mazocraes alosæ* Hermann, is identical with *Octobothrium lanceolatum* Leuckart, the genotype of Octobothrium. Hence the name Octobothrium must fall into the synonymy of Mazocraes, and there is no justification for retaining the better-known name Octobothrium and treating Mazocraes as a synonym, as has been done by some recent authors.

The junior author has found certain Trematodes which are believed to represent new species. These are not included in the present list, and will be described elsewhere.

It is a pleasure to acknowledge the kind attention and help which we received at the hands of the Director and staff of the Plymouth Laboratory, and the interest which they took in our work.

LIST OF SPECIES COLLECTED.

TREMATODA.

Order MONOGENEA.

Fam. **Capsalidæ** (=Tristomatidæ).

ENTOBDELLA SOLEÆ (v. Ben. and Hesse, 1864). Skin of *Solea vulgaris*.

Fam. **Udonellidæ.**

*UDONELLA CALIGORUM Johnston, 1835. Numerous young specimens attached to a Caligus ♀ (determined by Dr. I. Gordon as probably *C. rapax* M. Edw., 1840) found free in plankton, January 12th, 1932, by Mr. F. S. Russell.

Fam. **Monocotylidæ.**

CALICOTYLE KROYERI Diesing, 1850. Cloaca of *Raja maculata*.

*MICROBOTHRIUM [PARACOTYLE] CANICULÆ (Johnstone, 1911). Skin, on dorsal surface, of ‡*Scyllium canicula*.

ACANTHOCOTYLE SP. Skin of *Raja clavata* and ‡*R. maculata*.

Fam. **Polystomatidæ.**

*ONCHOCOTYLE APPENDICULATA (Kuhn, 1829). Gills of *Raja clavata* (26 cm. across), *R. blanda* (41 cm.), †‡*R. oxyrhynchus*, ‡*R. batis* and ‡*Scyllium canicula*.

Fam. **Octocotylidæ.**

*MAZOCRAES ALOSÆ Hermann, 1782 (=*Octobothrium lanceolatum* Leuckart, 1827). Gills of ‡*Clupea finta*.

*MAZOCRAES HARENGI (v. Ben. and Hesse, 1864). Gills of †‡*Clupea alosa*.

MAZOCRAES SCOMBRI (Kuhn, 1829). Gills of *Scomber scombrus*.

*DACTYCOTYLE DENTICULATA (Olsson, 1876). Gills of †‡*Merluccius merluccius*.

DACTYCOTYLE MERLANGI (Kuhn, 1829). Gills of ‡*Gadus merlangus*.

*GASTROCOTYLE TRACHURI v. Ben. and Hesse, 1864. Gills of ‡*Caranx trachurus*.

AXINE BELONES Abildgaard, 1794. Gills of §*Belone acus* (abundant in several specimens).

§ Collected by Miss M. Rothschild.

Order DIGENEA.

Fam. **Bucephalidæ.**

BUCEPHALOPSIS GRACILESCENS (Rud., 1819). Stomach and intestine of *Lophius piscatorius* (in each of 3 specimens); 2 specimens in stomach of †*Conger vulgaris* (about 3 ft.), possibly accidental.

RHIPIDOCOTYLE MINIMA (Wagener, 1852). Intestine of *Trigla hirundo* (24 cm.) and *T. cuculus* (24 cm.).

PROSORHYNCHUS ACULEATUS Odhner, 1904. Stomach, intestine and rectum of *Conger vulgaris*.

PROSORHYNCHUS CRUCIBULUM (Rud., 1819). Intestine of *Conger vulgaris*; one immature specimen (?) in intestine of *Lophius piscatorius* (47 cm.).

Fam. **Fellodistomidæ** (=Steringophoridæ).

*STERINGOPHORUS FURCIGER (Olsson, 1868). Immature specimens in stomach and intestine of *Pleuronectes limanda* (18·5 and 19 cm.).

STERINGOTREMA CLUTHENSE (Nicoll, 1909). Immature specimens in intestine of *Pleuronectes microcephalus* (21·5 cm.) and *P. limanda* (18·5 cm.).

STERINGOTREMA DIVERGENS (Rud., 1809). Stomach and intestine of *Blennius ocellaris*, each of three specimens (12–14 cm.).

Fam. **Zoogonidæ.**

*ZOOGONUS? RUBELLUS (Olsson, 1868). Immature specimens in intestine of †*Pleuronectes limanda* (16 cm.) and †*Labrus mixtus* (27 cm.).

ZOOGONOIDES VIVIPARUS (Olsson, 1868). Rectum of ‡*Callionymus lyra* and ‡*Pleuronectes microcephalus*; immature specimens in rectum of *Pleuronectes platessa* (36·5 cm.).

Fam. **Allocreadiidæ.**

PODOCOTYLE ATOMON (Rud., 1802). Intestine of *Cottus bubalis*.

PODOCOTYLE REFLEXA (Creplin, 1825). Intestine of *Spinachia vulgaris*, each of 4 specimens (12·5–16 cm.); intestine of †‡*Onos tricirratus*.

PODOCOTYLE SYNGNATHI Nicoll, 1913. One specimen in intestine of *Entelurus æquoreus* (44 cm.).

LEBOURIA VARIA Nicoll, 1910. Intestine of *Callionymus lyra*, †*Labrus mixtus* (two out of four specimens, ♂ 27 cm., ♀ 21 cm.) and †‡*Labrus bergylta*.

*HELICOMETRA FASCIATA (Rud., 1819). Intestine of ‡*Crenilabrus melops*.

TABLE II.

Composition of Landings from Ray Nets—Seasons 1930, 1931, and 1932.

(Not included in Table III, p. 620.)

Date.	Total number of Fish in Landing.	Total ♂♂	Total ♀♀	Percentage ♂♂	Percentage ♀♀
1930.					
February 20	137	7	130	5	95
,, 20	65	3	62	5	95
,, 21	156	7	149	4	96
,, 21	52	3	49	6	94
,, 24	197	21	176	11	89
,, 24	36	13	23	36	64
March 4	34	1	33	3	97
,, 8	26	8	18	31	69
,, 8	38	12	26	32	68
,, 10	35	2	33	6	94
,, 10	14	0	14	0	100
,, 11	104	67	37	64	36
,, 12	69	28	41	41	59
,, 15	38	38	0	100	0
1931.					
January 12	161	2	159	1	99
,, 13	5	0	5	0	100
,, 13	14	0	14	0	100
,, 13	102	0	102	0	100
,, 16	51	2	49	4	96
,, 19	60	0	60	0	100
,, 19	72	0	72	0	100
,, 19	68	2	66	3	97
,, 20	108	3	105	3	97
,, 20	53	2	51	4	96
,, 22	64	1	63	2	98
,, 22	12	0	12	0	100
,, 23	72	9	63	12·5	87·5
,, 23	68	8	60	12	88
February 3	17	1	16	6	94
,, 3	24	0	24	0	100
,, 3	38	1	37	3	97
,, 4	5	0	5	0	100
,, 4	14	0	14	0	100
,, 4	102	0	102	0	100
1932.					
January 9	75	3	72	4	96
February 1	53	1	52	2	98
,, 1	15	0	15	0	100
,, 1	24	0	24	0	100
,, 1	3	0	3	0	100
,, 2	23	0	23	0	100
,, 2	51	8	43	16	84
,, 3	16	0	16	0	100
,, 3	8	0	8	0	100
,, 3	50	2	48	4	96
,, 4	34	4	30	12	88
,, 4	22	1	21	5	95
,, 4	14	0	14	0	100
,, 6	15	0	15	0	100
,, 8	64	8	56	12·5	87·5
,, 8	14	0	14	0	100
,, 8	11	2	9	18	82
,, 8	7	1	6	14	86
,, 9	10	0	10	0	100
,, 9	10	0	10	0	100
,, 9	12	0	12	0	100

TABLE III.

Numbers (with percentages) of Males and Females of seven species of Raia included in Samples from Landings from the English Channel—irrespective of Mode of Capture.

Date.		R. clavata.					R. montagui.					R. brachyura.					R. nævus.					R. circularis.					R. fullonica.					R. batis.				
		Male.		Female.		Sex Predominating.	Male.		Female.		Sex Predominating.	Male.		Female.		Sex Predominating.	Male.		Female.		Sex Predominating.	Male.		Female.		Sex Predominating.	Male.		Female.		Sex Predominating.	Male.		Female.		Sex Predominating.
		No.	%	%	No.		No.	%	%	No.		No.	%	%	No.		No.	%	%	No.		No.	%	%	No.		No.	%	%	No.		No.	%	%	No.	
1930																																				
January	15	33	*52*	*48*	30	M	9	*30*	*70*	21	F	11	*42*	*58*	15	F	–	–	–	–		–	–	–	–		12	*67*	*33*	6	M	–	–	–	–	
,,	16	2	*100*	–	–	M	24	*47*	*53*	27	F	22	*38*	*62*	36	F	25	*51*	*49*	24	M	–	–	–	–		2	*50*	*50*	2	=	–	–	–	–	
,,	17	39	*62*	*38*	24	M	4	*33*	*67*	8	F	5	*50*	*50*	5	=	–	–	–	–		3	*43*	*57*	4	F	2	*33*	*67*	4	F	2	*100*	–	–	M
,,	17	10	*40*	*60*	15	F	7	*47*	*53*	8	F	–	–	–	–		1	*100*	–	–	M	–	–	–	–		5	*42*	*58*	7	F	1	*50*	*50*	1	=
,,	20	3	*60*	*40*	2	M	23	*49*	*51*	22	M	18	*53*	*47*	16	M	13	*54*	*46*	16	M	–	–	–	–		4	*57*	*43*	3	M	–	–	–	–	
,,	20	17	*42·5*	*57·5*	23	F	17	*44*	*56*	22	F	–	–	*100*	1	F	–	–	–	–		–	–	–	–		1	*50*	*50*	1	=	–	–	–	–	
,,	22	12	*22*	*78*	43	F	15	*60*	*40*	10	M	10	*48*	*52*	11	F	–	–	–	–		–	–	–	–		–	–	*100*	3	F	–	–	–	–	
,,	23	11	*32*	*68*	23	F	29	*48*	*52*	31	F	1	*100*	–	–	M	17	*44*	*56*	22	F	–	–	–	–		2	*50*	*50*	2	=	2	*50*	*50*	2	=
,,	24	10	*45*	*55*	12	F	8	*44*	*56*	10	F	10	*32*	*68*	21	F	–	–	–	–		–	–	–	–		1	*100*	–	–	M	–	–	–	–	
,,	25	10	*40*	*60*	15	F	12	*43*	*57*	16	F	–	–	–	–		11	*46*	*54*	13	F	–	–	–	–		2	*25*	*75*	6	F	–	–	*100*	1	F
,,	27	8	*44*	*56*	10	F	23	*59*	*41*	16	M	4	*36*	*64*	7	F	14	*82*	*18*	3	M	–	–	–	–		4	*40*	*60*	6	F	22	*56*	*44*	17	M
,,	31	20	*61*	*39*	13	M	12	*39*	*61*	19	F	–	–	*100*	1	F	13	*30*	*70*	31	F	–	–	–	–		4	*50*	*50*	4	=	1	*50*	*50*	1	=
February	2	23	*62*	*38*	14	M	2	*12*	*88*	14	F	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	3	6	*60*	*40*	4	M	8	*50*	*50*	8	=	10	*40*	*60*	15	F	–	–	*100*	10	F	–	–	–	–		–	–	*100*	3	F	–	–	–	–	
,,	3	19	*56*	*44*	15	M	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	5	33	*43*	*57*	43	F	4	*44*	*56*	5	F	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	11	10	*50*	*50*	10	=	11	*31*	*69*	24	F	17	*30*	*70*	40	F	–	–	–	–		–	–	*100*	1	F	4	*67*	*33*	2	M	–	–	–	–	
,,	11	13	*57*	*43*	10	M	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	17	13	*46*	*54*	15	F	20	*42*	*58*	28	F	15	*43*	*57*	20	F	5	*31*	*69*	11	F	4	*33*	*67*	8	F	3	*33*	*67*	6	F	–	–	–	–	
,,	17	22	*61*	*39*	14	M	13	*42*	*58*	18	F	16	*42*	*58*	22	F	6	*32*	*68*	13	F	–	–	–	–		12	*50*	*50*	12	=	3	*75*	*25*	1	M
,,	17	14	*38*	*62*	23	F	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	27	28	*37*	*63*	47	F	3	*50*	*50*	3	=	–	–	*100*	1	F	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
March	3	17	*42·5*	*57·5*	23	F	1	*33*	*67*	2	F	–	–	–	–		1	*100*	–	–	M	–	–	–	–		–	–	–	–		–	–	–	–	
,,	5	10	*37*	*63*	17	F	11	*44*	*56*	14	F	22	*41*	*59*	32	F	3	*37·5*	*62·5*	5	F	3	*30*	*70*	7	F	6	*60*	*40*	4	M	–	–	–	–	
,,	7	21	*60*	*40*	14	M	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	12	23	*46*	*54*	27	F	19	*46*	*54*	22	F	28	*42*	*58*	39	F	13	*42*	*58*	18	F	–	–	–	–		9	*45*	*55*	11	F	3	*50*	*50*	3	=
,,	16	–	–	*100*	207	F	–	–	–	–		3	*100*	–	–	M	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	19	7	*28*	*72*	18	F	11	*32*	*68*	23	F	16	*40*	*60*	24	F	15	*56*	*44*	12	M	4	*31*	*69*	9	F	4	*36*	*64*	7	F	10	*40*	*60*	15	F
April	4	6	*55*	*45*	5	M	2	*67*	*33*	1	M	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	10	31	*53*	*47*	28	M	1	*50*	*50*	1	=	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	28	6	*24*	*76*	19	F	1	*100*	–	–	M	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
May	6	7	*58*	*42*	5	M	2	*50*	*50*	2	=	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	14	25	*48*	*52*	27	F	13	*39*	*61*	20	F	1	*33*	*67*	2	F	12	*29*	*71*	30	F	–	–	–	–		3	*33*	*67*	6	F	–	–	–	–	
,,	21	14	*37*	*63*	24	F	6	*37·5*	*62·5*	10	F	20	*39*	*61*	31	F	–	–	–	–		–	–	–	–		9	*35*	*65*	17	F	1	*33*	*67*	2	F
,,	28	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		41	*25*	*75*	125	F
,,	29	10	*18*	*82*	46	F	–	–	*100*	2	F	–	–	–	–		2	*100*	–	–	M	1	*14*	*86*	6	F	4	*57*	*43*	3	M	–	–	–	–	
,,	30	24	*44*	*56*	30	F	–	–	–	–		–	–	–	–		1	*100*	–	–	M	1	*14*	*86*	6	F	12	*29*	*71*	29	F	–	–	–	–	
,,	31	54	*39*	*61*	85	F	4	*44*	*56*	5	F	–	–	*100*	2	F	8	*57*	*43*	6	M	4	*25*	*75*	12	F	19	*41*	*59*	27	F	–	–	–	–	
June	2	3	*16*	*84*	16	F	1	*100*	–	–	M	–	–	–	–		2	*40*	*60*	3	F	2	*50*	*50*	2	=	4	*40*	*60*	6	F	–	–	–	–	
,,	3	6	*43*	*57*	8	F	5	*45*	*55*	6	F	–	–	*100*	1	F	5	*42*	*58*	7	F	–	–	–	–		7	*64*	*36*	4	M	–	–	–	–	
,,	3	2	*67*	*33*	1	M	6	*60*	*40*	4	M	152	*83*	*17*	31	M	–	–	*100*	9	F	–	–	–	–		–	–	–	–		–	–	–	–	
,,	4	–	–	–	–		1	*3*	*97*	28	F	469	*57*	*43*	355	M	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	14	99	*40*	*60*	147	F	7	*47*	*53*	8	F	–	–	–	–		13	*28*	*72*	33	F	6	*32*	*68*	13	F	89	*47*	*53*	102	F	–	–	–	–	

July	**10**	**7**	**47**	**53**	**8**	**F**	**6**	**29**	**71**	**15**	**F**	**8**	**24**	**76**	**25**	**F**	–	–	–	–		**1**	**60**	**60**	**1**	**=**	**4**	**80**	**20**	**1**	**M**	–	–	–	–	
,,	17	13	43	57	17	F	17	50	50	17	=	8	36	64	14	F	9	64	36	5	M	–	–	–	–		4	44	56	5	F	10	48	52	11	F
,,	21	16	44	56	20	F	16	39	61	25	F	19	43	57	25	F	9	37·5	62·5	15	F	5	36	64	9	F	4	36	64	7	F	–	–	–	–	
August	1	26	47	53	29	F	14	54	46	12	M	3	37·5	62·5	5	F	20	51	49	19	M	4	40	60	6	F	–	–	–	–		–	–	–	–	
,,	20	15	36	64	27	F	–	–	–	–		–	–	–	–		33	35	65	62	F	2	40	60	3	F	–	–	100	3	F	2	29	71	5	F
,,	20	–	–	–	–		–	–	100	1	F	1	1	99	170	F	2	100	–	–	M	–	–	–	–		–	–	–	–		–	–	–	–	
,,	21	12	29	61	19	F	3	37·5	62·5	5	F	–	–	–	–		25	34	66	49	F	–	–	–	–		3	60	40	2	M	–	–	–	–	
,,	23	–	–	–	–		4	57	43	3	M	60	43	57	79	F	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	23	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	100	9	F	–	–	–	–	
November	7	6	43	57	8	F	15	52	48	14	M	19	38	62	31	F	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	10	14	42	58	19	F	4	33	67	8	F	5	33	67	10	F	–	–	–	–		1	3	67	2	F	4	57	43	3	M	1	50	50	1	=
,,	18	31	42	58	42	F	23	40	60	34	F	32	46	54	38	F	14	58	42	10	M	5	33	67	10	F	6	40	60	9	F	2	50	50	2	=
,,	24	17	39	61	27	F	6	37·5	62·5	10	F	11	48	52	12	F	–	–	–	–		–	–	–	–		9	82	18	2	M	2	33	67	4	F
,,	28	18	39	61	28	F	11	58	42	8	M	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
December	8	24	50	50	24	=	19	59	41	13	M	2	29	71	5	F	15	44	56	19	F	–	–	–	–		4	44	56	5	F	–	–	–	–	
,,	11	16	43	57	21	F	22	52	48	20	M	–	–	100	2	F	18	50	50	18	=	–	–	–	–		6	50	50	6	=	–	–	–	–	
,,	16	22	71	21	9	M	2	33	67	4	F	5	36	64	9	F	–	–	100	4	F	–	–	–	–		–	–	–	–		–	–	–	–	
,,	22	–	–	100	2	F	1	17	83	5	F	13	43	57	17	F	–	–	–	–		–	–	–	–		7	64	36	4	M	–	–	–	–	
1931.																																				
January	8	–	–	100	4	F	22	51	49	21	M	–	–	–	–		11	37	63	19	F	–	–	100	1	F	–	–	–	–		–	–	–	–	
,,	16	27	37·5	62·5	45	F	2	25	75	6	F	–	–	–	–		–	–	–	–		–	–	–	–		–	–	100	6	F	1	50	50	1	=
,,	17	14	48	52	15	F	10	53	47	9	M	1	13	67	2	F	–	–	100	1	F	–	–	–	–		10	62·5	37·5	6	M	–	–	–	–	
,,	23	1	33	67	2	F	23	55	45	19	M	26	39	61	40	F	33	59	41	23	M	–	–	–	–		1	20	80	4	F	–	–	100	2	F
February	3	7	17	83	35	F	14	52	48	13	M	31	60	40	21	M	–	–	–	–		–	–	–	–		4	27	73	11	F	–	–	100	4	F
,,	5	21	40	60	32	F	26	51	49	25	M	–	–	100	1	F	–	–	–	–		–	–	–	–		1	50	50	1	=	–	–	–	–	
,,	9	25	43	57	33	F	30	49	51	31	F	–	–	–	–		22	61	39	14	M	–	–	–	–		–	–	–	–		–	–	–	–	
,,	13	11	44	56	14	F	3	27	73	8	F	–	–	–	–		–	–	–	–		–	–	–	–		5	42	58	7	F	12	44	56	15	F
,,	16	1	25	75	3	F	14	34	66	27	F	11	44	56	14	F	12	33	67	24	F	–	–	–	–		4	31	69	9	F	1	33	67	2	F
,,	21	21	47	53	24	F	29	43	57	39	F	1	100	–	–	M	29	66	24	15	M	–	–	–	–		3	60	40	2	M	–	–	–	–	
,,	24	28	65	35	15	M	7	24	76	22	F	23	50	50	23	=	–	–	–	–		–	–	–	–		5	38	62	8	F	–	–	–	–	
,,	26	12	40	60	18	F	11	61	39	7	M	–	–	–	–		17	40	60	26	F	–	–	–	–		–	–	100	3	F	1	50	50	1	=
March	3	14	47	53	16	F	5	36	64	9	F	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	3	–	–	–	–		17	50	50	17	=	–	–	–	–		16	46	54	19	F	5	29	71	12	F	12	80	20	3	M	2	50	50	2	=
,,	5	18	53	47	16	M	24	56	44	19	M	14	31	69	31	F	–	–	–	–		4	50	50	4	=	6	60	40	4	M	5	28	72	13	F
,,	9	2	40	60	3	F	13	41	59	19	F	15	39	61	23	F	7	24	76	22	F	–	–	–	–		–	–	–	–		2	33	67	4	F
April	25	16	43	57	21	F	16	46	54	19	F	22	54	46	19	M	–	–	–	–		7	44	56	9	F	6	55	45	5	M	–	–	–	–	
,,	29	16	39	61	25	F	10	48	52	11	F	26	39	61	41	F	–	–	–	–		–	–	–	–		–	–	–	–		8	31	69	18	F
May	4	18	55	45	15	M	4	14	86	25	F	12	32	68	26	F	–	–	–	–		12	52	48	11	M	–	–	–	–		1	33	67	2	F
,,	11	20	43	57	26	F	27	45	55	33	F	19	40	60	28	F	–	–	–	–		–	–	–	–		14	70	30	6	M	1	33	67	2	F
,,	12	14	54	46	12	M	3	50	50	3	=	1	25	75	3	F	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	22	21	47	53	24	F	8	26	74	23	F	14	40	60	21	F	–	–	–	–		–	–	–	–		3	37·5	62·5	5	F	2	33	67	4	F
,,	26	21	42	58	29	F	15	48	52	16	F	3	100	–	–	M	19	47·5	52·5	21	F	–	–	–	–		5	83	17	1	M	–	–	–	–	
June	1	11	37	63	19	F	2	40	60	3	F	–	–	–	–		1	100	–	–	M	–	–	–	–		9	69	31	4	M	–	–	–	–	
,,	4	29	45	55	36	F	29	48	52	31	F	2	100	–	–	M	35	48	51	36	F	–	–	–	–		3	33	67	6	F	3	33	67	6	F
,,	4	6	40	60	9	F	11	50	50	11	=	–	–	–	–		–	–	–	–		–	–	–	–		6	29	71	15	F	2	40	60	3	F
,,	8	5	42	58	7	F	10	62·5	37·5	6	M	11	34	66	21	F	19	49	51	20	F	–	–	–	–		15	47	53	17	F	–	–	–	–	
,,	10	27	44	56	34	F	29	41	59	41	F	–	–	–	–		3	30	70	7	F	–	–	–	–		12	52	48	11	M	1	33	67	2	F
,,	15	20	48	52	22	F	19	46	54	22	F	18	51	49	17	M	–	–	–	–		–	–	–	–		7	39	61	11	F	–	–	100	1	F
,,	16	22	48	52	24	F	26	50	50	26	=	–	–	100	1	F	31	47	53	35	F	–	–	–	–		10	48	52	11	F	5	50	50	5	=
,,	23	29	63	37	17	M	15	79	21	4	M	23	38	62	37	F	–	–	–	–		–	–	–	–		3	43	57	4	F	3	43	57	4	F
July	3	17	49	51	18	F	9	50	50	9	=	15	65	35	8	M	–	–	–	–		–	–	–	–		4	57	43	3	M	–	–	100	1	F
,,	3	16	67	33	8	M	–	–	100	1	F	–	–	–	–		8	62	38	5	M	–	–	–	–		4	50	50	4	=	–	–	–	–	
,,	13	13	48	52	14	F	18	47	53	20	F	27	47	53	31	F	–	–	–	–		3	50	50	3	=	3	43	57	4	F	–	–	–	–	
,,	14	17	57	43	13	M	8	62	38	5	M	1	100	–	–	M	–	–	100	9	F	–	–	–	–		–	–	–	–		–	–	–	–	
,,	29	26	15	85	149	F	–	–	–	–		–	–	–	–		12	63	37	7	M	–	–	100	1	F	17	52	48	16	M	–	–	100	1	F
October	10	22	51	49	21	M	1	50	50	1	=	7	70	30	3	M	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	28	14	45	55	17	F	4	50	50	4	=	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
November	2	–	–	100	3	F	2	50	50	2	=	2	67	33	1	M	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	27	5	23	77	17	F	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
December	2	4	40	60	6	F	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	15	6	32	68	13	F	2	50	50	2	=	–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–		–	–	–	–	
,,	23	11	61	39	7	M	4	57	43	3	M	–	–	100	2	F	–	–				–	–				–	–				–	–	–	–	

seen from the table that few males were present in any landing and that not infrequently an entire catch would consist wholly of female fish. This is not explainable by any selective action of the nets as these were the same at the beginning as at the end of the season in 1930. Nor does it appear to be true that the males are not caught because they exhibit some difference (or absence) of movement. When present they are taken quite as successfully as the females.

There is no doubt, therefore, that on this particular fishing ground, during the first three or four months of the year, the Ray population may consist entirely or almost entirely of one sex of a single species. The composition of this population may change rapidly and completely during the brief season of the net fishery, which is simply the time during which fully adult fish are present on the ground in large numbers. The main population consists first, and for the greater part of the season, of mature females with, in some seasons at least, mature males appearing later and for a shorter time towards the end of the season.* Finally, for the greater part of the year, only a residuum of immature individuals of both sexes is present, the adult fish having migrated elsewhere.

Having discovered such very definite segregation of the sexes of *R. clavata* on the Plymouth net fishing ground, coupled with a definite migratory movement of greater or less extent, the question now arises as to whether or not this is an isolated phenomenon or whether there is evidence of similar segregations and migrations elsewhere and for other species. For the purpose of obtaining true samples of fish stocks fixed nets possess a unique superiority over other fishing implements such as trawls and long-lines in that their fishing action is restricted to one very small patch of ground. Unfortunately the writer is not aware of the existence of any other ray-net fishery such as that carried on from Plymouth at any other point on the coast, at any rate within his range of investigation. Nevertheless, a considerable though less complete body of evidence is available from catches obtained by other methods of fishing.

On the night of Saturday–Sunday, March 15th–16th, 1930, between the hours of 7 p.m. and 2 a.m., a steam trawler fishing in shallow water off the Cornish coast caught 210 large Rays, 207 of them being *R. clavata*, every one of which was a female. Obviously this vessel had fallen upon a shoal of female fish similar to that fished by the nets on the Plymouth grounds. It is not to be expected, however, that such a pure landing will occur in trawl or line fishing except at very rare intervals, because even one haul of a trawl or a fleet of lines once shot samples a large area of the sea floor ; and every landing is the product not of one but of many hauls

* Unfortunately, owing to the onset of unfavourable weather conditions, this fishery was brought to a premature close in both 1931 and 1932, so that it is not known whether or not the males appeared towards the end of the season in those years.

of the trawl or a fleet of lines several if not many times shot. That the landings from both trawlers and liners should, in spite of this, not infrequently consist largely and sometimes almost entirely of one sex of a single species points clearly to the occurrence of sexual segregation among species other than *R. clavata* and on grounds other than that fished by the Plymouth nets. Some of the most striking of such landings recorded by the present writer are enumerated below.

On June 3rd, 1930, a small inshore trawler fishing near Newlyn, Cornwall, brought ashore 205 Rays. Of these no less than 183 were *R. brachyura*, all immature, and containing 152 males. Nine *R. nævus* were included in this catch, every one a female. On the following day a small liner fishing on or near the same ground landed 853 Rays, 824 of which were immature specimens of *R. brachyura*. In this catch, however, males and females were present in more nearly equal numbers, there being 469 males and 355 females. *R. montagui* was the only other species included in the catch. Of these 29 individuals, all were adult fish and consisted of 28 females with only a single male included among them. In August of the same year this liner was still fishing on the same ground, but the *R. brachyura* which she was then landing were all mature fish which must have migrated there (*vide* **12**, p. 23). On August 20th this vessel landed 171 adult Rays of this species of which only one was a male. Three days later another but smaller catch was landed in which adult males and females were almost equally represented, there being 60 of the former and 79 of the latter sex. After this date the writer had to leave Newlyn, otherwise it would have been interesting to have noted whether or not the males eventually exceeded the females in number or even completely "replaced" them as happened in the case of *R. clavata* on the Plymouth net grounds in the spring of the year.

There was another interesting landing on August 23rd. A liner which had been fishing in deep water caught only 9 Rays on its full fleet of lines which had been shot once. All these were *R. fullonica* and all adult females.

On July 29th, 1931, a liner from the same port landed 175 *R. clavata* in addition to small numbers of other species. Of these Thornback Rays 149 were adult females; the 26 males were mostly immature. On May 31st, 1932, a liner's catch was observed to contain 19 *R. marginata*, all females over 100 cm. in width of disc, and all containing ripening ova. On June 2nd another landing contained 39 *R. batis* of which 37 were mature or nearly mature males and 2 were immature females.

In no instance was any information available as to how the fish were distributed on the lines. In the hope that an interesting catch similar to one of those mentioned might be taken in his presence the writer went to sea in a liner and recorded the species and sex of every Ray which

came up in the order in which it appeared (*vide* **12**, p. 28). Unfortunately only a very " ordinary " catch rewarded his efforts ; 192 *R. clavata* were taken the majority of which were immature and the two sexes were more or less indiscriminately intermingled all along the line. There was a slight excess of females. The catch of *R. nævus*, the only other species taken in any numbers, was more interesting ; 142 specimens were taken, 104 of which were males, most of them fully adult. The females, of which only an occasional specimen occurred here and there at wide intervals, were found on examination to be mainly immature, only 7 out of the total 38 containing ripe or ripening ova.

Other species were represented by only a very few scattered individuals.

It seems clear, however, from the main body of the evidence brought together in this paper, that the so-called abnormal sex-ratio found among the commercial landings of Rays and Skates is due not to any differential production of males and females at birth, or to a differential mortality after birth, but to differential catches of the sexes owing to segregation of the larger fish into unisexual shoals for at least part of the year. The females, particularly when in a gravid or spawning condition, form more compact schools than do the males, and therefore tend to be captured in greater numbers.

This fact is of much more than theoretical interest ; it has a direct practical bearing on the commercial fishery for these species, which have now become of primary and growing importance as national food fishes. It is well known that for the maintenance of any animal stock the female is, from the numerical point of view, the more important sex. Since, therefore, the females of the Raiidæ as a general rule are captured in considerably greater numbers than the males, it follows that the greatest drain of the fishery upon the fish stock falls upon its most vulnerable part. These Elasmobranch fishes will therefore be much more rapidly and more severely affected by intense fishing in any particular area—such as the English Channel—than species in which there is not an excess of females caught by ordinary fishing methods. Such an effect will tend to be greatly minimised in the case of strongly migratory species—such as the Spur Dogfish, for instance. The stock of such fishes on any particular fishing ground will be exposed to capture only for so long as it remains in that region. Not only so, its numbers will always tend to be sustained or replenished by immigrants from other localities where fishing is less intense or non-existent. It may be highly significant, therefore, that from being a very flourishing concern, the English Channel fishery for Spur Dogfish has, in the course of the last five years, shrunken to almost negligible proportions* owing to the

* The Ministry of Agriculture and Fisheries returns of landings from the English Channel during this period are : 1928, 54,206 cwt. ; 1929, 28,920 cwt. ; 1930, 27,188 cwt. ; 1931, 16,049 cwt. ; 1932, figures not yet available.

scarcity of these fish—*and that in spite of their being a pelagic and migratory species.*

On the other hand, the adverse effect of intensive fishing will be correspondingly increased in the case of species—such as the Raiidæ—whose migrations appear to be very restricted or even quite local in character. Moreover, these very same factors which by their action will assist the commercial forces of depletion will be equally potent in retarding recovery once a decline has been brought about in the stocks.

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