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Fish Biology

CHARACTERISTICS OF THE NORTH SEA SPURDOG
(*Squalus acanthias* L.) STOCK
CHARAKTERYSTYKA STADA KOLENI (*Squalus acanthias* L.)
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The paper presents the analysis of the stock of spurdog caught from the North Sea in 1974. The analysis covers length and age composition of the stock as well as percentage contributions of both sexes. The spurdog growth rate in terms of length and weight has been studied; fecundity and 1+ embryo length have been described as well. The conclusions concerning the stock protection against overfishing have been drawn.

INTRODUCTION

Spurdog is a species widely distributed in the North Atlantic waters. Holden (1965) distinguishes between three spurdog stocks in the North Sea and adjacent waters, the most abundant one being the Scottish-Norwegian stock inhabiting mainly the northern North Sea from the Norwegian coast in the east to the Hebrides in the west.

Spurdog is a species of a certain commercial value, caught for consumption. The North Sea catches are based mainly on the Scottish-Norwegian stock. Within 1960–1974, the

catches ranged from 16.889 to 33.784 t in the years 1964 and 1961, respectively, an average annual catch over that period amounting to 25.885 t. The North Sea spurdog catches contribute about 80% of the total NEAFC spurdog catches.

Biological investigations on spurdog caught in the northern North Sea were carried out in 1974. The results obtained form the contents of the present paper.

MATERIAL AND METHODS

The studies were carried out in May-June and October-November 1974; the analyses were being performed aboard RV "Wieczno" and ST "Wałpusza", the latter being a reconnaissance vessel. Total length was measured and sex determined in all spurdog individuals examined, the length being measured to the nearest cm from the snout tip to the end of tail. Sexual dimorphism was taken advantage of when determining the sex of an individual.

Spurdog were weighed, the weather permitting, with the 10 g accuracy; spines were taken out for age determinations.

Several mature females yielded 1+ embryos with the purpose of determining their abundance, body length, and sex.

Table 1 summarises the amount of material collected, serving as a basis for the present report.

Table 1

Numbers of spurdog individuals examined in 1974

Date	Vessel	No of fishes			No of females embryos of which were examined	No of embryos examined
		measured, sex, determined	weighed	yielding spines		
May June	RV „Wieczno”	1 419	1 156	182	15	103
October November	ST „Wałpusza”	732	95	732	2	14
Total		2 151	1 251	914	17	117

Spurdogs were studied in regions of their major concentrations, mainly in the northern North Sea and off the Shetlands. A part of the material was obtained from the Norwegian Furrow and from the Rona fishing ground (N of Cape Wrath and Butt of Lewis). The sites of examined spurdog collections are shown on a map (Fig. 1).

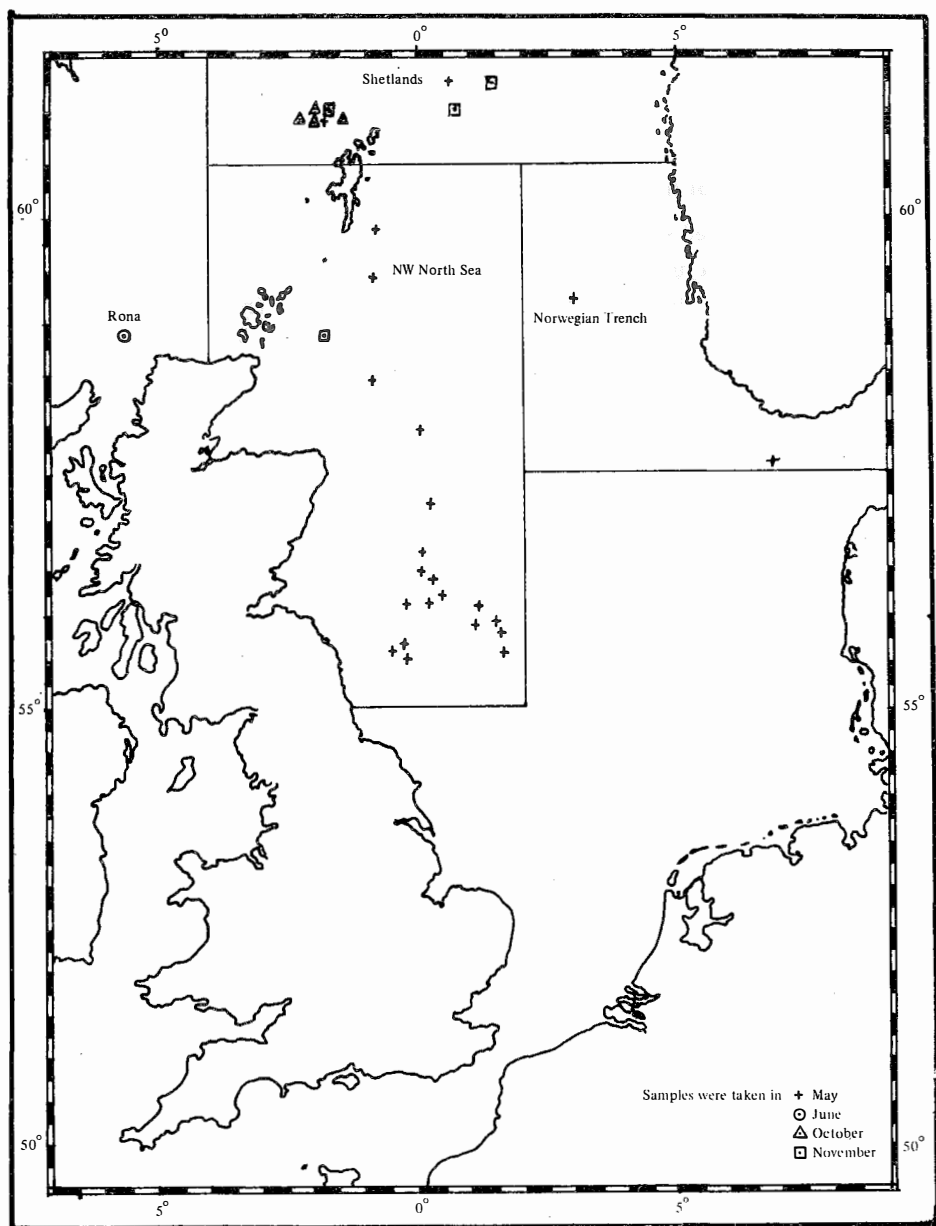


Fig. 1. Map of sampling sites

The second dorsal fin spines were collected for age determinations. These spines are relatively larger than those from the first dorsal fin and thus more legible. In some instances when a second fin spine was damaged, a spine from the first dorsal fin was taken instead. Out of 914 spines collected, 826 were legible enough to allow the age determination to be made. The age was read interpreting the rings visible on spines as described in Holden and Meadows (1962).

Spurdog growth parameters as well as length (weight relationships were calculated using appropriate programs run on the RV "Profesor Siedlecki" computer.

RESULTS

Length composition of the stock

The spurdog studied showed a considerable range of body lengths: from 21 to 115 cm. In order to perform a more detailed analysis of length, the study area was subdivided into four fishing grounds; their boundaries are marked in Fig. 1. The following rationale lies behind this subdivision and the subsequent pooling of the materials: most individuals studied were caught from the NW North Sea and N of Shetlands. Fishes from those two fishing grounds showed relatively few differences in length, but they had been caught in different seasons. Relatively fewer Norwegian Furrow and Rona fishes were examined;

Table 2

Length composition in spurdog caught from each North Sea region in 1974

Length class (cm)	Numbers of individuals caught					
	Norwegian Furrow	NW North Sea		Rona	Shetlands	
	May	May	November	June	October	November
21-25		1				
26-30		6				
31-35		7			1	
36-40		6			1	4
41-45	19	6			2	6
46-50	95	7		7	7	7
51-55	45	25	2	14	24	13
56-60	18	49	1	32	46	39
61-65	8	99	6	61	59	63
66-70	7	130	6	53	49	43
71-75	6	162	12	61	46	43
76-80	7	157	30	44	35	37
81-85	5	90	17	4	12	20
86-90		73	8		3	19
91-95		55	9	1		14
96-100		42	11			19
101-105		15	4			9
106-110		1				1
111-115		1	1			1
Total	210	932	107	277	287	338

they were, however, separated because those from the Norwegian Furrow differed in their length composition from spurdog caught elsewhere, whereas the geographic position of the Rona fishing grounds called for a separate consideration.

Most spurdog individuals examined were caught in the NW North Sea. The May studies showed a prevailing length range of 61–80 cm, while the November measurements revealed a higher contribution of larger spurdog (Table 2). It should be borne in mind, however, that the number of fishes measured in November was much smaller than in May, which may have affected the results obtained.

Spurdog examined in October and November in the area N of Shetlands showed their length composition to be similar to that of fishes from the NW North Sea. This statement holds true for fishes caught both in the western and eastern parts of the area. The length ranged within 31–115 cm the prevailing range being 56–80 cm.

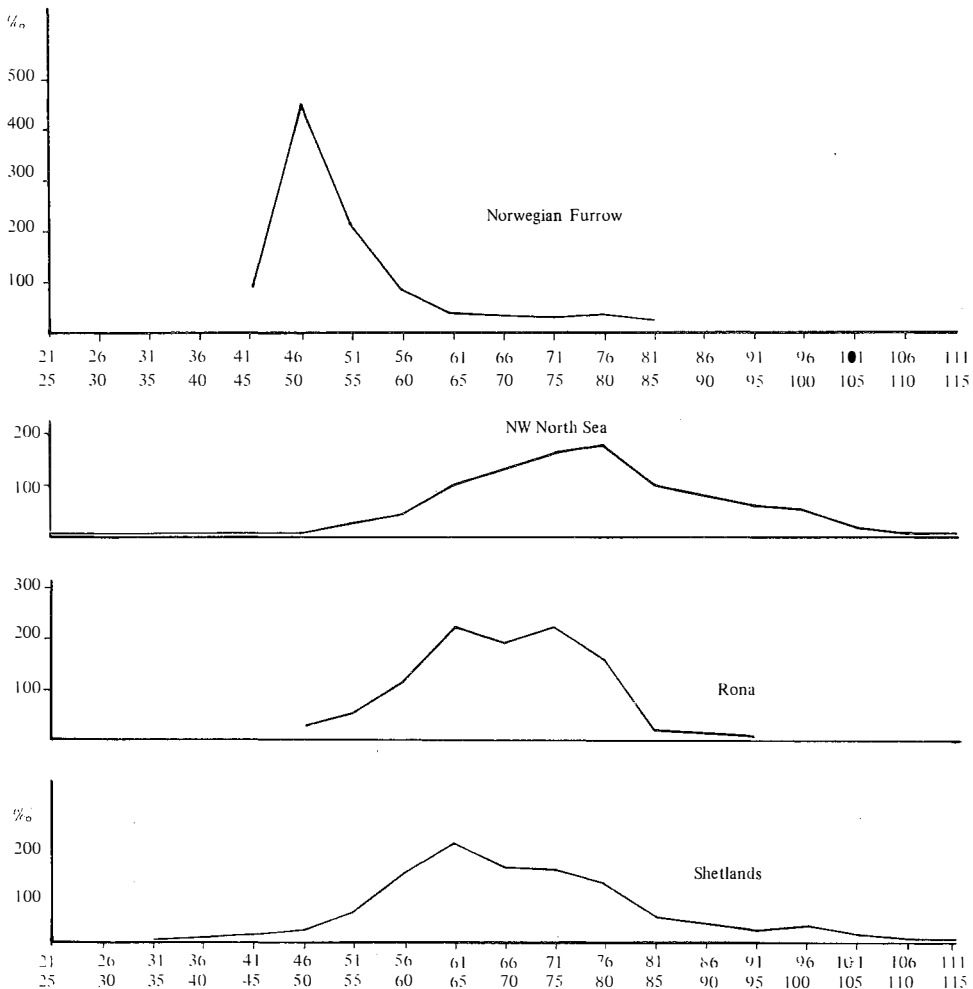


Fig. 2. Length distribution of spurdog caught in 1974 from different North Sea regions

The same length intervals were found for most of the Rona spurdog examined in June (Fig. 2). A shorter length range proved typical for this fishing ground. The length range found there was 46–95 cm.

A completely different length composition was revealed in spurdog caught in May from the southern Norwegian Furrow. The body length ranged from 41 to 85 cm with 46–55 cm long individuals prevailing.

It can be stated, when considering the above data, that the western North Sea fishing grounds in the two seasons of study as well as the fishing grounds N of Shetlands and Hebrides were inhabited by a spurdog stock uniform in terms of length. On the other hand, the waters of the Norwegian Trench housed mainly smaller individuals, i.e., juveniles of the stock under investigation.

Table 3

Length composition in spurdog caught from the North Sea in 1974

Length class (cm)	Sex		Total ♂ + ♀
	Males	Females	
21–25	1		1
26–30	2	4	6
31–35		8	8
36–40	3	8	11
41–45	9	24	33
46–50	45	78	123
51–55	49	74	123
56–60	91	94	185
61–65	137	159	296
66–70	142	146	288
71–75	220	110	330
76–80	222	88	310
81–85	69	79	148
86–90	10	93	103
91–95	3	76	79
96–100	1	71	72
101–105		28	
106–110		2	2
111–115		3	3
Total	1004	1145	2149

In 1974, regardless of a fishing ground, the stock as a whole was found to consist of individuals ranging in size from 21 to 115 cm (Table 3). Most fishes belonged to the 61–80 length classes. The length distribution according to sex is shown in Fig. 3. As seen from the figure, males and females were equally abundant up to a 70 cm length, the males prevailing quantitatively in the length interval of 71–80 cm. The larger length classes were dominated by females.

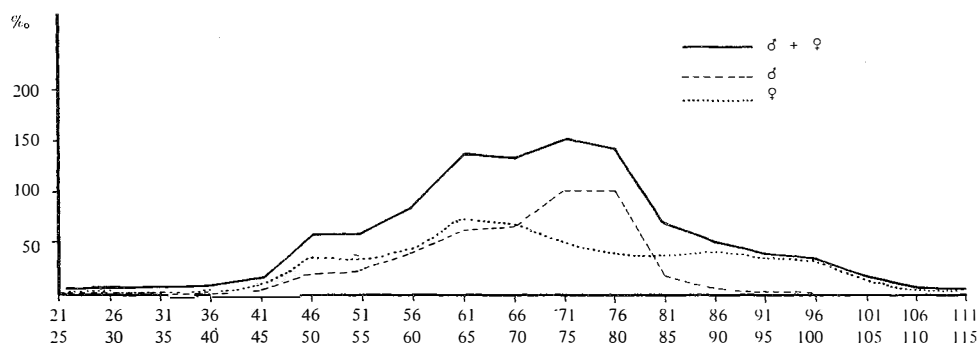


Fig. 3. Per mille length composition of the North Sea spurdog examined in 1974

Age composition of the stock

An attempt was made to arrive at an exact determination of the annual rings number up to the 19th year of life. Older fishes' age was difficult to determine because annual increments were small and the rings tended to fuse. The enamel at the spine base was

Table 4

Per mille age composition of the North Sea spurdog stock in 1974

Age	1	2	3	4	5	6	7	8	9	10	11	12	13
$\%_{\text{oo}}$	12	21	25	65	75	76	107	108	70	80	68	63	48

14	15	16	17	18	19	19+
49	30	21	15	23	8	36

frequently eroded, which was particularly evident in males. The fishes older than 19 years were pooled and denoted 19+. The 1974 age composition of the stock was determined using the age (length clue) (Fig. 4).

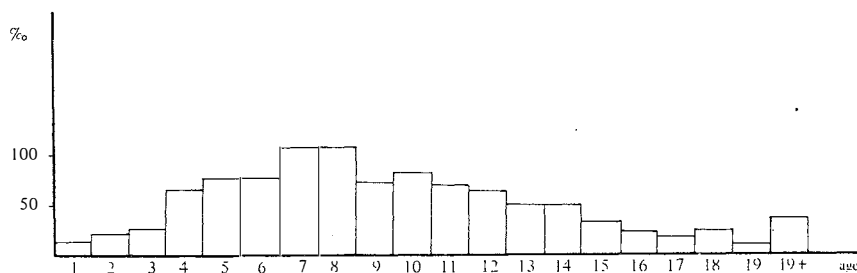


Fig. 4. Age distribution in the North Sea spurdog stock in 1974

The results showed the stock to consist of a number of year classes. A diagram of each group's contribution indicates a normal distribution. Seven- and eight-years-old individuals predominated in the stock.

Sex ratio in the stock

The whole material studied was slightly predominated by females contributing 53% of the stock. Sex ratios differed between the regions studied. A numerical prevalence of females was found both in the NW North Sea and in the Norwegian Trench (Table 5). N of Shetlands a slight predomination of males was recorded while in the Rona fishing grounds males prevailed definitely.

Table 5

Percentage contribution of malea and females on the North Sea fishing grounds in 1974

Fishing ground	Sex		No. of individuals examined
	Males	Females	
Norwegian Furrow	42	58	210
NW North Sea	39	61	1039
Shetlands	51	49	625
Rona		32	277
Total	47	53	2151

Spurdog growth rate

a) Growth in length

In order to study the spurdog growth rate, mean length in each age group was calculated for males and females separately and jointly for both sexes. The results of those calculations are given in Table 6. The data thus obtained served also to compute the length growth curve parameters according to the von Bertalanffy equation:

$$L_t = L_{\infty}(1 - e^{-K(t-t_0)})$$

The parameters are:

	Males	Females	Both sexes jointly
L_{∞}	81.66	137.12	101.54
K	0.1887	0.0537	0.0957
t_0	1.4672	4.7057	3.4873

Fig. 5 presents curves drawn using the above parameters. When empirical data are compared to those obtained from the theoretical growth curve (Fig. 5), a similarity of both data sets is evident.

The studies presented prove males and females to grow equally fast up to about ten years of life until reaching ca 75 cm body length. The growth of males slows down

Table 6

Mean length of spurdog in age classes

Age	Males		Females		Males + females	
	cm	n	cm	n	cm	n
1	24.00	1	35.00	5	33.16	6
2	42.57	7	43.71	7	43.14	14
3	45.33	3	46.21	14	46.06	17
4	51.95	19	52.21	19	52.07	38
5	58.16	30	55.13	30	56.65	60
6	61.80	45	59.91	34	60.98	79
7	64.12	47	64.51	54	64.34	101
8	66.68	58	67.97	45	67.25	103
9	70.48	37	69.71	32	70.13	69
10	73.60	28	74.15	32	73.90	60
11	75.79	34	76.11	27	75.93	61
12	74.75	12	82.48	29	80.21	41
13	78.08	25	84.52	19	80.86	44
14	77.86	22	90.57	14	82.80	36
15	78.60	15	92.50	10	84.16	25
16	78.85	7	93.57	7	86.21	14
17	77.00	10	94.60	5	82.86	15
18	76.16	6	97.62	8	88.42	14
19	77.50	4	98.28	7	90.73	11
19+	75.25	5	97.33	12	91.81	16

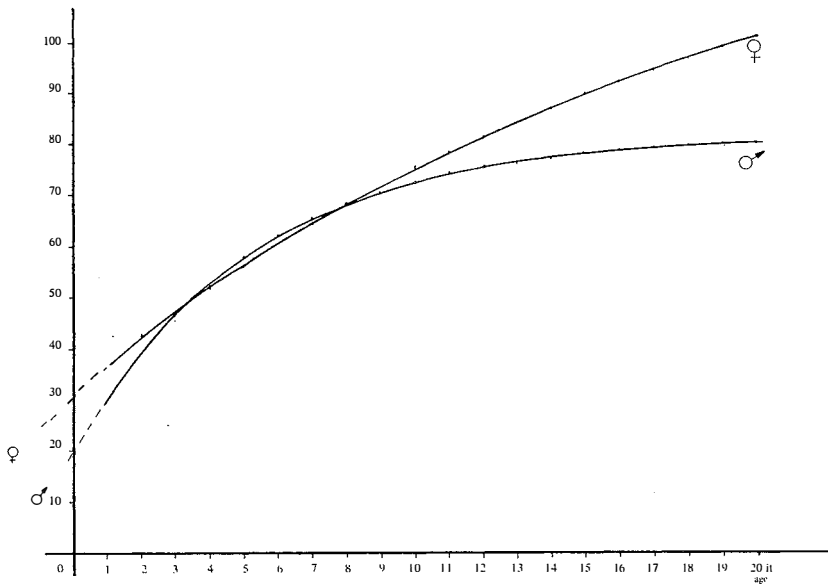


Fig. 5. North Sea spurdog growth

thereafter while females still attain large annual increments. For instance, in the 20th year of life there is as large as a 22 cm difference in body length between females and males.

The difference in both sexes' growth rates is shown in Fig. 5. Theoretical curves pass the 0 year at 20–30 cm. It is well known that newly born spurdogs are that long. The convergence of those data points out that the von Bertalanffy theoretical growth curve is consistent with the actual growth in the North Sea spurdog.

Holden and Meadows (1962) refer to the data on growth rate calculated by themselves and by several other authors. Particular sets of data differ in some age groups. The authors referred to by Holden and Meadows had given the combined growth for both sexes; only Holden and Meadows separated the sexes in their calculations. It should be stressed that the present results are close to these authors' data and the natures of the von Bertalanffy growth curves obtained are almost identical. It can be also contended that the results obtained corroborate the appropriateness of the age determination technique used and the interpretation of results.

b) Weight growth

Spurdog weight increases rapidly with fish growth, which is evidenced by coefficients governing the length/weight relationship curve according to

$$W = k \cdot l^n$$

The coefficients calculated from empirical data are

	Males	Females	Both sexes combined
k	0.0032	0.0013	0.0016
n	3.0377	3.2732	3.2180

Data obtained from 508 males and 743 females served to calculate the coefficients.

Comparing values of the n coefficient, the weight of females is seen to grow faster with length than the weight of males, which is shown in Fig. 6. Bearing in mind the fact that adult females are longer than males, the females' weight at the age of, say, 20 is twice that of males. The weight of the Scottish-Norwegian spurdog stock is similar to the results given by Templeman (1944) for the New Foundland spurdog.

Table 7 summarises mean weights in each age class. The males and females of up to the 10th age group show more or less equal weight; in older fishes, however, the difference between sex's weight is very conspicuous owing to the already mentioned fact of females reaching larger weight than males of the same length and, primarily, to the larger body length attained by females.

FECUNDITY

Spurdog females are sexually mature in their seventh year of life (70 cm length). According to Holden and Meadows (1964), about 50% of females reach maturity at the age of 9–10; they are then 83 cm long. The smallest and the largest of the 17 1+ embryo-containing females studied here were 86 and 99 cm long, respectively. Egg

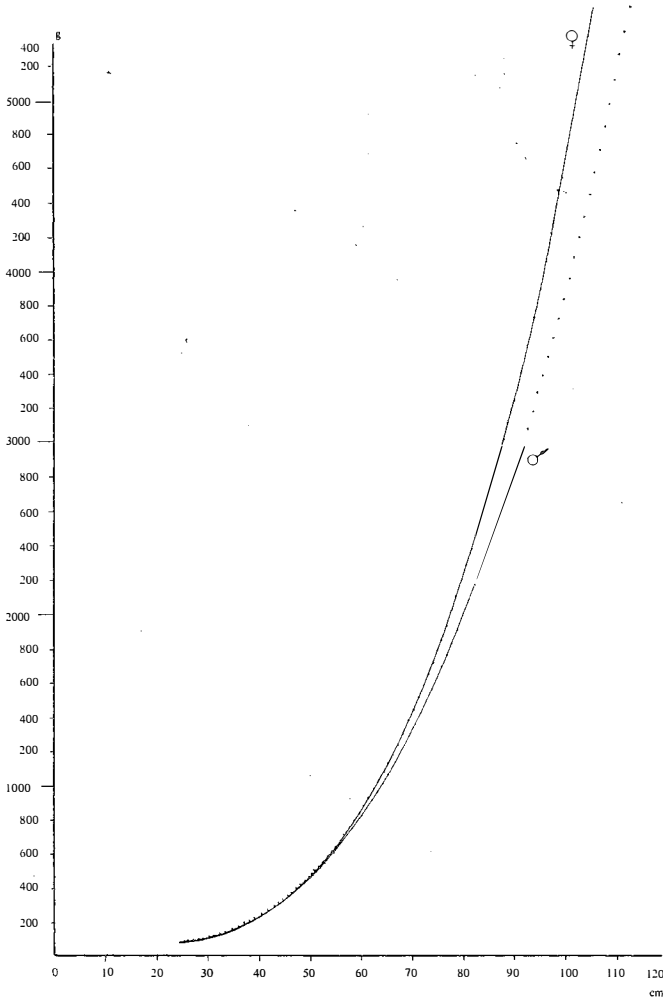


Fig. 6. Weight of the North Sea spurdog in length classes

incubation and embryonal development take about 2 years. Young spurdogs are given birth usually from April through the end of summer. Newly born individuals are 22–27.5 cm long. A mean number of large 1+ embryos per female was estimated at 4–6. Holden and Meadows (1964) and Templeman (1944) revealed that number of embryos depended on the female's length.

The females examined for this project contained 3–11 embryos. The body length of embryos examined ranged within 15–19 cm and 23–27 cm in May and November, respectively. A total number of 117 embryos was measured and their sex determined. Fig. 7 shows the length distribution found; values of mean length were 17.22 and

Table 7

Mean weight (g) of spurdog in age classes

Age	Males		Females		Males + females	
	g	n	g	n	g	g
1-5	579	20	471	41	506	61
6-10	1141	69	1139	58	1140	127
11-15	1642	39	1965	15	1732	54
16-19+	1651	9	4497	6	2789	15

24.93 cm in May and November, respectively. Females prevailed among the embryos contributing 57 %. Templeman (1944) found equal contributions of both sexes in spurdog

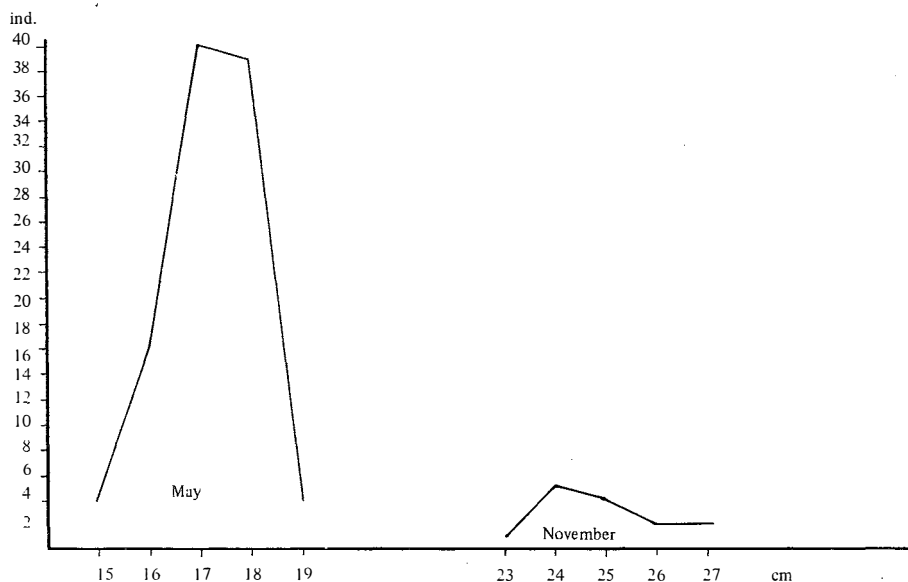


Fig. 7. Length distribution in I + spurdog embryos

off New Foundland. It is possible that the same is true in the Scottish-Norwegian stock; the results reported herein were derived from a small amount of material.

CONCLUSIONS

Knowing the age of maturity in females and the growth rate, a conclusion can be drawn that they should not be caught before they reach the 70 cm length.

The age composition of the stock in question allows to state its optimal exploitation in 1974. Seven- to eight-years-old fishes prevailed in the stock; this is the age of their reaching sexual maturity. Considering a relatively slow maturation and a low individual

fecundity, the stock exploitation should be implemented so that the resources are not exceedingly reduced.

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Streszczenie

Badania wykazały, że prawie w całym rejonie północnej części Morza Północnego w 1974 roku występowało jednolite pod względem długości stado koleni. Jedynie na Rynnie Norweskiej kolenie charakteryzowały się stosunkowo mniejszymi długościami.

Długości zbadanych koleni mieściły się w przedziale od 21 cm, do 115 cm; większość osobników miała długości od 61 cm do 80 cm. Większe klasy długości były reprezentowane głównie lub jedynie przez samice. Wiek badanych koleni wynosił od 1 roku życia do 20 lat. Występowały również, lecz nieznacznie, osobniki starsze. Najwięcej koleni było w wieku 7 i 8 lat. Stado charakteryzowało się mniej więcej jednakowym udziałem samców i samic. Wzrost długości koleni obu płci był do 10 roku życia na ogół jednakowy. W następnych latach życia wzrost samców jest już niewielki, gdy tymczasem samice osiągają jeszcze stosunkowo duże przyrosty. W konsekwencji starsze samice są większe od samców tego samego wieku. Badania zależności i ciężaru od długości koleni wykazały, że samice są cięższe od samców o tej samej długości. Stosunkowo większy ciężar samiec od ciężaru samców tej samej długości, oraz szybszy wzrost długości samiec dają w konsekwencji znaczną różnicę ciężaru koleni obu płci w starszych grupach wieku. Na przykład w wieku 15-20 lat samice są ponad dwukrotnie cięższe od samców. Samice koleni osiągają dojrzałość płciową w wieku 7-9 lat, mając wówczas długość około 70 cm. U zbadanych samic stwierdzono od 3 do 11 embrionów w wieku 1+. Biorąc pod uwagę wiek osiągnięcia dojrzałości płciowej samic, oraz tempo wzrostu należy stwierdzić, że samice nie powinny być łowione poniżej 70 cm długości.

Skład wiekowy koleni badanego stada pozwala uważać, że było ono eksploatowane optymalnie. Największy udział w stadzie miały kolenie 7-8 letnie. W tym wieku samice osiągają dojrzałość płciową. Biorąc pod uwagę stosunkowo późne osiągnięcie dojrzałości płciowej i niską płodność, eksploatacja stada powinna być rozważna aby nadmiernie nie obniżyć zasobów.

ХАРАКТЕРЫ ИСТИКАСТАДА КАТРАНА (SQUALUS ACANTHIAS L.)
ИЗ СЕВЕРНОГО МОРЯ

Р е з ю м е

Проведенные опыты показали, что почти во всем районе северной части Северного моря в 1974 году наблюдалось однородное по длине тела стадо катрана. Только в Норвежском жёлобе представители этого вида имели сравнительно меньшие размеры.

Длина исследованных особей катрана составляла от 21 до 115 см, большинство же особей имело длину от 61 до 80 см. Большей длиной характеризовались главным образом или же исключительно только самки.

Возраст исследуемых особей катрана составлял от 1 года до 20 лет. Встречались также, хотя и в незначительном количестве, особи более старшего возраста. Наиболее многочисленной была группа особей, возраст которых составлял от 7 до 8 лет. Стадо характеризовалось почти одинаковым количеством самцов и самок. Рост длины тела отдельных особей катрана обоих полов до 10 лет жизни был в основном одинаковым. В последующие годы жизни рост самцов становится замедленным, в то время как самки растут ещё довольно интенсивно, в результате чего последние бывают намного больше самцов того же возраста.

Исследования зависимости веса от длины тела у особей этого вида показали, что самки тяжелее самцов того же возраста. Большой вес самок по сравнению с весом самцов той же длины и более быстрый рост длины тела самок являются причиной значительной разницы в весе катрана обоих полов в старших возрастных группах. Например, в возрасте 15-20 лет самки весят в два с лишним раза больше, чем самцы.

Самки катрана достигают половой зрелости в возрасте 7-9 лет при длине тела около 70 см. У исследуемых самок обнаружено от 3 до 11 эмбрионов в возрасте 1+.

Таким образом, принимая во внимание возраст, при котором самки достигают половой зрелости, и темп их роста, следует утверждать, что вылов самок длиной менее 70 см должен быть запрещён.

Возрастной состав катрана из исследуемого стада позволяет сделать вывод, что до сих пор это стадо эксплуатировалось оптимально. В стаде преобладали особи в возрасте 7-8 лет, когда самки достигают половой зрелости. Учитывая сравнительно позднее достижение половой зрелости и низкую плодовитость данного вида во избежание снижения его запасов предлагается эксплуатировать стадо катрана более рационально.

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