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Sex and Cycle of Maturity in Haddock from the Grand Bank of Newfoundland

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The sex was determined by visual examination of the gonads, which in most cases is easily done. As the study was made on board fishing vessels where no microscope was available, it was not possible to distinguish between the sexes in specimens smaller than 15 cm. It is easy to distinguish the ovaries which are conical and rose-coloured from the lobular fringed testes of a whitish colour. The maturity scale for cod used includes six stages based on the colour and microscopic examination of the sexual products. Stage 5 is that of full spawning with transparent flowing eggs and freely flowing sperm.

Proportion of Males and Females - Of the 2,081 specimens studied, 1,003 or 48.2% were males, 1,078 or 51.8% were females. There is a slight preponderance of females of 3.6%. The study was made over a period of two years and from wide regions fairly far apart from one another.

Sexual Dimorphism - In spite of the large number of specimens examined, it has not been possible to find true secondary sexual characteristics, neither in the colouration nor in the external organs. The differences in weight, size, growth, etc. between males and females will be dealt with in detail in the respective documents.

Study of the Eggs - We have had at our disposal only a small number of specimens for the study of the eggs due to difficulties for the preservation of the individuals on the fishing boats. Only 19 samples were studied and rather small numbers only, but the results correspond to the studies carried out on the haddock from the North Sea, for instance that of Raitt (1933). The whole ovaries were preserved in 10% formalin and thereafter examined in the laboratory.

(a) Types of Eggs - As is the case with the cod and other gadoids, three types of eggs were found:

(1) Big translucent eggs, diameter between 1.3 and 1.7 mm., average 1.47 mm.

(2) Thickly opaque eggs, diameter between 0.20 and 0.67 mm., average 0.47 mm.

(3) Transparent small eggs, diameter less than 0.[illegible] mm., minimum diameter 0.04, average 0.11 mm.

(b) Size of Eggs - A comparison of the values found by Raitt for haddock in the North Sea with those from the Grand Bank gives the following results:

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Group of Eggs		Grand Bank of Newfoundland	North Sea
1.	Minimum	1.3	1.0
	Average	1.47	1.2
	Maximum	1.7	1.5
2.	Minimum	0.2	0.4
	Average	0.47	0.7
	Maximum	0.67	1.0
3.	Minimum	0.04	-
	Average	0.11	-
	Maximum	0.2	0.1

The eggs of types (1) and (3), big translucent eggs and small transparent eggs respectively, are larger in the Grand Banks than in the North Sea, however those of type (2) are smaller.

(c) Egg Counts - The same method as used by Mitchell was used for counting the eggs with a slight modification. Mitchell boiled the ovaries in order to separate the eggs easily, but we have found it unnecessary to do this and the eggs could be separated easily from the tissues of the ovaries by scraping.

In the first place the volumes of the ovaries were measured. In the very big specimens only one ovary was measured. From the ovary three pieces were then cut from each end and from the centre, and their volume was measured. These pieces of ovary were then flattended to a thin layer on a sheet of glass squared in centimetres. The number of eggs in 10 cm. squares were counted and from these figures the total numbers of eggs in both ovaries were calculated. In the attached table the characteristics of the examined ovaries and the number of eggs found are summarized. For these counts, we have only used the opaque eggs and not the translucent ones, because it is possible that many of these latter could have been spawned. The small transparent eggs were not counted.

Date	Length	Age	Stage of Maturity	Weight of Ovaries	Volume of Ovaries	No. of Eggs
8-3	44 cms.	4	IV	20 gr.	17 cc.	204.000
9-3	43 "	4	III	10 "	10 "	158.330
	59 "	8	III	45 "	54 "	732.888
27-3	40 "	4	IV	36	31 "	175.244
	42 "	4	IV	19	14.8 "	178.525
	42 "	6	III	21	11 "	249.480
	44 "	4	IV	-	18 "	171.072
	46 "	5	IV	42	39 "	355.914
	50 "	6	IV	52	45 "	201.024
9-4	68 "	9	IV	-	112.5 "	714.662
	71 "	8	IV	-	144 "	1.318.400
	74 "	9	IV	-	130 "	1.556.912
14-4	37 "	4	IV	-	23.5 "	237.613
	48 "	5	IV	-	40 "	505.267
	52 "	6	IV	-	115 "	777.400
17-4	41 "	4	III	105	92.5 "	518.365
	63 "	6	III	120	107.5 "	763.680
18-4	47 "	5	IV	-	42 "	277.438
	52 "	6	IV	-	37 "	546.227

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Relation of Fecundity to Size and Age - In spite of the small number of samples, a clear and true relation between fecundity and size is found (see table below). The maturity stages are shown in brackets.

Cms.	All Ages	4 Years	5 Years	6 Years	8 Years	9 Years
37	237.613	237.613 (IV)				
40	175.244	175.244 (IV)				
41	518.365	518.365 (III)				
42	214.003	178.525 (IV)		249.480 (III)		
43	158.330	158.330 (II)				
44	187.536	204.000 (IV)				
		171.072				
46	355.914		355.914 (IV)			
47	277.434		277.434 (IV)			
48	405.267		405.267 (IV)			
50	201.024			201.024 (IV)		
52	676.814			546.227 (IV)		
				777.400 (IV)		
59	732.888				732.888 (III)	
63	763.680			763.680 (III)		
68	714.662					714.662(IV)
71	1.318.400				1.318.400 (IV)	
74	1.556.912					1.556.912
Average		234.735	346.205	507.562	1.025.644	1.135.787

The mean number of eggs was calculated for the various ages from Raitt's paper for the North Sea haddock. In Fig.1 these figures are compared with those from the Grand Banks.

Years	North Sea	Grand Banks
2	31.700	
3	150.488	
4	353.723	234.735
5	359.005	346.205
6	261.910	507.562
7	310.000	
8		1.025.644
9		1.135.787

The number of eggs from fish of each 3 cm. size group are shown in the following table for the North Sea and for the Grand Bank haddock.

Length	North Sea	Grand Banks
23	26.663	
26	53.933	
29	102.266	
32	128.833	
35	181.866	
38	229.666	237.613
41	302.133	303.537
44	405.566	172.933
47	505.600	346.205
50	590.300	201.024
53	689.050	661.314
56		---
59		732.888
62		763.680
65		---
68		714.662
71		1.318.400
74		1.556.912

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The tables clearly show (1) that the fecundity increases with age; and (2) that the fecundity is proportional to size. Franz states that the fecundity is proportional to the square of the length, i.e.

$$\text{Fecundity} = K. \text{Length}^2$$

but Raitt disputes this opinion. On account of the small number investigated we have not been able to study this matter further.

Relation between Fecundity and Weight - The numbers of eggs corresponding to each gram of weight of ovary and each gram of total fish weight were calculated from the few specimens which were examined.

Weight of Ovary	Total Weight	No. of Eggs	No. of Eggs per Gr. of Wt. of Ovary	No. of Eggs per Gr. of Body Wt.
10	500	158.330	15.833	317
45	2.500	732.888	16.286	293
36	567	175.244	4.868	309
42	794	355.914	8.474	448
52	1.049	201.024	3.866	192
105	750	518.365	4.937	691
120	2.500	763.680	6.264	305
		Average..	8.660	365

As far as absolute fecundity by ages, the haddock of the North Sea are advanced compared to those of the Grand Bank. All the specimens of one or two years from the Grand Bank were immature and of the 3rd year only 3.7% had spawned once, another 3.7% were in Stage II, probably going to become mature for the first time. Thus there is a retardation of nearly two years in sexual maturity of haddock from the Grand Bank compared to European haddock. The haddock of the Grand Bank spawns later in life but the number of eggs is greater (Fig.1).

The haddock of the Grand Bank has a longer period of maturity. Thus Raitt states that at seven years of age, the North Sea haddock decreases in fecundity. On the Grand Bank specimens of 8-9 years were observed with a notable production of eggs.

Average Stage of Maturity - The spawning period of the Grand Bank haddock is from February to June with a maximum in May. This is based on observations on a large number of mature specimens.

In order to establish these data more definitely, an index of mean maturity for each month was calculated.

There are no data from January and February as Spanish vessels do not fish in these months, and the data from September onwards has not been used as then only immature individuals, or those which have already spawned, are caught and the average index would give the wrong impression that all would be in the spawning period. We have thus only used the individuals which were spawning or which were in a stage of maturing. Those specimens which were finishing spawning were also used. In the attached table the mean maturity for males for each month is shown.

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Date	No.	Frequency of Stages of Maturity	Average Maturity
Mar.(1953-1954-1955)	17	$(II)^{10} + (III)^{7}$	2.41
April	45	$(II)^{12} + (III)^{32} + (VI)^{1} =$	2.80
May	12	$(II)^{7} + (III)^{5}$	2.46
June	79	$(II)^{19} + (III)^{19} + (IV)^{2} + (V)^{17} + (VI)^{22} =$	4.05
Jul.(1954-1955)	160	$(II)^{25} + (III)^{20} + (V)^{40} + (VI)^{75} =$	4.75
Aug.	53	$(II)^{4} + (III)^{3} + (IV)^{4} + (VI)^{42} =$	5.37

For the females the index is somewhat higher for the same date as is shown in the following table giving the index of maturity for the females.

Date	No.	Frequency of Stages of Maturity	Average Maturity
Mar.(1953-1954-1955)	37	$(II)^{9} + (III)^{11} + (IV)^{16} + (VI)^{1} =$	3.30
April	69	$(II)^{19} + (III)^{8} + (IV)^{34} + (V)^{2} + (VI)^{6} =$	3.53
May	14	$(II)^{3} + (IV)^{6} + (V)^{3} + (VI)^{2} =$	4.07
June	44	$(II)^{13} + (III)^{1} + (V)^{22} + (VI)^{8} =$	4.25
Jul.(1954-1955)	55	$(II)^{27} + (III)^{1} + (IV)^{2} + (V)^{25} =$	3.45
Aug.	52	$(II)^{1} + (IV)^{1} + (VI)^{50} =$	5.88

From Fig.2 it is seen that the females apparently mature earlier in the year than the males, not as to age but within the period of spawning. However during the spawning period both sexes coincide as to stage of maturity, which is logical (Fig.2). The main spawning period is in May. In August nearly all have spawned and in September practically all.

It can be observed both for males and for females that there are two periods or cycles of spawning, as if there was a new intensification of sexual activity caused by new late spawners entering the schools of spawning fish.

It has already been shown that the haddock of the Grand Banks become mature later than those of the North Sea. All the specimens caught at one or two years of age were immature on the Grand Banks.

Age	Males	Females	Total
From 3 Years	7.4%	3.33%	3.54
4	74.7	72.5	73.61
5	91.54	85.24	88.23
6	96.73	97.54	97.19
7	100	-----	-----
8	100	100	100

In the figure the percentages of immature individuals are given for the various ages.

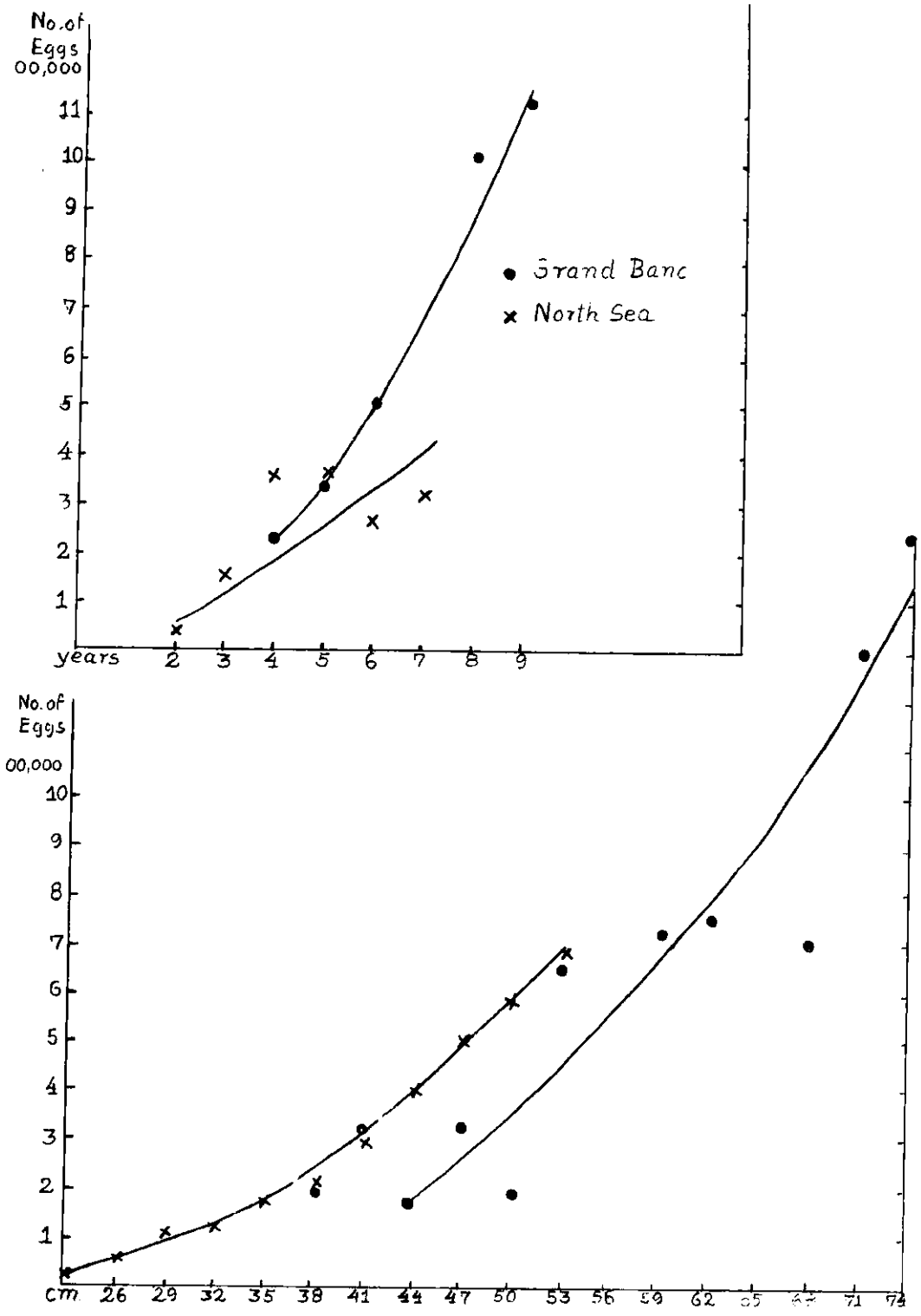

Figure 1. Haddock, absolute fecundity by ages (above), and by sizes (below).

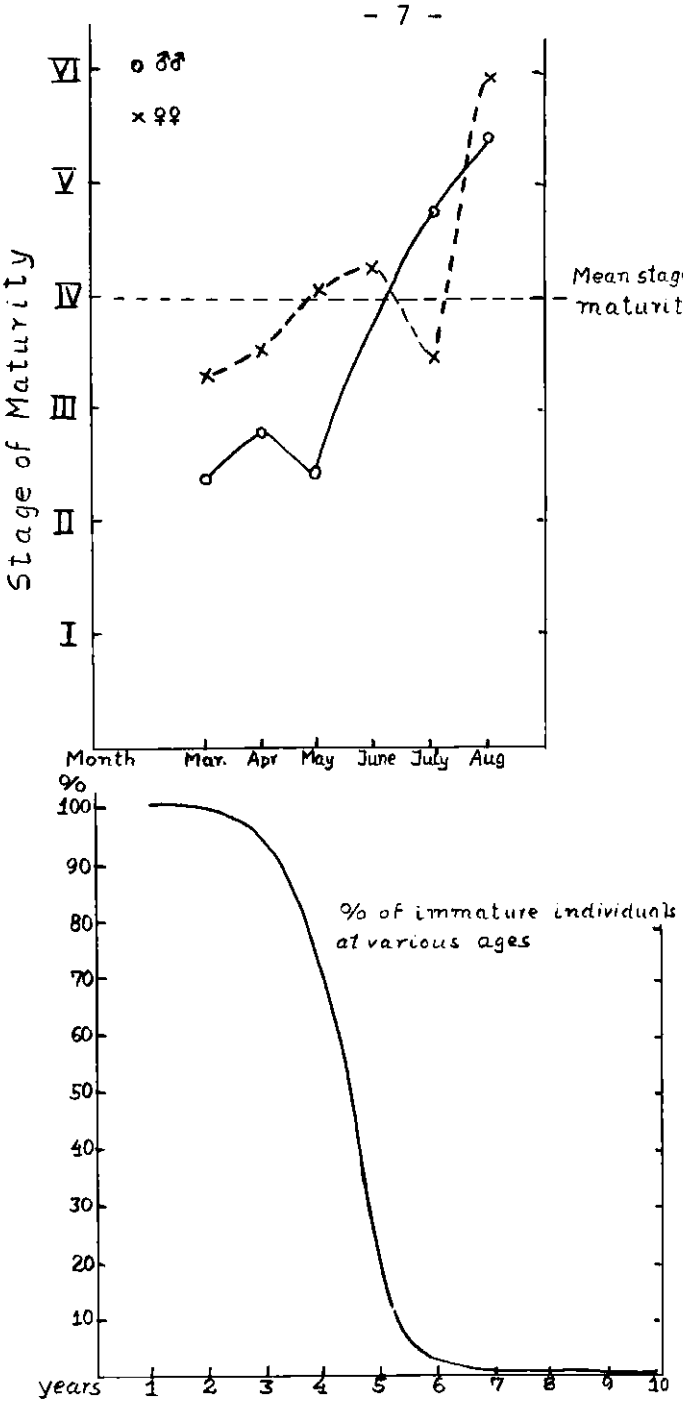

Figure 2. Haddock. Grand Bank. Above: cycle of sexual maturity for males and females. Below: percentage of immature individuals at various ages.