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KOMMISSIONEN FOR HAVUNDERSØGELSER

SERIE: FISKERI · BIND V

NR. 5. P. JESPERSEN: CONTRIBUTIONS TO THE LIFE-HISTORY OF THE NORTH ATLANTIC HALIBUT (HIPPOGLOSSUS VULGARIS, FLEM.). WITH 1 PLATE AND 16 FIGURES IN THE TEXT

KØBENHAVN
I KOMMISSION HOS C. A. REITZEL
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CONTRIBUTIONS TO THE LIFE-HISTORY

OF

THE NORTH ATLANTIC HALIBUT

(*HIPPOGLOSSUS VULGARIS*, FLEM.)

BY

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I. Introduction.

Among the economically important fishes found in Iceland waters, the Halibut (*Hippoglossus vulgaris* Flem.) takes a prominent place.

It is met with in great quantities both at the Færoes and Iceland, in fairly shallow water as well as out at greater depths. In Iceland waters, most of the halibut are taken in the trawl, at 30—60 m.; they may, however, also be encountered in far deeper spots, as is shown by the capture of a specimen in 920 metres of water, south of the Vestmanna Islands (Thor's St. 170, 1903). It is met with on all the coasts of Iceland, though probably in greatest numbers to the south and west. An intensive halibut fishery is carried on both at Iceland and the Færoes, but in both cases the greater part of the yield falls to foreign vessels. England has even started a special fishery with long-line steamers, chiefly directed towards the capture of halibut; apart from this, however, quantites of the fish, more especially the smaller sizes, are taken by trawlers of various nationalities. A similar long-line fishery was carried on for some years by American schooners, but this fishery has now apparently ceased altogether; as far back as 1903 there were only a couple of American vessels working off the coast of Iceland. (Johs. Schmidt 1904 b). Further information as to the British long-line fishery will be found for instance in Johs. Schmidt: Fiskeriundersøgelser ved Island og Færøerne i Sommeren 1903.

It will doubtless be worth while to investigate what may be the importance of the halibut fishery in Northern Europe, what nations participate therein, and which fishing grounds take foremost rank. As a basis for such investigations, I have had recourse to the "Bulletin statistique des pêches maritimes des pays du nord de l'Europe", utilising the material furnished by the statistics for 1910 to give an idea as to the importance of the fishery. From the following pages, it will be directly seen what part the various fishing grounds play in the halibut fishery, and to what extent the different nationalities participate in the same. The statistics for Norway are unfortunately not so full as was to be desired, and it is possible that a considerable part of the catch recorded as from the Norwegian Sea should in reality be ascribed to the Færoes. The position of these two grounds in the table is therefore somewhat uncertain.

England is indisputably first among the various nations here concerned, over half the total annual yield falling to English vessels. One fourth of the yearly catch is made by Scottish vessels, and about one-fifth by Norwegians. These three nationalities are far in advance of the rest, making up together 94—95 % of the total haul. Glancing then at the different fishing grounds, it will at once be noticed how markedly the Iceland fishery here predominates. The Norwegian Sea comes next; the exact place which should be accorded to this locality in the table is, however, as mentioned, somewhat uncertain. Next in order are the West Coast of Scotland and North coast of Ireland; after these, the Færoes and the North Sea. The five most important fishing grounds represent about 88 % of the total yield, half of which percentage again is contributed by Iceland.

The total yield amounted in 1910 to 14,058,762 kg. with a value of £ 456,909 (1 kg. = 0.78 shillings) or Mk. 11,247,009 (1 kg. = 0.80 Mark). It will be interesting in this connection to note the rise which has

Importance of the Halibut Fishery for the different Nations and Fishing Grounds northern in Europe. 1910. Yield in kilos.

	England	Scotland	Norway	Germany	Denmark (Iceland)	Nether-lands	Russia	Belgium	Total Quantity	
									Kg.	Percentage
Iceland	4,631,741	927,933	..	418,986	132,300	25,514	..	10,916	6,147,390	43,72 %
Norwegian Sea	..	..	1,884,754	..	..	..	..	..	1,884,754	13,40 -
W.-coast of Scotland, N.-coast of Ireland	487,731	1,174,976	..	1,158	..	..	..	..	1,663,865	11,83 -
Færoes	1,036,980	345,626	..	..	..	2,448	..	..	1,385,054	9,85 -
North Sea	233,172	826,607	127,616	83,146	6,858	49,486	..	..	1,326,885	9,43 -
Rockall	446,684	326,123	..	..	..	..	..	..	772,807	5,49 -
Polar Sea	..	..	331,137	..	..	..	..	..	331,137	2,35 -
W.- and S.-coast of Ireland	136,448	..	..	..	..	..	..	..	136,448	0,97 -
Skager Rak	..	..	101,292	33,794	10	..	..	..	135,096	0,96 -
Barents Sea	23,216	..	..	..	..	..	11,280	..	34,496	0,24 -
W.- and N.-coast of England	6,807	..	..	..	..	..	..	..	6,807	0,04 -
Kattegat	..	..	..	2,413	..	..	..	..	2,413	0,01 -
Bay of Biscay and southern waters	153	..	..	..	..	..	..	..	153	0.001-
Mixed regions	224,688	..	..	6,769	..	..	..	..	231,457	1,64 -
Total ...	7,227,620	3,601,265	2,444,799	546,266	139,168	77,448	11,280	10,916	14,058,762	
Percentage ...	51.41 %	25.62 %	17.39 %	3.88 %	0.99 %	0.55 %	0.08 %	0.07 %		

taken place in the price of halibut during recent years. The English statistics give the following figures for 1904—1914.

Average value per cwt. of Halibut landed in England and Wales in each year from 1904 to 1914.

	£	s	d
1904	1	16	11
1905	1	16	11
1906	1	17	9
1907	1	13	8
1908	1	19	9
1909	2	5	4
1910	2	10	3
1911	2	13	8
1912	3	0	0
1913	3	5	6
1914	3	7	2

The price per cwt. has thus risen to very nearly double in the course of ten years.

The various tables will in themselves suffice to show the great importance of the halibut fishery to several countries, as also the extremely prominent part played by the waters around the Færoes, and particularly Iceland, in this fishery. It is therefore matter for surprise that the halibut, despite its high economical value, is not included in the programme of the International Investigations. The reason of this must presumably be that the halibut is of but relatively slight importance to the fishing industry of the inner waters, such as the North Sea, the Skagerak, etc. These waters apart, however, and taking in consideration Iceland, the Færoes, Rockall and the coasts of Scotland and Ireland, it must be admitted that the halibut is of great economical importance to the fisheries. It should accordingly be worth while endeavouring to clear up various points in the biology of the species, many of which, indeed are still altogether unknown.

The first important contribution to the study of reproduction among halibut was, as we know, furnished in 1904 by Dr. Johs. Schmidt, in his reports on the finding of pelagic larval stages off the coasts of the Færoes and Iceland, during the cruise of the marine research steamer "Thor" in those waters. It was thereby demonstrated that the halibut must spawn in the Atlantic off these islands, but the larval stages have, as far as I am avare, never since been found elsewhere, and it is thus still an open question whether the halibut has other spawning grounds in North-European waters. The time at which spawning takes place has more recently been ascertained with some degree of certainty, but neither the eggs in a free state nor the earliest bottom stages can as yet be altogether certainly determined. Various points would seem to indicate that the halibut in Iceland waters undertake considerable migrations; up to the present, however, nothing is known as to how such movements take place.[1] Again, no investigations have hitherto been made as to the grovth of the halibut in these waters, the age at which

[1] Marking experiments with halibut have also been made by the Danish investigations, but have given no results up to now.

they attain maturity, etc. Altogether, it must be admitted that there are numerous questions which clearly need to be investigated.

The present work is intended as a contribution towards the elucidation of some of these features, which are of considerable biological importance, and is especially devoted to the consideration of the following points:

1. The size of the Iceland Halibut (length and weight).
2. Growth of the Iceland Halibut.
3. Statistics referring to the Halibut fishery in Iceland and Færoe waters.
4. Further contributions to the study of propagation and developement in Halibut.

During the years 1903—06 on the cruises of the "Thor" in Iceland and Færoe waters, Dr. JOHS. SCHMIDT made occasional, and in 1908 systematic collections and investigations concerning the biology of the halibut. The material of otoliths collected on these cruises has since, at the instigation of Dr. Schmidt, been supplemented by Adjunkt BJARNI SÆMUNDSSON, and in addition, Capt. G. HANSEN was sent to Iceland in the summer of 1909 to procure material for age determination of the most important fishes, including the halibut.

In addition to the mentioned material of otoliths, the journals of the various cruises to Iceland and the Færoes form the basis upon which the present work has been compiled. The statistics are taken partly from the Fishery Reports of the various countries, and partly from the volumes issued of the "Bulletin statistique des pêches maritimes des pays du nord de l'Europe". Furthermore, at the request of Dr. JOHS. SCHMIDT, we have received from Scotland an extensive amount of statistical material concerning the Scottish halibut fishery at Iceland and the Færoes. The material in question has been furnished partly by Professor D'ARCY W. THOMPSON, of Dundee, and partly from Mr. WALTER DUFF, of the Aberdeen Fishery Office, forwarded through the Fishery Board for Scotland (Mr. D. T. JONES) at the instigation of Dr. T. W. FULTON, of Aberdeen.

I take this opportunity of expressing my thanks to the Leader of the Fishery Investigations at the Færoes and Iceland, Dr. JOHS. SCHMIDT, who has permitted me to deal with the present material, and has very kindly assisted me with all possible information throughout the work.

II. Size of the Iceland Halibut (Length and Weight).

The halibut attains, as we know, a size far exceeding that of any other flounder species. Instances are frequently cited in the literature, of specimens greatly beyond the measurements and weight generally met with. These giant fish are, however, comparatively rare, though individuals of very respectable size are by no means uncommon in the waters about Iceland and the Færoes. The largest specimen taken on the Iceland cruise of the "Thor" measured 186 cm. total length, and weighed 98,000 gr. An even larger one, of which the otoliths are preserved, was taken at the Færoes. Its total length was 81 inches, or 213 cm.

As will subsequently be seen, the growth of the halibut is not uniform in the various waters off the coasts of Iceland. In ordinary comparison between total length and corresponding weight, however, it will hardly be necessary thus to discriminate between the different localities. In the lists given below, showing the average weight per cm. total length, only fish from the West and North-western coasts of Iceland have been included, no information being available as to the weights of halibut taken on the eastern side. In addition to the average weight, the range of variation for all specimens of the respective total lengths has also been noted.

A further illustration of the proportionate increase in weight with increasing length is afforded by the accompanying graphical chart (fig. 1), drawn up for specimens ranging from 20 to 90 cm. total length. It will here be noticed how surprisingly the weight advances per cm. of length as soon as the fish have reached a total length of 60—70 cm.

The average increment of weight per cm. total length for the various sizes is approximately as follows.

Weight of Halibut at various lengths. Iceland.

Length cm.	No. of specimens	Average weight gr.	Range of variation gr.	Length cm.	No. of specimens	Average weight gr.	Range of variation gr.
186	1	98000		59	5	2069	1940—2190
176	1	75000		58	3	1982	1840—2115
174	1	76500		57	8	1934	1700—2205
154	1	49000		56	9	1946	1780—2500
135—141	6	29795	23000—39000	55	4	1668	1370—1900
116—120	3	20758	19500—21880	54	3	1495	1440—1570
111—115	5	17133	15000—19250	53	3	1845	1700—1960
106—110	5	13909	11500—16000	52	7	1489	1350—1670
101—105	7	13095	11700—14850	51	5	1445	1330—1620
96—100	5	11187	9750—12250	50	2	1350	1260—1440
91—95	8	9363	8250—10500	49	1	1100	..
90	2	8020	7500—8540	48	5	1413	1290—1550
89	3	7478	7200—7750	47	1	1180	..
88	4	7350	6885—8250	46	5	1145	1040—1300
87	7	7192	6310—8500	45	4	955	820—1070
86	6	6452	5500—7500	44	7	974	845—1080
85	2	6125	6000—6250	43	15	920	775—1150
84	4	6057	5680—6500	42	13	854	710—990
83	3	6385	5620—7000	41	11	797	710—900
82	1	4790	..	40	16	715	605—810
81	4	5338	5000—6270	39	21	656	570—860
80	4	5108	4600—5630	38	21	610	530—700
78	3	5235	5040—5500	37	28	558	430—680
77	6	5027	4720—5500	36	29	498	410—650
76	3	5122	5000—5300	35	29	448	400—550
75	8	4416	3900—5460	34	25	403	340—480
74	4	4260	3760—4620	33	28	364	320—420
73	4	4148	3820—4300	32	43	326	240—400
72	3	4528	4250—5000	31	50	288	250—350
71	6	3735	3420—4230	30	76	256	220—320
70	10	3677	3150—4500	29	35	236	200—310
69	7	3268	2950—3750	28	44	208	180—260
68	11	3240	2800—3950	27	28	187	160—230
67	6	3390	2900—4000	26	16	168	140—220
66	7	2801	2400—3110	25	16	155	130—200
65	7	2851	2640—3240	24	10	128	120—145
64	10	2750	2450—3500	23	14	112	105—140
63	9	2548	2000—3250	22	8	100	90—105
62	7	2528	2040—3000	21	5	80	80—80
61	7	2452	2150—2950	20	2	75	70—80
60	7	2539	1960—3000				

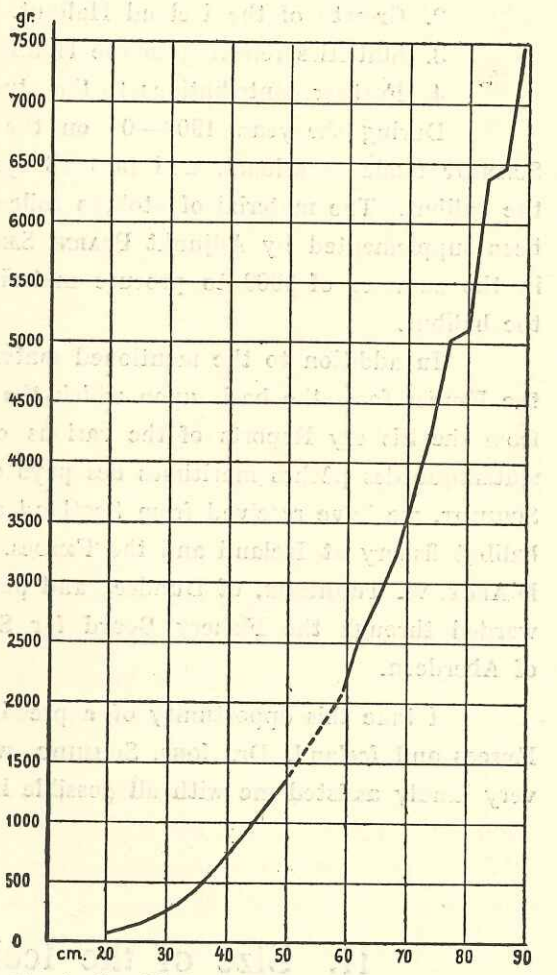


Fig. 1. Graphical Chart showing growth of the Iceland Halibut. Total length and weight.

The average increment of weight per cm. total length for the various sizes.

	cm.	gr.
Total length	25— 35	28.9
—	35— 45	50,7
—	45— 55	71.3
—	55— 65	118.3
—	65— 75	156.5
—	75— 85	170.9
—	85— 95	323.8
—	95—105	373.2
—	105—115	403.8

On further growth, the weight increment per cm. steadily increases, but the present material does not include sufficient number of large sizes to permit of our pursuing the calculation of average weight increment per cm. according to the same method. Some idea as to the comparatively enormous strides with

which the weight advances in the largest specimens may be gained from the fact that this works out roughly to an average of 1375 gr. per cm. for sizes between 154 and 174 cm., and 2300 gr. per cm. for 176—186 cm. It should be noted, however, that these figures are based on a very small number of specimens.

III. Growth of the Iceland Halibut.

The material employed in this investigation as to the growth of the Iceland halibut consisted of otoliths from fish taken on board the marine research steamer "Thor" during the Iceland cruises of 1908 and 1909. In addition, a smaller number of otoliths collected by Adjunkt BJARNI SÆMUNDSSON, of Reykjavik, from Halibut caught in Fakse Bugt during the autumn of 1909 and spring of 1910, have also been used. The following table shows the distribution of the 2921 fish from which the material was derived.

S. W. - Iceland	Faxebugt.	Taken by S/s "Snorri Sturluson"	1667	spec.
	—	— - marine research vessel "Thor"	387	—
	—	— - various Iceland cutters	21	—
	—	Collected by Adj. Sæmundsson	104	—
				2179 spec.
N. W. - Iceland	Bredebugt.	Taken by marine research vessel "Thor"	58	spec.
	—	— - S/s "Snorri Sturluson"	57	—
	Patrexfjord		289	—
	Arnefjord		97	—
	Ønundarfjord		100	—
	Sugandafjord		45	—
				646 spec.
East-Iceland.	Seydisfjord		87	spec.
	Off Glettinganes		9	—
				96 spec.
	Total		2921	spec.

After removal from the cranium, the otoliths were numbered and packed away in paper bags. The sex of the fish, its total length, and in most cases also the weight, were then noted against the corresponding number. In many instances the contents of stomach was likewise recorded, and for female specimens, the length of the ovary measured. The various data were at once entered on forms specially prepared for the purpose.

The otoliths of the halibut may generally be said to be well adapted for age determinations, showing far more distinctly than those of many other fish the annual rings on which the count is based. It has been found advantageous to clarify the otoliths, prior to examination, in glycerine or xylol. When then held up to the light, it has been found possible to read off the number of growth rings directly, by transmitted light. As a rule, a low power magnifying lens was used for readings. Generally, it was not found necessary to grind down the otoliths; in some few cases, however, where the number of rings was unusually high, this was done by way of experiment, but the results were not altogether satisfactory.

Both otoliths, right and left, of all specimens were preserved, and we find, as a constant feature, that there is a marked difference between the two in each case, the growth rings to the left otolith being always far more pronounced than those in the right. Practically speaking, this is as much as to say that for age determinations, the left otoliths should exclusively be employed.

The accompanying plate vill serve to give an idea of the shape of the otoliths and appearance of the rings. The otoliths themselves naturally vary in size according to the number of growth rings, and range from about 5—20 mm. in length. As a rule there is no difficulty in determining the smaller otoliths, though there may be individual differences in this respect. Those of the older fish, on the other hand, may often be hard to read with absolute accuracy, and the readings for these will therefore be subject to limits

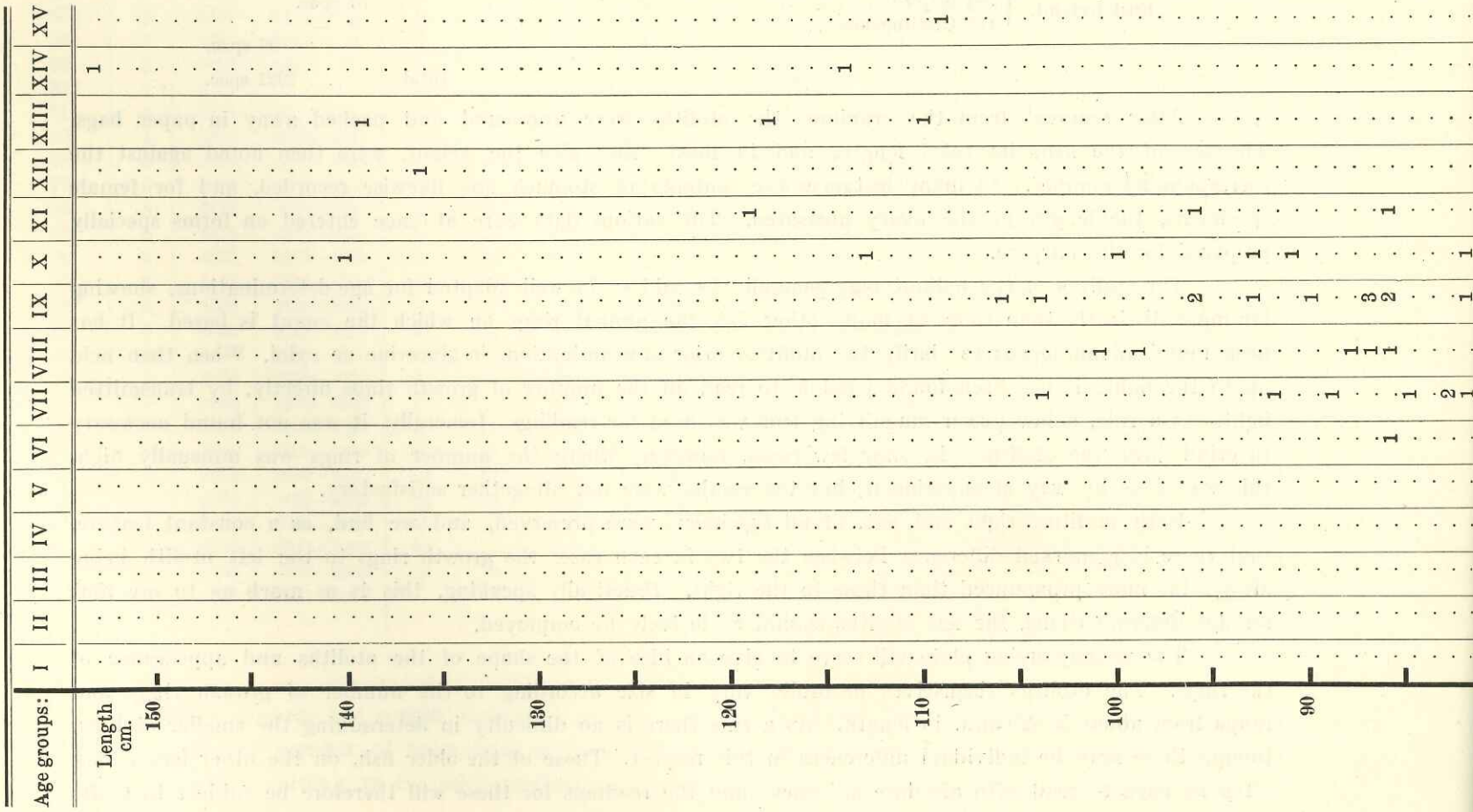
of possible error amounting to one or two years. Generally speaking, we may say that the age of fish below 50 cm. can be determined with certainty; in the case of fish from 50 to 110 cm., the results may not infrequently be somewhat doubtful (the possible error, however, hardly exceeding 1 year) while for specimens over 110 cm. any absolutely definite age determination will often be out of the question (limit of error 1—2 years). Out of the total quantity of material available, only 5—6 % proved unsuitable for the purpose of age determination, i. e. only in this percentage of cases did the limits of error exceed the figures above noted.

Before proceeding to apply the results of the age determinations, it will be best to point out at once that the present material does not afford any correct quantitative illustration of the yield from the various localities. The otoliths were taken partly by trawl and partly on lines, in addition to which, otoliths were often only taken from a small selection of the halibut in a haul. The trawl fishery, for instance, gives for the most part only smaller specimens, the III group in particular being numerously represented here. In several cases also, otoliths vere only taken from fish over 35 cm. and below 25 cm. between which limits lie the most frequently occurring sizes of the III group, the object of such selection being to prevent the group in question from taking too prominent a position, when only a small portion of a large haul could be utilised for collection of material.

In view of the considerable variation which has been observed in the growth of halibut from the different coasts of Iceland, it will be best to treat each locality separately. After going through the material, and preliminary comparison of the results, I have found it most convenient to make three sections; viz:

1. South-west Iceland (Faxe Bugt).
2. North-west Iceland (Bredebugt, Patrex-, Arne-, Ønundar- and Sugandafjords).

Halibut from Faxebugt. June—July 1908, 1909.



3. East Iceland (Seydisfjord, and off Glettinganes).

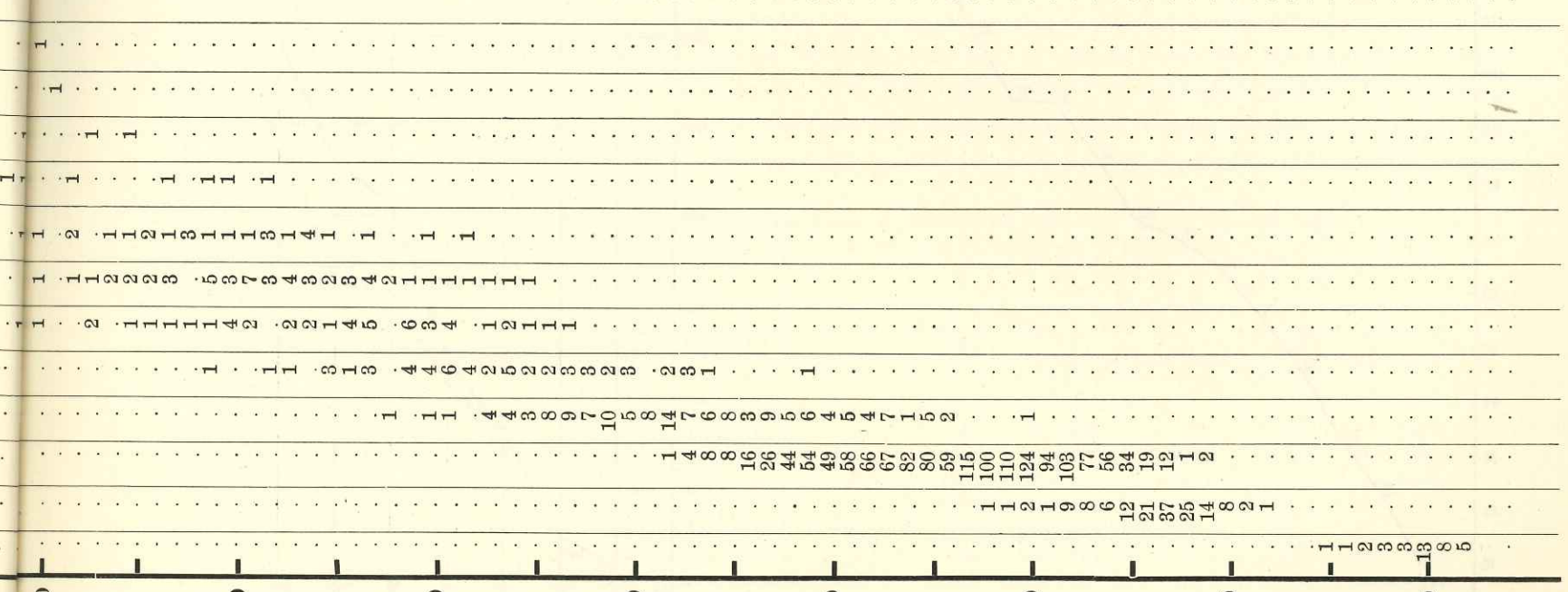
A consideration of these three localities, with a general comparison of the conditions there prevailing, will give the lines on which the growth investigations are here set forth.

1. South-west Iceland.

As will be seen from the general survey of the material, by far the greater part of the otoliths collected were from Faxe Bugt; this fjord will therefore be made the subject of more detailed consideration.

The total number of otoliths from Faxe Bugt found suitable for age determinations, amounted to 2719, the various year-groups being represented in the proportions shown in the graphical chart. The III group is here markedly predominant over the others, which is due, at any rate in part, to the fact that the greater portion of the material was taken in the trawl, and thus consisted mainly of smaller sizes than those generally brought in by the line fishery. The I and II groups are but poorly represented in comparison, the reason of which is presumably that these year-classes are for the most part found in shallow water. The older year-groups were taken either by trawl or by line; the latter in particular accounting for most of the oldest specimens.

The entire amount of material is derived from hauls made during the months of June and July, the smaller quantity collected by Adjunkt BJARNI SÆMUNDSSON at other seasons not being here included. Halibut of the 0-group, i. e. pelagic post-larval stages, have at this time of year a length of 1—3 cm., and it will also be noticed that the three youngest groups fall in point of size entirely clear one of another. The figures for the three groups in June-July are as follows:



0-group : Average length abt. 2 cm. varying from 1— 3 cm
I-group : — — 10 - — — 8—15 -
II-group : — — 23 - — — 18—32 -

The range of variation then for the 0, I and II groups is so slight that the three in no case overlap. It is otherwise, however, with the II and III groups, the range of variation of the last-named being so wide that the greater portion of the II group also falls within its limits. The older year-classes overlap still more, and it will thus be understood that the length of the fish in reality tells us very little as to the exact age of the fish, save in the case of the two youngest groups.

The range of variation for total length within the various year-groups increases more or less gradually, being comparatively slight for young specimens, but extending in the older groups, as is shown by the difference between the extreme limits of variation for the groups most fully represented.

Age group...	0	I	II	III	IV	V	VI	VII
Cm.....	3	8	15	28	33	31	35	50

In seeking to determine the cause of this common biological feature, we may doubtless here disregard the relatively slight difference in average size between the two sexes, which will be referred to later on. The explanation would then seem to be, that fish of tardier growth exhibit year by year a constantly inferior increment to that of their more rapidly growing fellows.

A growth curve showing the annual increment for all the Faxe Bugt material presents, as will be seen, a fairly regular course, albeit the somewhat inadequate material in the case of the oldest groups (over VIII) doubtless renders the results here less reliable on the whole, and gives a slightly irregular increment as between the groups concerned. This is moreover due first and foremost to the wide range of variation among the oldest groups.

The table below shows the average length, compared with range of variation, within the

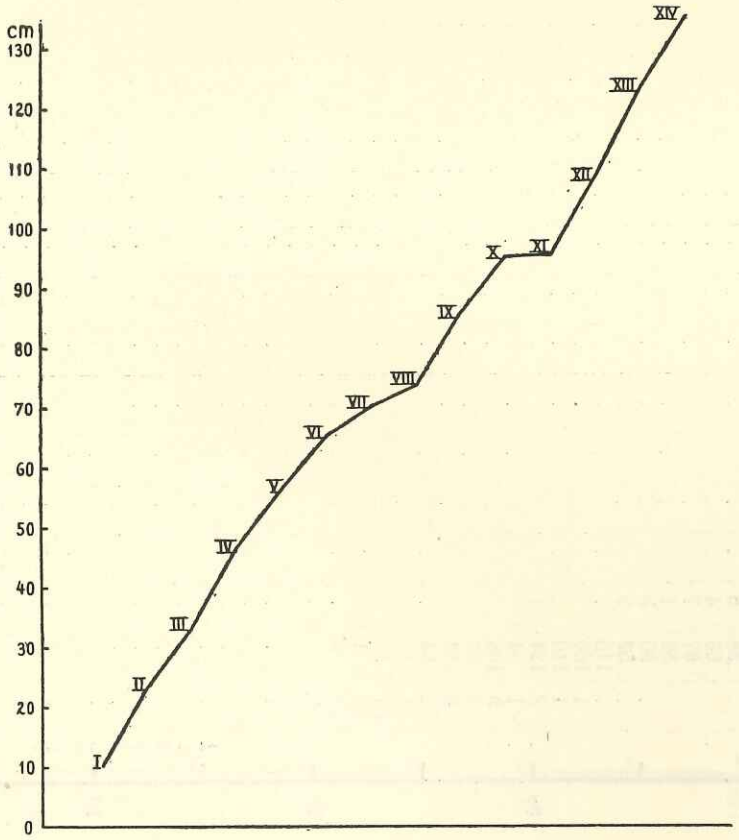


Fig. 2. — Growth Curve for Halibut from Faxe Bugt. I...XIV represents the age groups. June-July 1908, 1909.

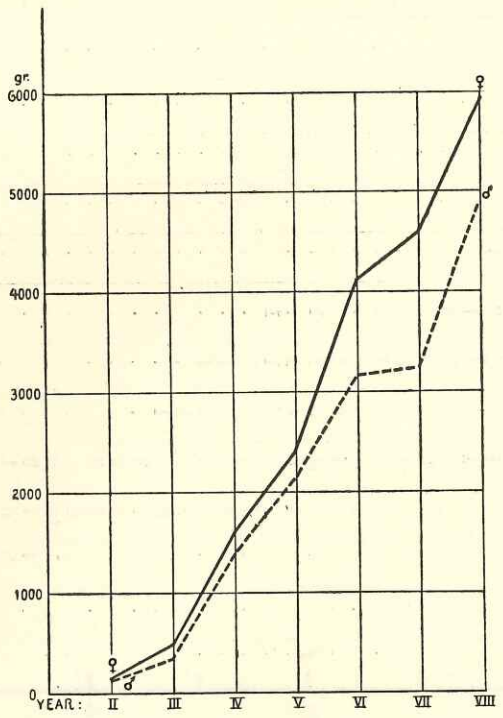


Fig. 3. — Graphical Chart showing weight of both sexes in Groups II—VIII. Halibut from Faxe Bugt. June-July 1908, 1909.

different groups for male and female respectively. The number of sex-determined specimens is about the same in both cases, the actual figures being 1009 ♂♂ and 993 ♀♀. From the results as shown, it might perhaps appear as if the ♂♂ did not reach so great an age as the ♀♀, though as a matter of fact they doubtless do. The apparent difference is due to the inadequacy of the material, as a comparison of the results from other Iceland localities, e. g. East Iceland, shows, that no such inequality exists. There seems then to be an essential difference in this respect between the halibut and the plaice (*Pleuronectes platessa*). In the latter, the ♂♂ do not appear to go beyond the VIII—IX groups, while the ♀♀, albeit but rarely, may attain an age of 20—30 years (see MAIER 1906, HEINCKE 1916).

Sizes of both sexes in the various age groups of halibut from Faxe Bugt. June—July 1908, 1909.

Age group	♂			♀			♂ + ♀		
	No. of specimens	Average length cm.	Range of variation	No. of specimens	Average length cm.	Range of variation	No. of specimens	Average length cm.	Range of variation
I	..	..	..	..	..	..	36	10.1	8—15
II	78	23.4	19—32	70	23.7	18—31	148	23.5	18—32
III	784	32.5	22—47	685	33.9	21—48	1469	33.2	21—48
IV	62	44.4	30—57	86	48.2	34—62	148	46.6	30—62
V	14	56.0	46—63	43	56.8	41—71	57	56.6	41—71
VI	17	62.2	57—70	32	66.9	53—87	49	65.3	53—87
VII	22	66.7	58—76	40	72.0	55—104	62	70.1	55—104
VIII	19	70.2	58—89	13	79.0	66—103	32	73.7	58—103
IX	7	83.5	68—104	12	87.2	71—107	19	85.8	68—107
X	4	95.5	75—113	5	95.2	77—141	9	95.3	75—141
XI	2	83.0	79—87	2	108.5	97—120	4	95.7	79—120
XII	..	..	..	2	108.5	80—137	2	108.5	80—137
XIII	..	..	..	2	129.5	119—140	3	123.3	111—140
XIV	..	..	..	1	155.0	..	2	135.5	116—155
XV	..	..	..	..	..	..	1	110.0	..

In accordance with what is known in the case of the plaice, we find also among halibut that the males are relatively smaller than the females of their year-class, as will be seen from the respective average lengths for the two sexes in the table above. The difference, however, is not very marked. On the other hand, we found, in the table of average weight per cm. length (p. 6) that a quite considerable increase was observable. And if we now glance at the average weights for each year class of males and females respec-

Weight of both sexes in the various age groups of halibut from Faxe Bugt. June—July 1908, 1909.

Age group	♂			♀			♂ + ♀		
	No. of specimens	Average weight gr.	Range of variation	No. of specimens	Average weight gr.	Range of variation	No. of specimens	Average weight gr.	Range of variation
I	..	..	..	..	..	..	..	..	..
II	28	121	70—370	12	145	80—260	40	130	70—370
III	292	342	100—1200	238	470	120—1200	530	400	100—1200
IV	17	1390	620—2400	28	1610	450—2500	45	1530	450—2500
V	4	2150	750—2800	9	2410	1550—4100	13	2330	750—4100
VI	5	3160	1900—4250	20	4123	1370—8800	25	3930	1370—8800
VII	9	3230	2050—4900	14	4590	1800—9700	23	4050	1800—9700
VIII	5	4860	2400—8000	8	5940	2520—7600	13	5520	2400—8000
IX	1	7300	..	1	5080	..	2	6190	5080—7300
X	2	10370	7700—13050	5	9080	5620—15600	7	9450	5620—15600
XI	..	..	..	1	14080	..	1	14030	..
XII	..	..	..	1	13400	..	1	13400	..

tively, it will be seen that the feature referred to is here far more distinctly apparent. The following table gives the figures concerned (p. 11).

If we confine ourselves to consideration of such year groups as are represented by a fair amount of material (II—VIII) in a graphical chart as that given below, (vide p. 10) it will be noticed that the average weight of the females is constantly somewhat beyond that of the males in the same group. The difference between the weight of the two sexes is, naturally enough, found to increase more or less regularly with advancing age.

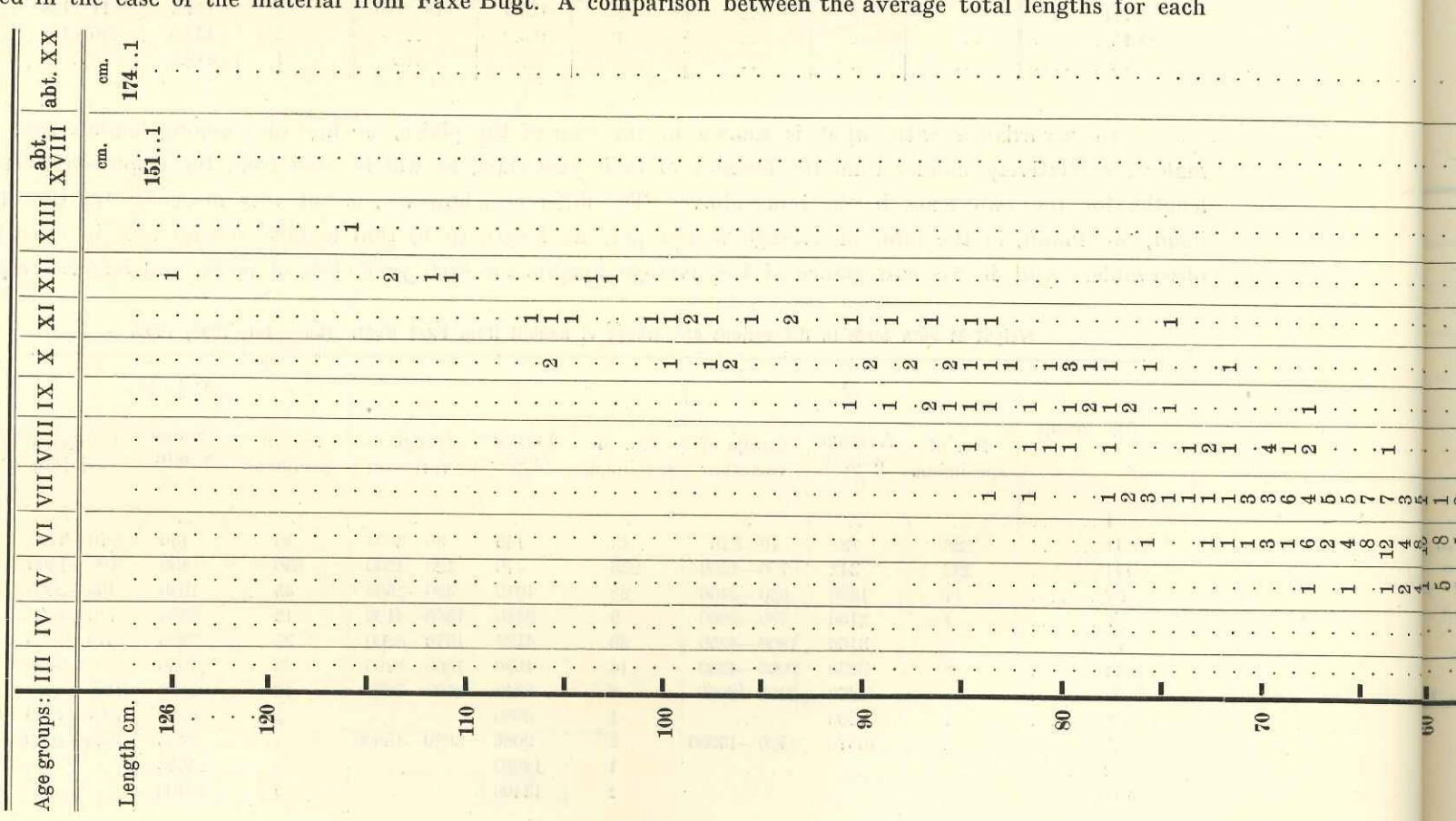
2. North-west Iceland.

In the fjords north of Faxe Bugt on the west coast of Iceland, a quantity of halibut were taken, partly on board the marine research steamer "Thor", and partly by the Icelandic trawler "Snorri Sturluson". From these hauls, a considerable number of otoliths were procured, representing in all 646 fish, from the following fjords or the waters at mouth of the same: Bredebugt, Patrexfjord, Arnefjord, Ønundarfjord, and Sugandafjord. There might perhaps be some ground for treating the material from these fjords separately, as the hydrographical conditions are hardly uniform for all. Such distinction would, however, here involve breaking up the material into quite small portions, hardly representative of the respective localities, and I have therefore preferred to treat the results from these waters under one head. A comparison of the figures from here with those for Faxe Bugt will make it clear that these two localities should be treated separately.

As seen from the general survey and graphical chart for average total lengths of the two sexes in each year-group, so also here we find a difference in size between the total lengths of the males and of the females in the respective groups.

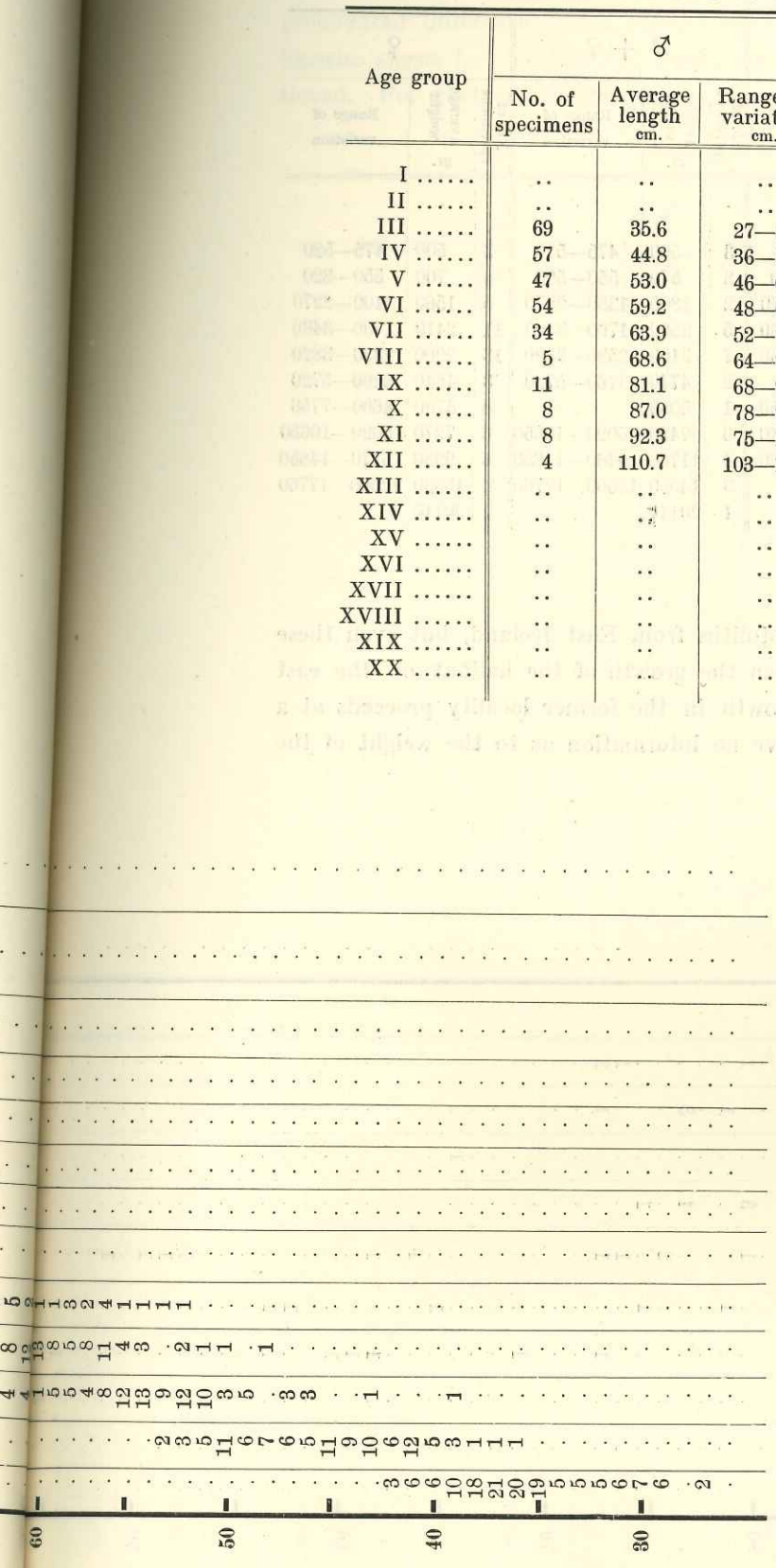
This difference between the sexes will be found in all essentials to correspond entirely with what was noted in the case of the material from Faxe Bugt. A comparison between the average total lengths for each

Graphical Chart showing sizes of halibut from North-West Iceland.
June, July 1908, 1909.



Sizes of various age groups. Halibut from North-West Iceland. June, July 1908, 1909.

Age group	♂			♀			♂ + ♀		
	No. of specimens	Average length cm.	Range of variation cm.	No. of specimens	Average length cm.	Range of variation cm.	No. of specimens	Average length cm.	Range of variation cm.
I	..	..	..	..	..	..	..	..	..
II	..	..	..	..	..	..	..	..	..
III	69	35.6	27—42	70	35.7	29—42	139	35.7	27—42
IV	57	44.8	36—51	45	46.0	37—53	102	45.4	36—53
V	47	53.0	46—66	61	56.1	39—68	108	54.7	39—68
VI	54	59.2	48—68	67	62.6	54—76	121	61.1	48—76
VII	34	63.9	52—78	43	67.5	53—84	77	65.9	52—84
VIII	5	68.6	64—70	12	75.3	68—85	17	73.3	64—85
IX	11	81.1	68—91	5	80.2	75—87	16	81.5	68—91
X	8	87.0	78—98	15	87.6	72—106	23	87.3	72—106
XI	8	92.3	75—106	9	96.7	85—107	17	94.7	75—107
XII	4	110.7	103—114	3	113.6	104—126	7	112.0	103—126
XIII	..	..	..	1	117.0	..	1	117.0	..
XIV	..	..	..	..	..	..	..	..	..
XV	..	..	..	..	..	..	..	..	..
XVI	..	..	..	..	..	..	..	..	..
XVII	..	..	..	..	..	..	..	..	..
XVIII	..	..	..	1	151.0	..	1	151.0	..
XIX	..	..	..	..	..	..	..	..	..
XX	..	..	..	1	174.0	..	1	174.0	..



year group from Faxe Bugt and the fjords here treated reveals, however, the interesting feature that the halibut in the last-named waters attain a relatively smaller size than in Faxe Bugt, albeit the difference is not very marked, as will be seen from the following survey.

♂+♀	III	IV	V	VI	VII	VIII	IX	X	XI
Faxe Bugt	33.2	46.6	56.6	65.3	70.1	73.7	85.8	95.3	95.7
N. W.- Iceland ..	35.7	45.4	54.7	61.1	65.9	73.3	81.5	87.3	94.7

We have unfortunately no material of the II group from Bredebugt and the remaining fjords of North-west Iceland, and are thus unable to determine whether this difference in the growth first makes itself apparent in the IV group. The average figures for the III group are, as we see, — despite the relatively large amount of material — the reverse of these for the remaining groups. As regards weight, the records from North-west Iceland include only a small number of specimens. On comparing the average weight per year-group with the corresponding values for Faxe Bugt, the above mentioned difference in the growth as between the different localities is extremely marked, as a glance at the following curves will show.

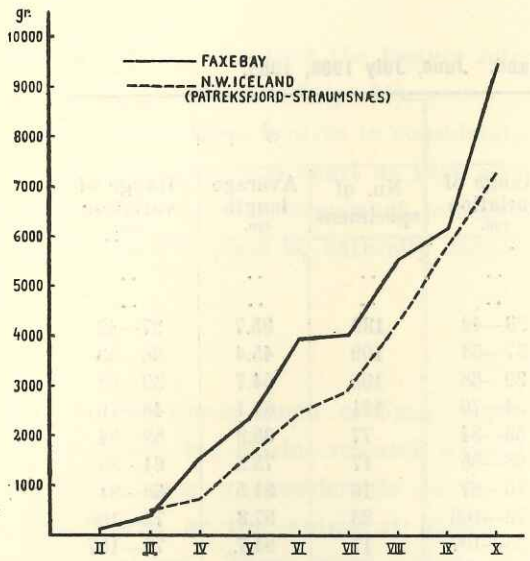


Fig. 4. — Graphical Chart showing average weights of various age groups of Halibut from Faxe Bugt and North-west Iceland.

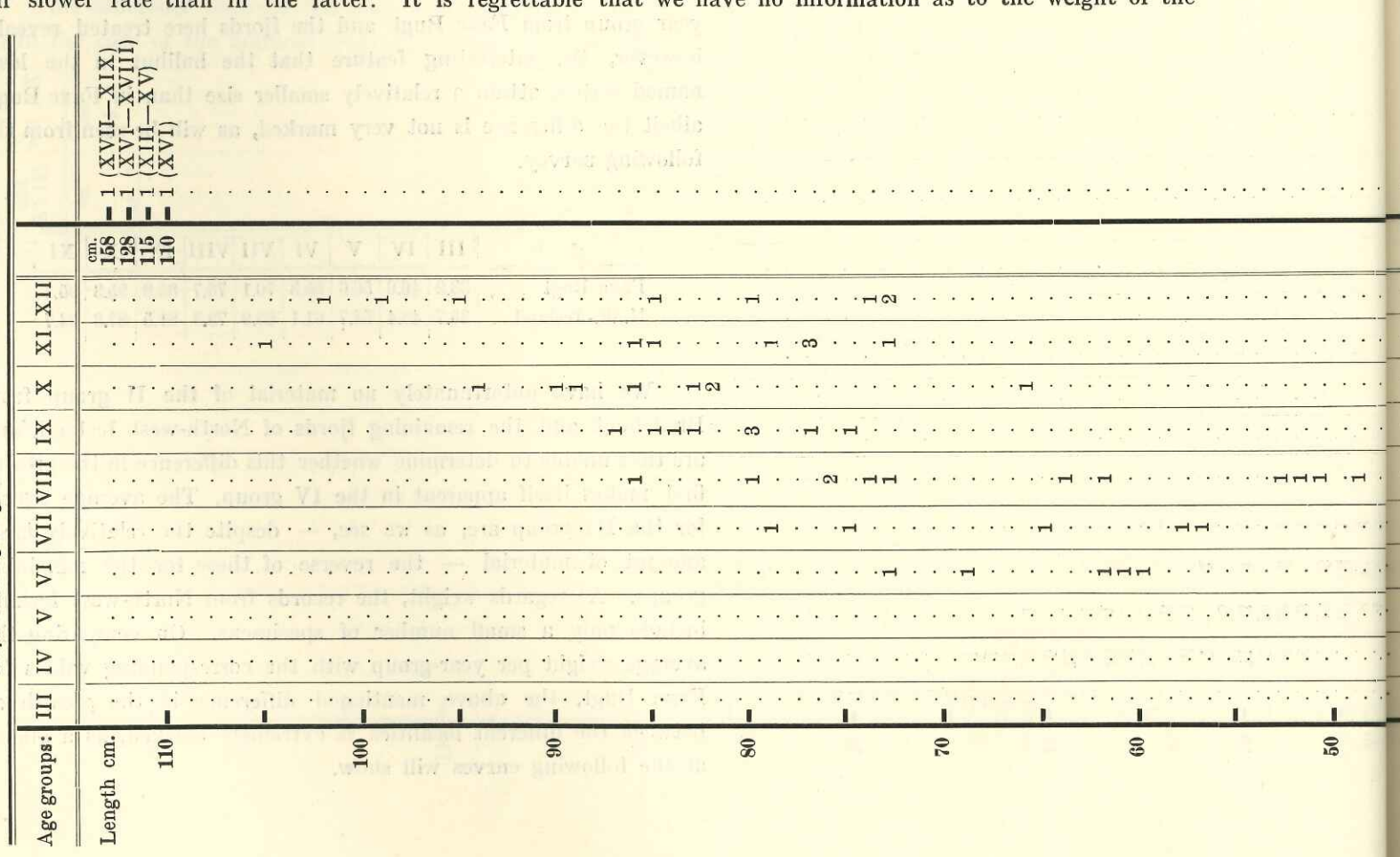
Weights of various age groups. Halibut from North-west Iceland.

Age group	♂			♂ + ♀			♀		
	No. of specimens	Average weight gr.	Range of variation	No. of specimens	Average weight gr.	Range of variation	No. of specimens	Average weight gr.	Range of variation
I	.	.	.	.	.	.	.	.	.
II	.	.	.	.	.	.	.	.	.
III	.	.	.	3	500	475—520	3	500	475—520
IV	3	830	775—820	3	570	550—590	6	700	550—820
V	3	1400	1100—1570	2	1800	1330—2270	5	1560	1100—2270
VI	6	2330	1780—3460	5	2500	1700—3420	11	2410	1700—3460
VII	6	2670	2390—3150	7	3100	2590—3820	13	2900	2390—3820
VIII	1	3260	.	2	4740	3760—5720	3	4240	3260—5720
IX	7	5890	4600—7750	1	5055	.	8	5790	4600—7750
X	3	7130	5120—8540	3	7420	5020—10650	6	7270	5020—10650
XI	2	6290	6170—6420	4	11760	9400—14850	6	9930	6170—14850
XII	1	17680	.	3	14550	12500—17760	4	15330	12500—17760
XIII	.	.	.	1	20110	.	1	20110	.

3. East Iceland.

We have unfortunately only a small number of halibut otoliths from East Iceland, but even these are sufficient to show that there is a considerable difference between the growth of the halibut on the east coast and that of the fish from the west. We find that the growth in the former locality proceeds at a far slower rate than in the latter. It is regrettable that we have no information as to the weight of the

Graph showing lengths of halibut from East Iceland.



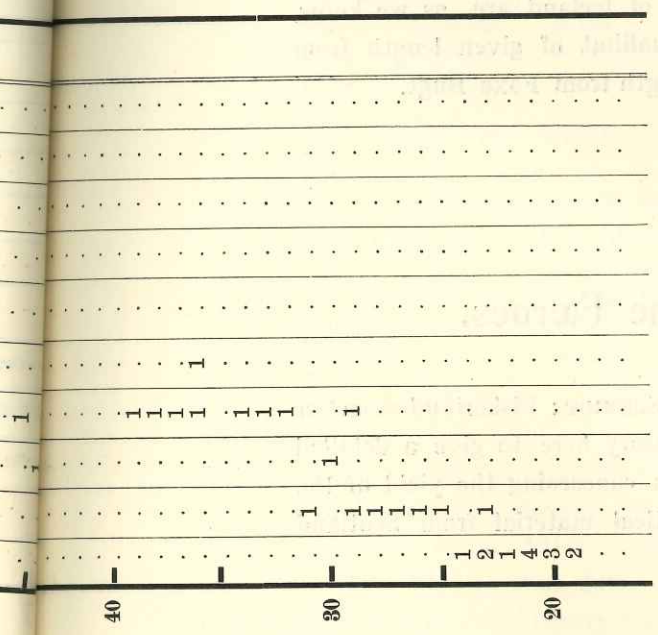
fish from these waters, as the weights would further — and doubtless even more distinctly — show the pronounced difference which exists between the halibut of East and West Iceland. The graphical chart likewise shows how remarkably slight the growth is here when compared with the localities previously mentioned. For the rest, reference may also be made to the following section.

Sizes of various age groups. Halibut from East Iceland.

Age group:	♂			♀			♂ + ♀		
	No. of specimens	Average length cm.	Range of variation	No. of specimens	Average length cm.	Range of variation	No of specimens	Average length cm.	Range of variation
I.....	..	..	..	.	..	..	..	..	..
II.....	..	..	..	.	..	..	..	..	..
III.....	11	21.0	19—24	2	21.0	21	13	21.0	19—24
IV.....	4	26.0	23—29	3	28.3	26—31	7	27.0	23—31
V.....	..	..	..	2	37.0	30—44	2	37.0	30—44
VI.....	7	47.4	29—73	7	45.2	32—69	14	46.3	29—73
VII.....	3	63.3	57—75	3	60.0	36—79	6	61.6	36—79
VIII.....	4	63.5	51—76	8	67.7	49—86	12	66.3	49—86
IX.....	8	80.5	75—85	1	87.0	87	9	81.2	75—87
X.....	6	85.8	82—94	2	78.5	66—91	8	84.0	66—94
XI.....	6	79.5	73—86	2	91.5	77—106	8	82.5	73—106
XII.....	4	85.2	73—99	4	85.2	73—103	8	85.2	73—103
(XII—XV)....	1	115.0	..	.	..	..	1	115.0	..
XVI.....	1	110.0	..	.	..	..	1	110.0	..
(XVI—XVIII)	1	128.0	..	.	..	..	1	128.0	..
(XVII—XIX) .	..	..	..	1	158.0	..	1	158.0	..

4. Growth in Iceland Waters generally.

The investigations as to growth of the halibut in the various fjords on the west and east coasts of Iceland have shown (p. 16).



General survey of average lengths for halibut in the respective age groups at various localities in Iceland Waters.

Age group	S. W.-Iceland		N. W.-Iceland		E.-Iceland	
	♂	♀	♂	♀	♂	♀
II	23.4	23.7	..	..	..	..
III	32.5	33.9	35.6	35.7	21.0	(21.0)
IV	44.4	48.2	44.8	46.0	(26.0)	(28.3)
V	56.0	56.8	53.0	56.1	..	(37.0)
VI	62.2	66.9	59.2	62.6	47.4	45.2
VII	66.7	72.0	63.9	67.5	(63.3)	(60.0)
VIII	70.2	79.0	68.6	75.3	(63.5)	67.7
IX	83.5	87.2	81.1	80.2	80.5	(87.0)
X	(95.5)	95.2	87.0	87.6	85.8	(78.5)
XI	(83.0)	(108.5)	92.3	96.7	79.5	(91.5)
XII	..	(108.5)	(110.7)	(113.6)	(85.2)	(85.2)
XIII	..	(129.5)	..	(117.0)	..	..
XIV	..	(155.0)	..	..	(115.0)	..
XV	..	..	..	..	..	..
XVI	..	..	..	..	(110.0)	..
XVII	..	..	..	..	(128.0)	..
XVIII	..	..	..	(151.0)	..	(158.0)
XIX	..	..	..	..	..	..
XX	..	..	..	(174.0)	..	..

1. That there is a considerable difference in the growth of the halibut in the different fjords, presumably due chiefly to differences of temperature, and

2. That the females on an average attain a greater weight and length than the males of their respective year groups.

This last-mentioned point has previously been treated, especially in the case of Faxe Bugt, and in the other localities also there appears to be a somewhat similar relation between the growth of the two sexes. It will here suffice to note the sizes for all the different localities as illustrative of the difference in rate of growth.

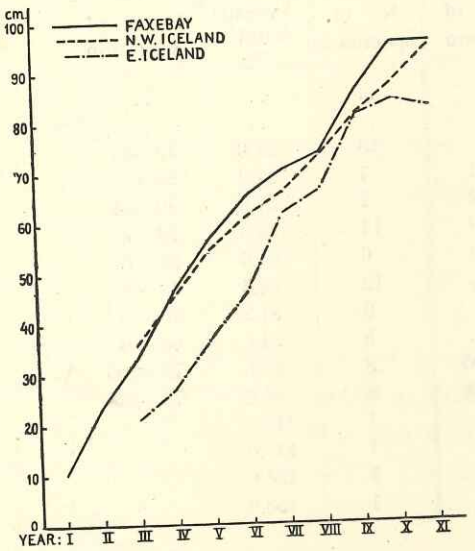


Fig. 5. — Growth Curves for Halibut from Faxe Bugt, N. W.-Iceland and E.-Iceland.

The above survey (p. 15) serves to give an idea as to the average lengths of males and females in the different year-groups at the three localities: South-west Iceland, North-west Iceland and East Iceland. A more concise wiev of the average lengths will be seen below, together with a graphical illustration of the average growth curves for these localities.

Average total length in cm. of Iceland halibut.

♂ + ♀	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Faxe Bugt.....	23.7	33.2	46.6	56.6	65.3	70.1	73.7	85.8	95.3	(95.7)	(108.5)
N.W.-Iceland ...	...	35.7	45.4	54.7	61.1	65.9	73.3	81.5	87.3	94.7	112.0
East-Iceland	...	21.0	27.0	(37.0)	46.3	61.6	66.3	81.2	84.0	82.5	85.2

It will be seen from the above, that the halibut find most favourable conditions in Faxe Bugt, and the least favourable in East Iceland. We have unfortunately no material from South Iceland, and can say nothing as to what may be the conditions there prevailing, but there can hardly be any doubt that the conditions affecting growth deteriorate from Faxe Bugt and northward round the coast to East Iceland. These conditions are then doubtless entirely dependent upon the hydrographical features of the different localities, of which temperature will presumably be the most important. The hydrographical conditions in Faxe Bugt and on the East coasts of Iceland are, as we know, widely different, and in accordance with these differences we find, that a halibut of given length from Seydisfjord will on an average be 2 to 3 years older than one of the same length from Faxe Bugt.

IV. The Halibut Fishery of Iceland and the Færoes.

A general description of the halibut fishery will be found, in JOHS. SCHMIDT: Fiskeriundersøgelser ved Island og Færøerne i Sommeren 1903, and it will therefore not be necessary here to give a detailed account. The following pages will accordingly be devoted mainly to statistics concerning the yield of the fishery in recent years, based on the various Fishery Reports, and the statistical material from Scotland previously mentioned.

1. Iceland.

In dealing with the halibut fishery of Iceland, it is necessary first of all to distinguish between the two methods employed in the industry. The branch more especially directed towards the capture of halibut

is the long line fishery, and this is accordingly of greater importance in economical respects. Far less important from this point of view is the trawl fishery for halibut, though this also is by no means insignificant. With the halibut, as with most other economically important fish in Iceland waters, only an extremely small percentage of the yield falls to the natives, the rich stock of halibut found on these grounds being exploited first and foremost by foreign vessels.

A. The native industry.

The halibut has always formed an prominent item in the Icelander's menu, and no small quantities of these fish are taken for private consumption; as an article of export, on the other hand the halibut has never been of any importance.

The fishery is carried out exclusively with lines, either cod lines and lines with halibut hooks, or hand lines. No exhaustive statistics are available as to the yield, but the information given in the annual reports, "Landshagsskýrslur fyrir Ísland" may nevertheless doubtless be taken as giving a fair idea of the amount represented. The records in these rapports give the number of halibut caught. In the following table, these figures have been worked out so as to show the weight taken, (reckoning the average as 9 kg. per fish) in accordance with the method followed by the statistical reports of the International Marine Investigations ("Bulletin statistique des pêches maritimes des pays du nord de l'Europe")[1].

1897	144,000 kg.	1905	361,440 kg.
1898	153,000 —	1906	299,250 —
1899	198,000 —	1907	375,030 —
1900	229,500 —	1908	253,350 —
1901	301,500 —	1909	172,800 —
1902	273,000 —	1910	132,300 —
1903	216,000 —	1911	233,190 —
1904	272.700 —		

B. Foreign Fishery in Iceland Waters.

Among the foreign nations carrying on halibut fishery in Iceland waters, England ranks incontestably first, accounting as a rule for well over twice the amount taken by all other nations together. The countries participating in this fishery are as follows: England, Scotland, Germany, Holland and Belgium. For 1906—1910, the yield falling to each is, according to the Bulletin Statistique, as follows: (weight in kilos)

	England	Scotland	Germany	Nether-lands	Bel-gium	Total Quantity
1906 ...	4,983,023	45,720	83,734	9,495	3,788	5,125,760
1907 ...	7,219,188	100,178	185,052	10,093	1,322	7,515,833
1908 ...	6,939,026	75,082	268,269	13,774	6,211	7,302,362
1909 ...	5,444,744	41,250	306,813	20,487	19,566	5,832,860
1910 ...	4,631,741	927,933	418,986	25,514	10,916	6,015,090

On adding up the proceeds for these five years, we obtain a total yield for each of the five countries as follows:

England	29,217,722 kg.
Scotland	1,190,163 —
Germany	1,262,854 —
Netherlands	79,363 —
Belgium	41,803 —

The graphical illustration of the share falling to the various participating countries shows how markedly predominant a position England occupies in comparison with the rest. The international statistical reports are, unfortunately, only available up to 1910, so that we cannot pursue the comparison beyond that date. As it happens, however, English statistics for this fishery have been issued up to 1914, and in view of the great importance of that country's interest

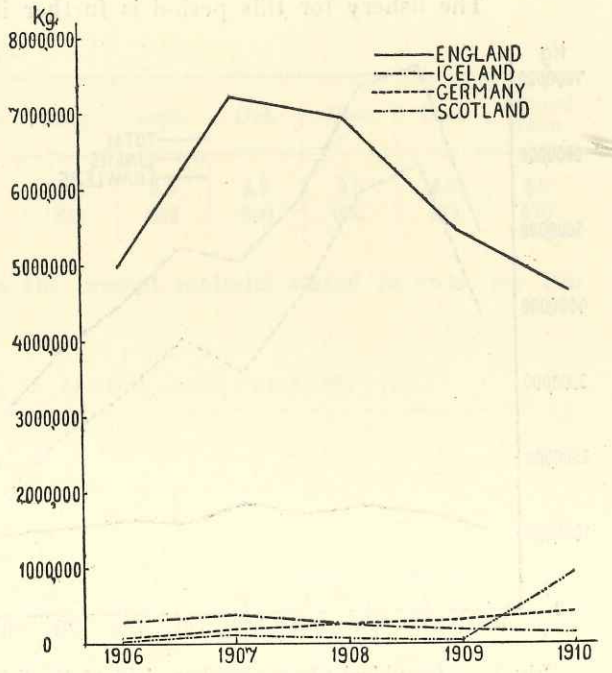


Fig. 6. — Graphical Chart showing Halibut Fishery of various nations in Iceland waters 1906—1910.

[1] In the Report for 1908, the yield of halibut for Iceland is erroneously stated as 2,533,500 kilos instead of 253,350 kilos.

in the Iceland halibut fishery it may be interesting to study the records in question further. The English halibut fishery is carried on partly by trawlers and partly with long lines, laid out from steamers specially equipped for the purpose. In the English Fishery Reports, these two methods are separately dealt with, and it is well worth while to note the difference in fishing capacity which the figures show.

The next table shows the annual yield in kilos for trawlers and line steamers respectively; also the percentage of halibut taken by British vessels in Iceland waters (for the Færoes *vide infra*) as compared with other grounds; also the proportional percentage of the halibut yield compared with the total catch of demersal fish. Finally, the daily haul for trawlers and liners is likewise noted. The figures for 1914 are shown in parentheses, as it is not impossible that the outbreak of war in August of that year may in part account for the comparative smallness of the yield.

English Halibut Fishery in Iceland waters 1906—1914.

	Trawlers	Liners	Total	Percentage taken in each region	Proportion per cent of Halibut to Quantity of demersal Fish	Average catch per day's absence	
						Trawlers	Liners
	kg.	kg.	kg.	%		kg.	kg.
1906	1,087,628	3,895,395	4,983,023	60.26	5.90	30.99	517.65
1907	1,303,172	5,916,016	7,219,188	68.26	8.51	38.61	647.19
1908	1,402,131	5,536,895	6,939,026	69.19	7.88	43.69	505.97
1909	1,298,143	4,146,601	5,444,744	65.99	7.86	47.75	392.18
1910	1,440,282	3,191,459	4,631,741	66.14	6.17	48.77	322.07
1911	1,190,092	3,641,039	4,831,131	69.54	5.79	39.11	321.06
1912	1,220,317	2,870,048	4,090,365	69.11	5.03	39.62	279.40
1913	1,140,511	2,359,609	3,500,120	66.08	3.69	30.99	261.11
(1914	1,060,094	1,589,278	2,649,372	65.90	2.60	27.43	195.58)

The fishery for this period is further illustrated by the accompanying graphical charts.

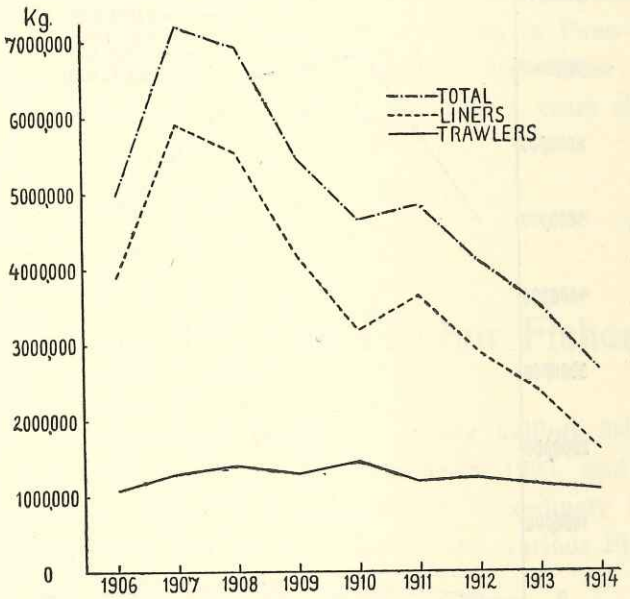


Fig. 7. — Graphical Chart showing yield of English Halibut Fishery in Iceland waters 1906—1914.

From the above it will be seen how greatly the total annual yield has fallen off during the period in question, even disregarding the low figures for 1914. In the course of six years, from 1907—8 to 1913—14, the total yield has as a matter of fact dwindled practically to half, i. e. from abt. 7 million kilos to abt. 3.5 million. Further investigation reveals the interesting fact that it is essentially the catch made by the line steamers which has undergone reduction. The yield of the trawlers has remained more or less constant throughout the whole time. This might, of course be supposed to be due to a decrease in the number of line steamers working the grounds, which would naturally give a smaller yield. There is always the possibility that something of this kind may have taken place, and the figures should not therefore be considered as of supreme importance, There is, however, another point which gives us a more correct idea of the state of things, to wit, a comparison of the average catch per day's absence during the different years. Albeit the outbreak of war in 1914 may

have affected the total yield for that year, it is hardly likely that the same fact should have influenced — at any rate in a marked degree — the average catch per day's absence.

The following chart shows as a matter of fact precisely the same picture, in a corresponding manner, as that of the total catch.

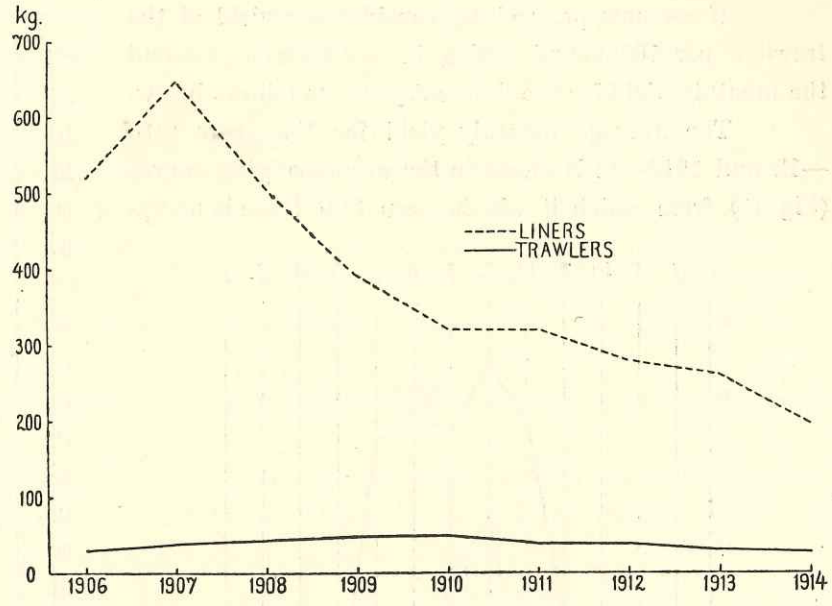


Fig. 8. — Average catch per day's absence. English Halibut fishery in Iceland waters 1906—1914.

The English halibut fishery in Iceland waters thus shows a more or less gradual decline of the total yield from the year 1907 to 1913. It will in this connection be of interest to consider the Scottish halibut fishery in the same waters in like manner. The investigations are here chiefly based upon the material procured as to the fishery of Aberdeen trawlers and liners in Iceland waters.

The material here received from Scotland as regards the halibut fishery includes specified statements for both liners and trawlers from Aberdeen. In the case of the line fishery, the number of trips from Aberdeen is noted, together with the number of lines employed during the different months of the years 1908—15. The mean values for these are:

Aberdeen Liners. Iceland.

	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean
No. of Trips	5.0	4.5	4.0	2.0	3.7	3.5	4.4	4.0	3.6	4.2	5.0	4.5	4.0
No. of Lines	529	467	535	220	524	556	805	848	627	600	655	474	570

The average monthly yield for the various years is in the present material stated in cwts. per 100 lines fishing.

Average monthly yield of halibut in ctws. per 100 lines fishing for Aberdeen Liners, Iceland 1908—1915.

	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean
1908.....	..	..	..	..	65.3	..	..	..	..	..	..	..	..
1909.....	..	..	33.3	..	..	..	..	..	..	..	..	..	..
1910.....	.	..	..	..	..	..	..	..	..	..	18.8	19.3	..
1911.....	..	..	..	..	68.9	82.6	64.0	70.8	51.7	16.0	..	5.3	..
1912.....	..	..	..	40.2	64.6	65·8	66.4	64.0	75.8	39.5	8.6	3.5	..
1913.....	23.3	18.0	52.5	..	42.4	59.6	77.0	62.0	74.5	..	6.7	3.7	..
1914.....	22.5	..	..	..	24.9	60.8	60.8	39.2	47.4	13.5	4.0	7.8	..
1915.....	5.7	17.2	10.8	25.6	30.6	46.8	30.9	13.1	17.6	8.4	3.4	11.6	18.5
Mean ...	17.2	17.6	32.2	32.9	49.4	63.1	59.8	49.8	53.4	19.4	8.3	8.5	34.3

A comparison of the yield for the different years shows an apparent decline during the latter part of the period. The graphical chart (Fig. 9), giving the mean values for 1911—12 and 1914—15, will sufficiently illustrate this.

If we now proceed to consider the yield of the trawlers per 100 hours' fishing in like manner, we find the monthly yield for the different years as follows below.

The average monthly yield for the years 1910—12 and 1913—15 is shown in the accompanying curves (Fig. 10), from which it will be seen that there is no ap-

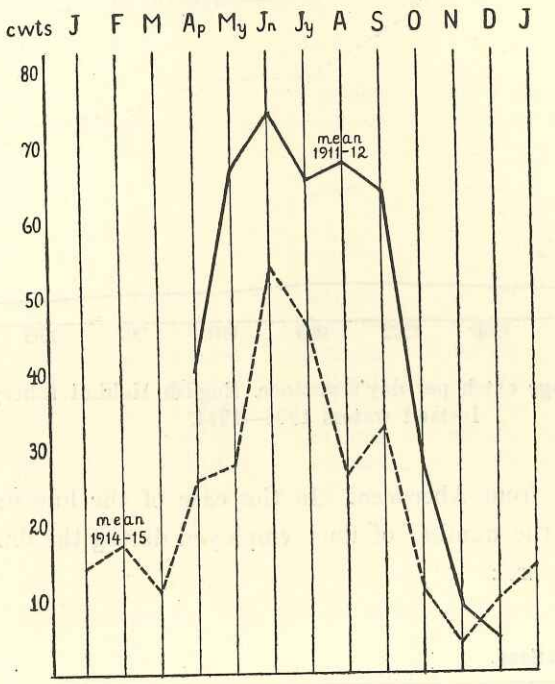


Fig. 9. Graph showing average monthly yield of halibut in cwts. per 100 lines fishing for the years 1911—12 and 1914—1915. Aberdeen Liners. Iceland.

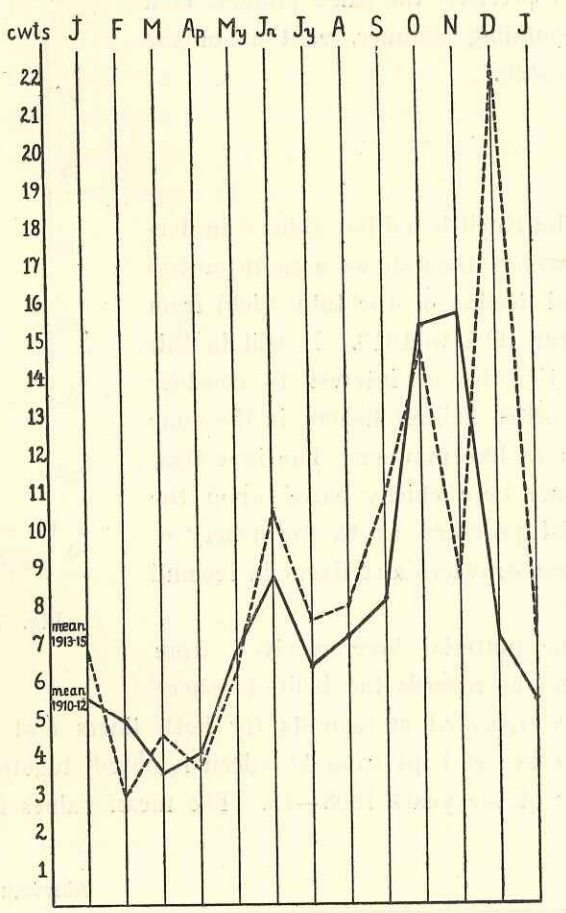


Fig. 10. Graph showing average monthly yield of halibut in cwts. per 100 hours fishing, 1910—1912 and 1913—15. Aberdeen Trawlers. Iceland.

Average monthly yield of halibut in ctws. per 100 hours fishing for Aberdeen trawlers, Iceland 1904—1915.

	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean
1904.....	16.7	..	..	4.7	13.2	12.7	12.0	24.2	29.2	35.0	..	..	..
1905.....	..	11.8	12.1	9.2	5.4	5.6	4.6	6.4	22.9	36.7	..	..	..
1906.....	5.0	1.1	2.5	5.0	4.0	6.4	7.8	10.1	8.8	2.9	0.9	5.5	5.0
1907.. ..	1.1	1.2	1.3	3.1	7.0	12.1	4.9	6.1	6.2	6.6	5.2	1.4	4.7
1908.....	0.8	1.8	1.9	4.1	5.5	4.7	5.6	5.5	9.6	7.3	..	2.8	..
1909.....	3.3	2.8	5.2	4.7	2.4	6.5	7.3	9.1	4.7	3.3	..	9.2	..
1910.....	3.4	5.8	3.5	3.0	4.4	8.2	5.5	8.0	10.7	13.7	15.1	7.2	6.5
1911.....	7.2	4.6	4.9	5.1	7.4	9.8	7.8	8.5	9.3	24.2	20.5	8.0	9.8
1912.....	5.7	4.4	2.2	4.1	8.3	8.1	5.7	4.9	4.5	8.1	11.4	6.3	6.1
1913.....	7.1	2.3	2.3	1.7	5.1	7.8	5.7	4.4	5.5	5.6	4.6	2.5	4,6
1914.....	2.0	1.8	1.0	1.5	3.2	7.4	5.0	6.3	11.8	9.8	17.1	24.0	7.6
1915.....	12.2	4.6	10.2	7.7	10.4	16.0	11.8	13.1	15.1	28.8	4.2	40.6	14.6
Mean ...	5.9	3.8	4.3	4.5	6.4	8.8	7.0	8.9	10.7	15.2	9.9	10.8	8.0

parent difference in the results. It is nevertheless worth while to note the relatively large yield for 1915, indicated by the above, this at any rate does not seem to suggest that any decline should have taken place of late years.

It is interesting to glance at the results of the fishery as noted for the various months. The average monthly number of trips and of fishing hours will be seen from the table below, giving the mean values for the years 1904—15.

Aberdeen Trawlers. Iceland.

	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann. Mean.
No. of Trips.	13.1	16.5	29.5	52.0	52.4	33.3	18 3	17.5	10.1	4.8	5.8	13.1	22.2
No. of Hours.	1327	1644	2214	3517	4469	3479	2618	2293	1410	657	737	1370	2145

From this it will be seen, that the fishery of the Aberdeen trawlers in Iceland waters is at its height during the months of April—June.

The outbreak of war in 1914 has, it need hardly be said, strongly affected the work of the Scottish trawlers in Iceland waters. The number of trips to Iceland was during the years 1910—1915 as follows:

1910.....	289	Trips.
1911.....	318	—
1912.....	399	—
1913.....	479	—
1914.....	449	—
1915.....	96	—

The effect of the war is even more distinctly evident when we compare the number of trips in 1914—15 August to July inclusive, with that for the previous year 1913—14 similarly reckoned. The number of trips to Iceland made by Aberdeen trawlers in these years was 80 and 568 respectively. Such a falling off must necessarily involve a considerable decrease in the total yield of the trawl fishery.

Summing up the various results on the basis of the present material, regarding the Scottish halibut fishery in Iceland waters, we obtain the impression that there has of late years been a considerable decrease in the yield of the line fishery, whereas the trawling industry has more or less maintained the same level as before. These results thus agree in the main with those noted for the English Halibut fishery in the same waters.

Since we thus find that a decrease has actually taken place in the total yield of the Halibut fishery in Iceland waters during late years, the question naturally arises, what are the conditions which have brought about this reduction of the yield.

The following points suggest themselves as possible explanation of the fact in question:

1. Decrease due to temporary fluctuation.
2. Decrease due to transference of craft to other economically important branches of the fishing industry, e. g. the cod fishery.
3. Decrease due to a reduction in the stock of halibut owing to overfishing.

These points will now be further considered.

1. The suggestion as to decrease due to temporary fluctuation can neither be proved nor disproved from the material available.

2. There is one thing which seems to indicate that the decrease in the yield might possibly be due to certain alterations in the industry. This should in particular apply to the line fishery, where, as we have seen, the decrease is far more pronounced than elsewhere; it could for instance be supposed that a number of these line steamers had of late years gone over to cod fishing instead of halibut. This might involve a movement to other fishing grounds, where the yield of halibut is only minimal. This theory is especially

supported by the following extract from a communication dated 31. Oct. 1916 from Mr. WALTER DUFF, Aberdeen, to the Secretary, Fishery Board for Scotland (Mr. D. T. JONES) Edinburgh. "From landings of Grimsby vessels at Aberdeen it may be inferred that in recent years, English vessels have been engaged more in cod fishing than in quest for halibut. In 1914 for instance, 16,774 cwts. of cod, in the total of 21,245 cwts., were landed in October, November and December. Further, every endeavour is made to supply as much squid as possible for bait, as the squid is reckoned to be the best bait for cod, at the season. The grounds then frequented on the

Trawling hauls of Halibut in Faxe Bugt. S/S "Snorri Sturluson".

			Average no. per hour	Average weight per hour
I	9.—10. June 1908	16 Hours Trawling: 428 spec. = 184,9 kg	27 spec.	11.5 kg
II	5.—6. July 1908	5½ - — 33 - = 74,7 -	6 —	13.5 -
III	6.—7. July 1908	8 - — 73 - = 67,6 -	9 —	8.5 -
IV	June—July 1909	79 - — 1724 - = 999 -	22 —	12.6 -

Trawling hauls of halibut from Faxe Bugt. 10 June 1908. S/S "Snorri Sturluson".

Age group	♂									♀									♂ + ♀								
	II	III	IV	V	VI	VII	VIII	IX	Total	II	III	IV	V	VI	VII	VIII	IX	Total	II	III	IV	V	VI	VII	VIII	IX	Total
20 cm.	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1
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30 —	.	41	.	.	.	.	.	.	41	.	22	.	.	.	.	.	.	22	.	63	.	.	.	.	.	.	.	63
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35 —	.	11	.	.	.	.	.	.	11	.	9	.	.	.	.	.	.	9	.	20	.	.	.	.	.	.	.	20
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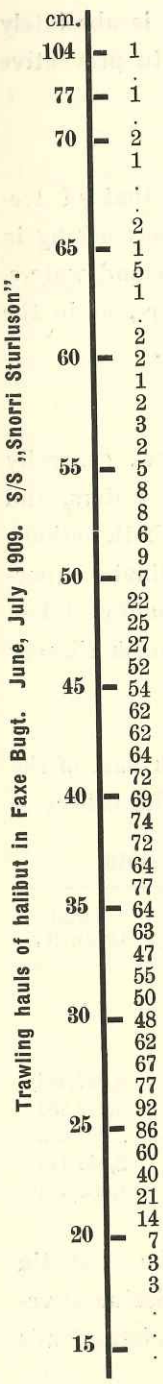

east side of Iceland (off Seidis Fjord, Havilsbak and Easter Horn) yielded heavy shots of cod, but very few halibut."

There is thus much to support the view that the decrease in the yield is due to the partial transference of the fishery during late years to grounds where there is a better chance of obtaining good hauls of cod.

3. The question as to whether the intensive fishery which has for years been carried on in Iceland waters after halibut may possibly be one cause of the decline in the yield of late is one which it would be most desirable to have answered. The point will therefore be subjected to closer enquiry.

As already mentioned, the hauls made with the implements used in modern trawling include great numbers of quite young halibut, and it is therefore more or less natural to seek an explanation of the decreasing yield in reduction of the stock on the grounds.

On the south-west coast of Iceland, great numbers of young halibut are found in Faxe Bugt, and as an intensive trawl fishery is carried on in this very locality, the young fish are here destroyed on a large scale. The following typical examples of trawling hauls made in Faxe Bugt will serve to give an idea as to the inroads made by the great number of trawlers on the stock of halibut (*vide* p. 22).

It will be seen that each trawler takes on an average abt. 16 halibut with a total weight of 11.5 kilos per hour. The average weight per fish for these four hauls is 0.43, 2.26, 0.92 and 0.57 kilos respectively, which is enough to show that the fish taken by this method are mostly small. The survey above of a typical trawl catch from Faxe Bugt will make clear what age groups are chiefly taken in the trawl, and the distribution of the two sexes in the material (*vide* p. 22).

A further illustration of the fact that the smaller sizes of halibut are incontestably taken mainly by the trawl will be gained from the table on this page showing the capture of 1724 halibut from trawl fishery, (S/S "Snorri Sturluson") in Faxe Bugt in June—July 1909, comprising in all 79 hours fishing.

Considering the large number of trawlers which under normal conditions ply their trade in Faxe Bugt, and reckoning the catch of each to average 16 halibut = 11 kilos weight per trawling hour, it will readily be understood that the quantity of young halibut annually destroyed by the trawl fishery is by no means inconsiderable. Most of these fish are from 2—3 years old, and when we remember that the halibut rarely attain maturity before their ninth or tenth year at the earliest, (*vide infra*, under propagation, p. 30) it does not seem impossible that such destruction of immature specimens can in the long run exert a detrimental effect upon the maintenance of the stock. And it need hardly be said that wholesale destruction of young fish is doubly fatal in the case of halibut, with their slow growth and late maturity.

The present material does not in itself suffice to determine which of the three factors here mentioned is responsible for the marked decrease in the yield of the halibut fishery of late years. The two first named explanations will hardly claim any particular attention; the last however, strongly demands consideration. An exhaustive statistical material would be required for its further discussion, and it will here, *inter alia* be of the highest importance to introduce a system of classification in the halibut statistics, which would render them far more valuable than hitherto. If then it is found, on continued investigation, that the evident decline in the yield is chiefly due to intensive fishery among the young fish, international regulations should be resorted to, concerning the capture of halibut in Iceland waters, with a view to the maintenance of the stock.

First of all, however, a closer investigation of the cause of the decline in the yield is absolutely necessary; this once established, is will then be time, if necessary, to discuss the question as to preventive measures.

2. The Færoes.

Although the halibut fishery round the Færoes does not attain the same importance as that of Iceland, the halibut is nevertheless a considerable item in the haul of the trawlers and line vessels fishing in these waters. The annual yield of halibut cannot, as mentioned, compare with that of the Iceland waters, but the fishery and its methods are otherwise precisely the same, only on a smaller scale. Here, as in the case of the Iceland fishery, the amount of line-caught fish far exceeds that taken by the trawl.

A. The native industry.

The native fishery of the Færoes falls, as we know, generally into two periods, one in the first half of the year in Færoe waters, and the other during summer off the coasts of Iceland. During both periods, halibut are taken on the line, but this fishery is of subordinate importance, and on the whole we may say that the amount of halibut taken by Færoe fishermen is but slight. Some figures from the Danish Fishery Reports will bear this out.

	Quantity	Value
1911.....	8510 kg	999,00 Kr.
1912.....	18525 -	4925,00 -
1913.....	10695 -	1646,00 -
1914.....	4103 -	820,60 -

B. Foreign fishery in Færoe waters.

As in the case of Iceland, so also at the Færoes we find that foreigners take the greater part of the rich yield, and here again, England is the dominant country as regards the halibut fishery. The fishery is carried on partly from steam trawlers and partly from line steamers, the most important season being during the winter months, due to the fact that a number of the same vessels are working the Iceland grounds during summer. Most of the trawlers and line vessels are from England and Scotland, but also German, Norwegian, Dutch and Belgian trawlers also work here.

Yield of Halibut Fishery at the Færoes 1903—1910.

	England	Scotland	Nether-lands	Total Quantity
1903.....	..	..	894	..
1904.....	..	142,697	300	..
1905.....	..	174,219	14,105	..
1906.....	1,970,684	60,960	5,840	2,037,484
1907.....	2,169,465	73,376	9,758	2,252,599
1908.....	1,810,106	233,934	7,602	2,051,642
1909.....	1,620,114	410,769	14,563	2,045,446
1910.....	1,036,980	345,626	2,448	1,385,054

We have no exhaustive statistics as to the hauls made by the ships of these various nations; in the case of the English and Scottish vessels, however, statistical information for a number of years is available. The figures in the "Bulletin Statistique des pêches maritimes des pays du nord de l'Europe", issued by the International Marine Investigations, cover the years 1903—1910 and show the yield for England, Scotland and the Netherlands as stated above.

Taking the total hauls for the period 1906—1910 the amounts for the three countries are as follows:

England..... 8,607,349 kilos.
Scotland..... 1,124,665 -
Netherlands..... 40,211 -

This shows how predominant is the English fishery in comparison with that of other countries, but the English halibut fishery at the Færoes is by no means comparable with the amount taken by the same country on the Iceland grounds. The Færoe fishery for these 5 years represents 8,607,349 kilos, whereas the Iceland fishery for the same period amounted to 29,217,722 kilos. In other words, the Iceland halibut fishery gives, as far as England is concerned, three and a half times as much as that of the Færoes. A

similar comparison in the case of Scotland shows that the difference in the halibut fishery of the two localities is here less pronounced. The yield of the Scottish fishery at the Færoes during the five years was 1,124,665 kilos, as against 1,190,163 kilos from Iceland.

It will be interesting to study further the English statistics for the Færoe fishery, in the same manner as with that of Iceland. Statistics are available for the years 1906—1914. The last-named year is here included, but the figures are noted in parentheses, as we cannot be sure that the yield for that year was not in some degree affected by the outbreak of war.

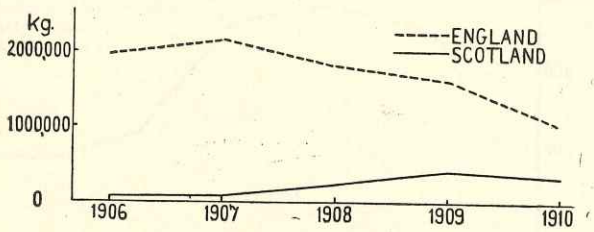

Fig. 11. Graph showing yield of English and Scottish Halibut fishery at the Færoes 1906—1910. [1])

It will be noticed that even disregarding the relatively small yield in 1914, there is nevertheless a decided falling off in the yield since 1907. This is even more markedly apparent in the accompanying graphical chart, showing the total yield for the various years (Fig. 12).

English Halibut Fishery at the Færoes 1906—1914.

	Trawlers kg	Liners kg	Total kg	Percentage taken in each region %	Proportion per cent of Halibut to Quantity of demersal Fish.	Average catch per day's absence	
						Trawlers kg	Liners kg
1906.....	577,240	1,393,444	1,970,684	23.83	6.27	33.52	284.48
1907.....	487,985	1,681,480	2,169,465	20.51	6.40	28.96	358,14
1908.....	251,816	1,558,290	1,810,106	18.05	8.88	21.84	381.51
1909.....	357,531	1,262,583	1,620,114	19.63	5.23	22.86	358.14
1910.....	393,243	643,737	1,036,980	14.81	3.53	22.35	215.90
1911.....	364,033	393,497	757,530	10.90	2.48	20.32	178.31
1912.....	301,650	488,137	789,787	13.34	2.48	16.26	187.45
1913.....	368,300	452,425	820,725	15.50	2.45	16.76	195.58
(1914.....	274,879	294,640	569,519	14.17	2.04	13.20	171.70)

We find here just the same state of things as in the case of the Iceland fishery. The total yield has since 1906—07 decreased to over half. Comparing the yield for the two periods of three years each, from 1906—08 and 1911—13, we find 5,950,255 and 2,368,042 kilos respectively. Taking the total yield for trawlers and for liners separately, we obtain the same impression as in the Iceland fishery. The yield of the trawlers is in all essentials constant, the entire decrease being borne by the line fishery.

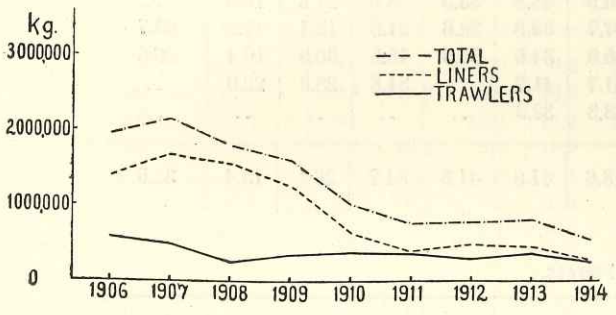

Fig. 12. Graph showing English Halibut fishery at the Færoes 1906—1914.

Again, if we consider the average haul per day's absence, as previously done in the case of Iceland, we here find confirmation of the view that the great decline in the total yield is due to a falling off in the average take per day's absence. This will be seen from the curves given below (Fig. 13), covering the period from 1906—14.

The English halibut fishery at the Færoes thus shows a corresponding decline in the yield to that noted in the Iceland waters, and a further investigation of the Scottish fishery will likewise be found to agree in all essentials with the results of the Iceland fishery.

[1] The curve for the Netherlands not marked, owing to the extreme smallness of the yield.

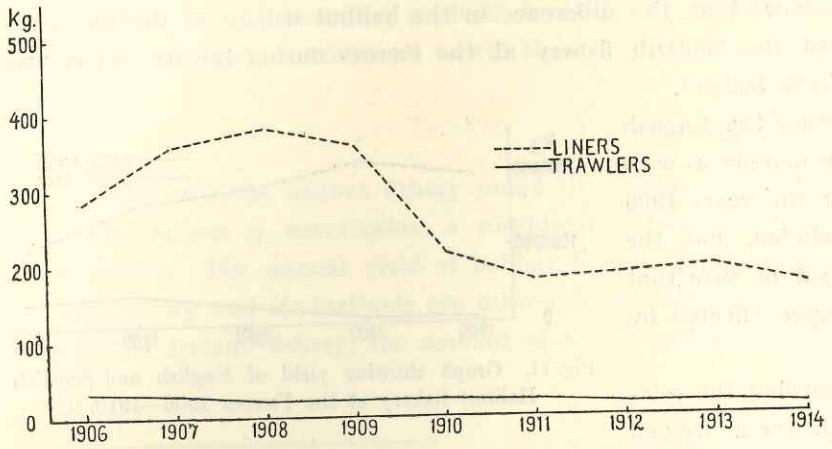

Fig. 13. Average catch per day's absence. English Halibut fishery at the Færoes. 1906—1914.

The Line and Trawl fishery may be treated separately, in the same way as with the Scottish fishery in Iceland waters.

The Scottish line fishery at the Færoes for the years 1908—15 gives the following mean values for number of trips and number of lines during the different months.

The average monthly yield per 100 lines fishing amounted during the different years to the following (in cwts.) (*vide infra*).

A graphical illustration of the mean values for the years 1908—11 and 1912—15 (Fig. 14) shows, that the yield per 100 lines fishing has decreased very considerably during the latter period, although the falling off is not so marked as in the case of the Scottish line fishery on the Iceland grounds.

Aberdeen Liners. Færoes.

	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann. Mean.
No. of Trips	3.6	7.2	10.3	8.4	7.3	12.7	17.4	9.6	9.0	7.1	6.9	7.1	8.9
No. of Lines	397	862	1246	1013	1033	1867	2372	1438	1162	909	785	786	1156

Average monthly yield in cwts. per 100 lines fishing, for Aberdeen liners at the Færoes. 1908—1915.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann. Mean.
1908.....	9.1	14.5	30.0	38.7	41.0	71.1	62.6	41.2	40.5	45.9	35.7	12.2	36.9
1909.....	17.0	..	20.8	38.6	80.8	69.4	69.1	60.0	62.1	36.8	29.5	15.9	..
1910.....	8.4	15.4	18.6	37.3	56.4	68.3	55.3	39.2	46.3	62.2	24.4	10.9	37.4
1911.....	27.8	..	28.1	39.6	38.2	..	44.9	43.8	33.9	26.6	21.3	10.3	..
1912.....	7.8	12.6	21.5	24.0	27.7	42.4	37.7	32.8	32.6	21.3	13.1	11.2	23.7
1913.....	11.1	17.2	18.2	29.8	34.8	44.3	35.9	34.6	35.5	15.5	30.8	10.4	26.5
1914.....	14.4	21.4	21.1	31.5	30.7	35.9	41.7	41.7	..	34.8	28.3	22.9	..
1915.....	7.8	13.3	14.8	30.4	40.0	57.8	43.3	32.9	..	..	..	..	..
Mean.....	13.0	15.7	21.6	33.7	43.7	55.6	48.8	41.8	41.8	34.7	26.1	13.4	32.5

Aberdeen Trawlers. Færoes.

	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann. Mean.
No. of Trips.....	9.8	15.4	36.5	41.4	29.5	26.8	27.0	14.9	15.1	9.1	4.1	8.3	19.8
No. of Hours....	662	1121	2239	2410	1987	2076	2186	1240	1243	727	304	715	1409

An investigation of the yield of the Scottish trawl fishery at the Færoes likewise shows a tendency — albeit but relatively slight — to decrease during the last few years.

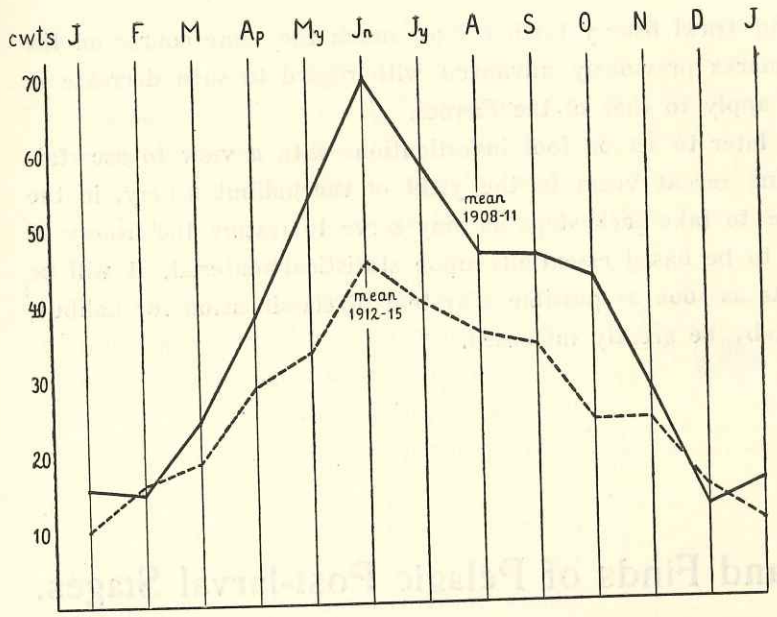

Fig. 14. Graph showing average monthly yield of halibut in cwts. per 100 lines fishing for years 1908—11 and 1912—15. Aberdeen Liners. Færoes.

The monthly share of the Aberdeen trawlers in the Færoe fishery will be seen from the figures p. 26, representing mean values for the years 1903—15.

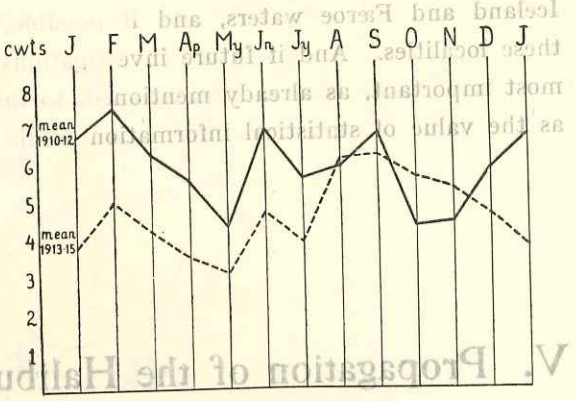

Fig. 15. Graph showing average monthly yield of halibut in cwts. per 100 hours fishing, for the years 1910—12 and 1913—15. Aberdeen Trawlers. Færoes.

The average yield in the different months per 100 hours fishing was as follows below (in cwts.).

The curves given Fig. 15 show the mean values for the yield per 100 hours' fishing during the different months of the three years 1910—12 and the similar period 1913—15, from which it will be seen that a decline, though relatively slight, is also discernible.

It will be seen from our consideration of the Scottish halibut fishery at the Færoes that this agrees, as regards its main features, with the English industry. Both Scottish and English line fishery show a conspicuous decline in the yield of halibut during recent years, while the trawling industry reveals but slight if any tendency to decline.

Average monthly yield of halibut in cwts. per 100 hours fishing for Aberdeen trawlers at the Færoes. 1903—1915.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann. Mean.
1903.....	8.3	..	5.0	9.2	10.7	8.6	24.4	19.8	..	..	22.9	..	..
1904.....	12.4	10.8	15.7	16.6	13.7	24.2	17.6	22.6	11.1	23.3	19.6	42.3	19.2
1905.....	6.2	..	13.0	11.2	11.0	11.3	13.3	10.0	11.7	..	27.2	..	..
1906.....	18.2	10.2	9.8	12.9	8.8	5.7	9.2	11.0	18.6	14.9	11.0	8.6	11.6
1907.....	8.2	6.5	9.9	9.1	6.8	11.3	9.2	9.6	13.3	11.6	6.0	8.5	9.2
1908.....	7.7	5.1	7.1	6.3	5.3	5.7	0.0	4.5	9.6	10.3	5.0	..	..
1909.....	..	..	7.1	6.5	5.2	10.5	12.4	8.2	6.2	10.3	..	9.0	..
1910.....	7.1	8.0	8.6	7.4	4.8	11.3	8.2	6.9	9.3	5.8	8.2	6.5	7.7
1911.....	7.6	7.9	6.1	6.0	4.9	5.7	4.9	7.6	7.9	5.2	1.7	6.6	6.0
1912.....	5.5	6.8	3.9	3.4	3.4	3.9	3.8	3.3	3.3	2.1	3.5	4.4	3.9
1913.....	3.8	5.8	4.6	4.1	3.3	3.9	3.5	5.4	5.3	4.4	4.2	3.5	4.3
1914.....	2.2	4.6	3.8	3.4	3.2	4.9	3.3	7.5	6.9	5.9	7.3	5.6	4.9
1915.....	5.5	4.6	4.2	3.1	3.0	5.4	5.1	5.4	6.4	6.6	4.4	4.8	4.8
Mean.....	7.7	7.0	7.6	7.6	6.5	8.6	8.8	9.4	9.1	9.1	10.1	10.0	8.5

The curves for the yield of the line and trawl fishery further show much the same course on the whole for the Færoes as for Iceland, and the remarks previously advanced with regard to such decrease in the case of the Iceland halibut fishery may also apply to that of the Færoes.

It will doubtless be necessary sooner or later to set on foot investigations with a view to ascertaining the cause of the considerable decline during recent years in the yield of the halibut fishery, in the Iceland and Færoe waters, and if possible, then to take such steps as may serve to restore the fishery of these localities. And if future investigations are to be based essentially upon statistical material, it will be most important, as already mentioned, to institute as soon as possible a system of classification for halibut, as the value of statistical information would thereby be greatly increased.

V. Propagation of the Halibut, and Finds of Pelagic Post-larval Stages.

Marine research has not yet succeeded in discovering the eggs of the halibut in a free state, but it is hardly to be doubted that they are bathypelagic, and to be found at great depths, as is also suggested by the investigations of Dr. JOHS. SCHMIDT on the finds of larval stages (*vide* JOHS. SCHMIDT 1904 a). The earliest bottom stage of the halibut, on the other hand, are as yet unknown.

The spawning time of the halibut has been the subject of considerable discussion, but we can now doubtless assert, that the general spawning season falls in the first months of spring, prob-

List of localities where pelagic post-larval stages of halibut (Hippoglossus vulgaris Flem.) have been caught. "Thor" 1904, 1905, 1908.

Station No.	Date	Position	Depth Meters	Temperature		Gear	Min.	Length m/m
				Surface	Bottom			
100	22/5 04	61° 21′ N, 10° 59′ W	> 1000	8° 50	—	Y. 15 Meters	30	13.5
113	24/5 04	63° 31′ N, 16° 06′ W	116	8° 01	7° 22	Y. 15 —	20	24.5
151	19/6 04	65° 25′ N, 27° 30′ W	ca. 750	7° 65	—	Y. 15 —	15	29.5
—	—	— —	—	—	—	Y. 70 —	15	22.0, 24.5
152	19/6 04	65° 00′ N, 28° 10′ W	1240	8° 30	4° 00	Y. 1000 —	30	25.0
—	—	— —	—	—	—	Y. 200 —	—	22.0
153	20/6 04	65° 20′ N, 27° 12.5′ W	740—768	7° 87	0° 10	Y. 820 —	30	27.0
154	20-21/6 04	65° 27′ N, 27° 10′ W	700—765	7° 71	—	Y. 50 —	240	23.0
—	—	— —	—	—	—	Y. 15 —	60	16.5
—	—	— —	—	—	—	Y. 80 —	60	19.5, 22.0
—	—	— —	—	—	—	Y. 75 —	180	16¼, 18, 19, 19¼, 19½
155	21/6 04	65° 28′ N, 26° 20′ W	223	7° 69	5° 78	Y. 15 —	30	22.0
173	7/7 04	64° 07′ N, 22° 39′ W	44	10° 70	8° 61	Y. 50 —	20	34.0
58	26/5 05	63° 07′ N, 16° 12′ W	1475	8° 05	ca. 3° 49	Y. 65 —	150	19.5, 29.0
60	28/5 05	61° 50′ N, 11° 38′ W	1110	8° 62	ca. 3° 07	Y. 25 —	30	26.0
—	—	— —	—	—	—	Y. 65 —	150	20, 21
64	30/5 05	59° 17′ N, 7° 29′ W	895	9° 88	7° 93	Y. 25 —	30	16, ca. 18
—	—	— —	—	—	—	Y. 65 —	60	22, 28.8
72	8-9/6 05	57° 52′ N, 9° 53′ W	1020—1550	10° 72	—	Y. 100 —	120	28
22	31/5 08	59° 10′ N, 13° 13′ W	> 1655	9° 5	—	Y. 65 —	30	26.0
23	1/6 08	59° 43′ N, 14° 07′ W	> 1500	9° 1	—	Y. 65 —	30	22.9
24	1/6 08	60° 31′ N, 15° 22′ W	> 1500	8° 8	—	Y. 100 —	30	26.0

ably February—April. This corresponds well enough with the finding of post-larval stages in May—July, as also with the relatively few known finds of spawning fish. EHRENBAUM (1905) writes as follows: "Die Laichzeit fällt in der Nordsee (?) und an den skandinavischen Küsten in die Zeit von Ende Februar bis Mai, besonders April bis Anfang May, bei Island in den Juni bis August." This statement, however, I consider to be not a little doubtful, as the young post-larval stages of 13—14 mm. should in such case be $^3/_4$ to 1 year old. As regards the spawning time in the northern part of the North Sea, H. C. WILLIAMSON, (1906) who presumes that the fish spawn there, writes: "The present records extend the spawning period for the northern part of the North Sea to five months viz., January to May." This statement is based on the finding of mature specimens from the area in question.

Since the publication, in 1904, of Dr. JOHS. SCHMIDT's report on the first finds of pelagic post-larval halibut young, 13 pelagic specimens have been found in the same area in the course of the investigations on board the marine research steamer "Thor" in those waters during 1905 and 1908. The total amount of material, of which a survey is given above (p. 28), thus includes 32 specimens of these post-larval stages, varying between 13.5 and 34 mm. and taken between the 22nd May and 7th July.

Considering the great number of pelagic hauls which have been made in these waters, it is not a little surprising that so few of these stages should have been found. One explanation may possibly be that the stages in question presumably spread over a considerable vertical distance in the water.

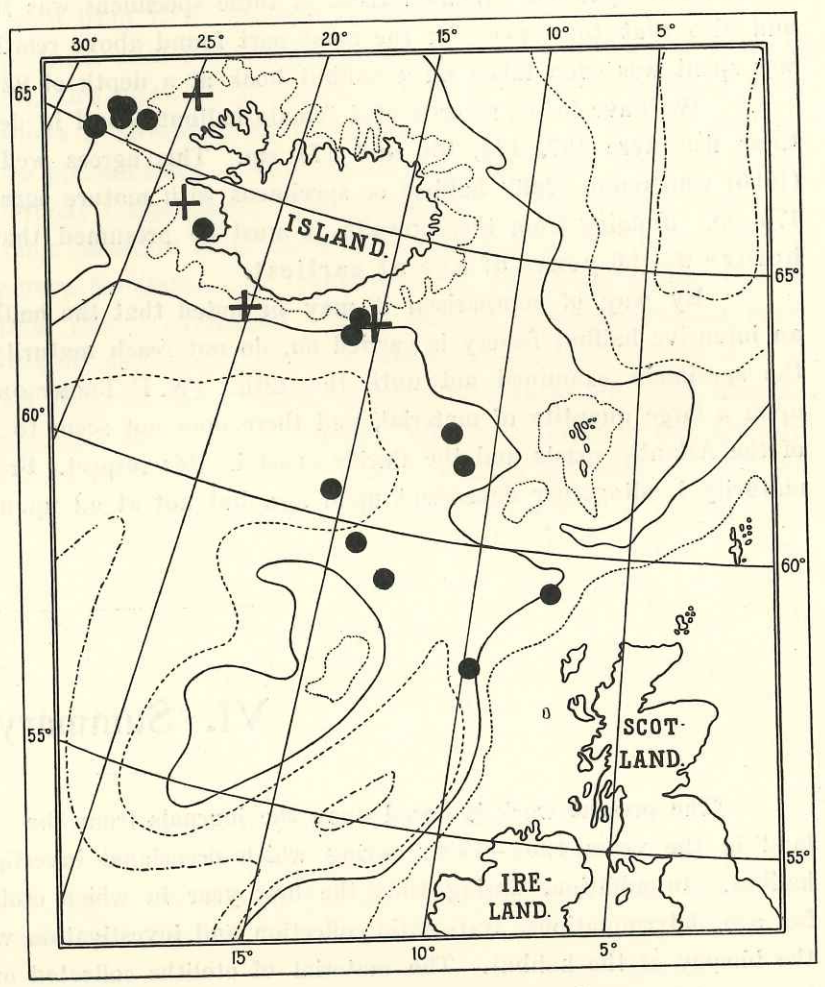

Fig. 16. Chart showing localities where post-larval stages of Halibut were found, or spent fish taken.
● Finds of pelagic post-larval stages of halibut.
+ Spent fish taken.
····· 200 Meter. ——— 1000 Meter. ------ 2000 Meter. ------- 3000 Meter.

The localities for these finds of pelagic stages will be seen from the accompanying sketch chart (Fig. 16), showing the very characteristic distribution between Scotland and Iceland. All the larval stages were found in water with great depth to bottom, most of them even beyond the 1000 metre line. The distribution seems decidedly to indicate that the halibut spawn in the Atlantic off the coasts of Scotland-Færoes-Iceland about or possibly even beyond the 1000 metre line, and shows at the same time that these fish seek deeper water for their spawning than the remaining flatfish of economical importance.

The present material is not sufficient to show more fully the course of the developement, but it is interesting to note the apparently great agreement between the pelagic young of the halibut and the pelagic larval stages of *Molva byrkelange* (*vide* JOHS. SCHMIDT 1909, Chart VII).

As we know, no larvæ of the halibut have ever been found in the North Sea or in the Norwegian

Sea. It is however, considered likely by many that the halibut spawn on the coasts of Norway It is probably more doubtful whether they do so in the North Sea. Nor would it seem likely that the entire stock of halibut both in the North Sea and Norwegian Sea should be derived from the Atlantic, but the possibility is not excluded until larval stages have been encountered in these waters.

Several points, by the way, seem to suggest that the halibut really do spawn at very considerable depths in the Atlantic. On the cruises of the "Thor" some few specimens of halibut were taken which had undoubtedly spawned. Characteristic of these specimens was the fact that they were very large individuals, and also that they were for the most part found above relatively great depths. The only specimen which was spent was even taken on a halibut hook at a depth of 920 metres (see chart p. 29).

We have in all records of 4 female halibut found in decidedly spent condition. The total lengths of these fish were 137, 144, 160 and 174 cm. This agrees well with the investigations of H. C. WILLIAMSON (1906) who found "full" halibut or specimens with mature eggs of the following total lengths: 127, 130 and 175 cm. Judging from these results, it must be presumed that the halibut do not become mature before 9—10 years of age at earliest.

By way of comparison it may be noted that the halibut on the Pacific coast, where, as we know, an intensive halibut fishery is carried on, do not reach maturity until the 8th year at earliest, and 50 % of the specimens examined not until the 12th. (W. F. THOMPSON 1914). The investigations there are based upon a large quantity of material, and there does not seem to be any marked difference between the halibut of the Atlantic coasts and the Pacific coast in this respect. From the investigations quoted, it appears that maturity is altogether dependent upon age, but not at all upon the size of the fish.

VI. Summary.

The present work is based upon the journals from the cruises of the "Thor" to the Færoes and Iceland in the years 1903—1906, during which occasional investigations were made as to the biology of the halibut. In addition, during 1908 the first year in which otoliths and bones from these waters were used for age determinations, systematic collection and investigation was carried on with a view to elucidation of the biology of the halibut. The material of otoliths collected on these cruises has since been supplemented by material procured by Adjunkt BJARNI SÆMUNDSSON, and Captain G. HANSEN, who was in Iceland during the summer of 1909, added likewise to the material of halibut otoliths. The statistical information is derived partly from the Fishery Reports of the various countries, partly from the hitherto published volumes of the "Bulletin Statistique des pêches maritimes des pays du Nord de l'Europe". In addition, detailed statistics have been received concerning the Scottish halibut fishery of the Færoes and Iceland, through the Fishery Board for Scotland, Edinburgh.

The age determinations are based exclusively upon otoliths. The total material of these represents 2921 halibut, either from the west of Iceland or from East Iceland. These regions have been separately dealt with, as it was found that the growth of the halibut takes place at a considerably more rapid rate on the west coast than on the east coast of Iceland. The reason is probably to be sought in the differing hydrographical conditions, temperature being probably the factor of most decisive importance in this respect.

A difference is also observable in the growth of the two sexes, the male being relatively smaller than females of the same year group.

Both at Iceland and the Færoes, an intensive halibut fishery is carried on, partly by line fishing and partly by trawling. The yield of the line fishery consists mostly of large fish, the trawlers taking almost exclusively small specimens. The economical importance of the former industry far exceeds that of the latter. The total yield of the halibut fishery for the five years from 1906—10 was for the Iceland waters abt. 35 million kilos, at the Færoes abt. 10 million kilos. In both places, by far the greatest yield falls to the English vessels there engaged.

The English statistics embrace the period from 1906—14, and closer investigations shows, that the yield of the halibut fishery both at Iceland and the Færoes has greatly decreased during the past 5—6 years. Within this period, the total yield has dwindled to half or less than half. The average catch per day's absence shows a corresponding reduction. Both the total yield and the average haul per day's absence are found to be preeminently diminished in the case of line steamers alone, the reduction of the trawl catches being relatively insignificant. The information available with regard to the Scottish fishery points essentially in the same direction as in the case of the English. As possible causes of the decline in the yield are cited, 1) Temporary fluctuation, 2) Transference of craft from halibut to cod fishery, or 3) A reduction in the stock of halibut due to overfishing. As a number of English vessels have of late years been chiefly occupied in cod fishing on Iceland grounds, where the stock of halibut is at a minimum, there is much to suggest that this may to some extent at least be responsible. The modern trawling methods, however, destroy large quantities of immature halibut, and it is therefore not unlikely that the intensive fishery has partly conduced to the decrease in the yield. Further investigations will be necessary with regard to this point. A classification of the halibut in the statistics would be highly desirable for the sake of such future investigations, as rendering the material far more valuable than at present.

Since the finds published in 1904 (Johs. Schmidt 1904 a) of pelagic post larval stages of halibut, thirteen more specimens have been taken in 1905 and 1908, total lengths ranging from 16 to 29 mm. All were found in the Atlantic over great depths, and serve, together with the previous finds, to support the view that the halibut spawn in the Atlantic off the coasts of Scotland—Færoes—Iceland, near or beyond the 1000 metre line. The spawning season probably falls in the months of February—April.

The journals of the "Thor" contain only records of 4 female halibut found in a decidedly spent condition. Characteristic for these was the large size in all cases (over 130 cm) as also the fact of their being taken at relatively considerable depths. From the size of the fish in question, it would seem that the halibut do not attain maturity until an age of 9—10 years.

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CONTENTS

IMPORTANT CORRECTIONS

Page 9, line 8, for 2719 read 2179.
— 14. Weights of various age groups. Halibut from North-west Iceland for ♂ + ♀ read ♀ and for ♀ read ♂ + ♀.

EXPLANATION OF PLATE

Otoliths of halibut (*Hippoglossus vulgaris*, Flem.) from Iceland. Reproduced from photos by Pacht & Crone, taken in reflected light.

Fig. 1.	No. of growth rings:	1—	length of fish 10 cm	Faxebugt.	$^{18}/_{6}$ 08.
- 2.	- - - -	2—	- - - 23 -	Weight 110 gr. ♀. Faxebugt.	$^{10}/_{6}$ 08.
- 3.	- - - -	3—	- - - 33 -	- 360 - ♂. -	- -
- 4.	- - - -	4—	- - - 52 -	- 1450 - ♀. -	- -
- 5.	- - - -	5—	- - - 60 -	♀. Faxebugt. July 1909.	
- 6.	- - - -	6—	- - - 59 -	Weight 2190 gr. ♀. Off Patrexfjord.	$^{14}/_{7}$ 08
- 7.	- - - -	7—	- - - 68 -	♂. Faxebugt. July 1909.	
- 8.	- - - -	8—	- - - 67 -	♂. -	$^{18}/_{7}$ 09.
- 9.	- - - -	9—	- - - 97 -	♂. - July 1909.	
- 10.	- - - -	10—	- - - 80 -	Weight 5120 gr. ♂. Off Arnarfjord	$^{17}/_{7}$ 08.
- 11.	- - - -	18—20	- - - 154 -	- 49000 - ♀. Faxebugt.	$^{4}/_{7}$ 08.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

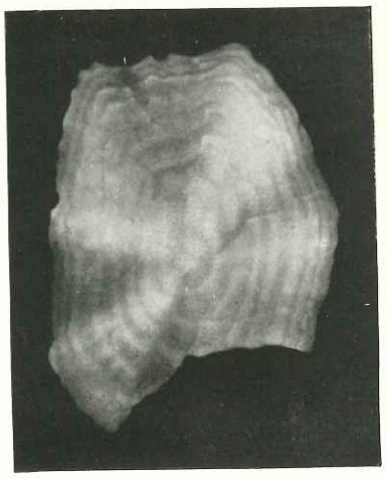

Fig. 9.

Fig. 11.

Fig. 10.

Otoliths of halibut (*Hippoglossus vulgaris*, Flem.) from Iceland.

Pacht & Crone ad naturam phot.

KBH. BIANCO LUNO

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