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GROWTH OF THE COD IN SUBAREA 1

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1. Material

The research reports received from Denmark, Iceland, Norway, and Portugal for 1952-55 give in most cases the mean lengths of the various age-groups.

As length-age has not been reported individually a full compilation of the material cannot be made. The averages for year, subdivision, etc. are calculated from the reported mean length. This results in equal weight being given to all samples regardless of the number of specimens in the sample. However, all mean lengths based on numbers smaller than 20 are disregarded. When several samples have been reported from the same fishery they are treated as one. Samples from the fjords are not considered.

Table 1 (attached) gives the separate mean lengths used in the compilation for the various age-groups (year-classes) in the years 1952-55, and the calculated averages for the separate subdivisions.

2. Growth of the whole stock of the Subarea

Table 2 shows, based on the data in Table 1, for all years and the whole Subarea 1 the mean length for each age-group (disregarding year-classes) for samples by each of the four reporting countries and for all four together. The mean lengths of age-groups from the samples of the separate countries agree fairly closely with one another. The small variation found may well be ascribed to selection by gear or through discarding. The good agreement between the countries means that the otoliths are interpreted by the scientists concerned in the same manner; a fact which ensures the reliability of the data reported.

TABLE 2

Mean length in cm. of age-groups (disregarding year-classes) for the whole of Subarea 1 and for the years 1952-55 in samples by the separate countries (based on Table 1):

Age-Group	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Denmark	46	54	60	67	71	75	77	78	80	80
Iceland	44	55	61	70	74	76	78	78		
Norway			60	67	70	72	76	78	80	80
Portugal		55	61	67	70	73	78	80	80	81
All countries	45.0	54.7	60.5	67.8	71.3	74.0	77.3	78.5	80.0	80.3

Age-Group	XIV	XV	XVI	XVII	XVIII
Denmark					
Iceland					
Norway			84		89
Portugal	91	90	91	96	
All countries	91.0	90.0	87.5	96.0	89.0

Figure 1 gives, based on the figures in Table 2, a growth curve for the W. Greenland cod; in the figure are included data from the Danish samples in coastal waters of the I, II and III groups. The figure thus comprises the age-groups I-XVIII, and the period 1952-55.

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It is apparent from the figure that up to age-group X-XI a fairly smooth growth curve can be drawn through the calculated averages (black dots). Up to age VI-VII the curve is rather steep, thereafter it gradually flattens; this decrease in growth rate is no doubt due to the maturing of the cod. After age-group XI the observed means no longer fall close to the smoothed curve "a" or its continuation "b". Groups XI-XIII fall below, groups XIV, XV and XVII far above it. The stipled curve a^1 is based on age-groups XI-XIII and an assumed steady decrease in growth rate; it is however apparent that that curve would never reach the high averages for the older age-groups XIV-XVIII. The curve "b" is drawn with equal regard to the low means for age-groups XI-XIII and the high means for groups XIV-XVIII. A continued curve with due regard separately to age-groups XI-XIII and XIV-XVIII is the curve "c" showing a rise in growth rate between ages XIII-XVIII. The possibilities indicated by this latter curve shall be discussed later, and the curve a-b is regarded as the growth curve for the W. Greenland cod.

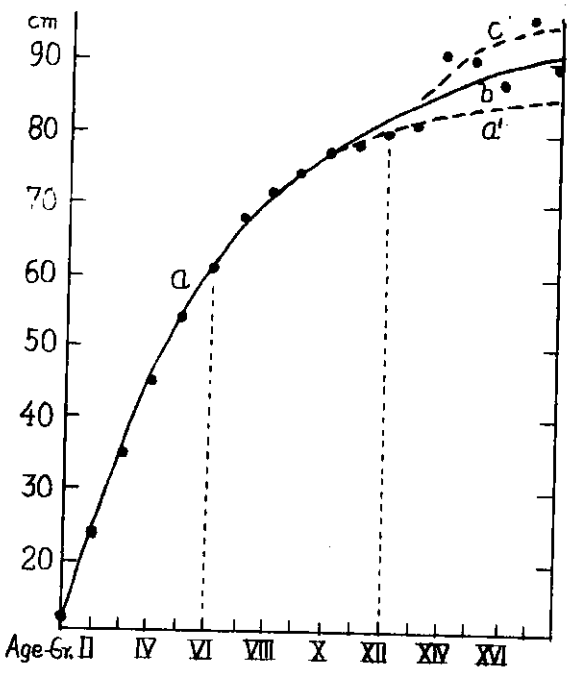

Fig. 1. Cod. Subarea 1. Growth curve from samples by Denmark, Iceland, Norway and Portugal. a-a^1 smoothed curve; b continuation of this curve disregarding the observed means for Groups XIV-XVIII; b curve based on these means.

The following table gives (based on the smoothed growth curve) the length growth of the Greenland cod in its first 18 years. The weight growth given in the same table is calculated from individual length-weight data included in Norwegian reports on conversion factor experiments in the years 1953-55. This material covers the age-groups VI to XIII; the weights for the younger age-groups are estimated, by means of log paper, from the data for groups VI-XIII.

Age-Group	Mean length in cm.	Yearly length increase in cm.	Yearly length increase in %	Mean weight grams	Yearly weight increase in grams	Yearly weight increase in %
0		12	∞		28	∞
I	12	12	100	28	137	480
II	24	11	46	165	285	173
III	35	10	29	450	450	100
IV	45	9	20	900	550	60
V	54	8	15	1450	550	38
VI	62	6	10	2000	600	30
VII	68	4	6	2600	400	15
VIII	72	3	4	3000	400	13
IX	75	3	4	3400	300	9
X	78	2	3	3700	300	8
XI	80	2	3	4000	200	5
XII	82	2	2	4200	100	2
XIII	84	2	2	4300		
XIV	86	2	2			
XV	88	2	2			
XVI	90	2	2			
XVII	92	1	1			
XVIII	93					

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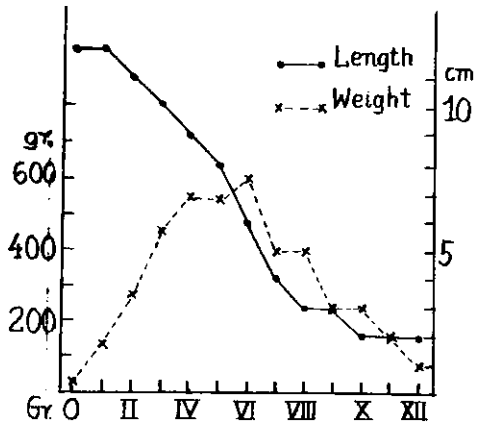

Fig. 2. Yearly increase of length (cm.) and weight (gr.), age-group 0-XII.

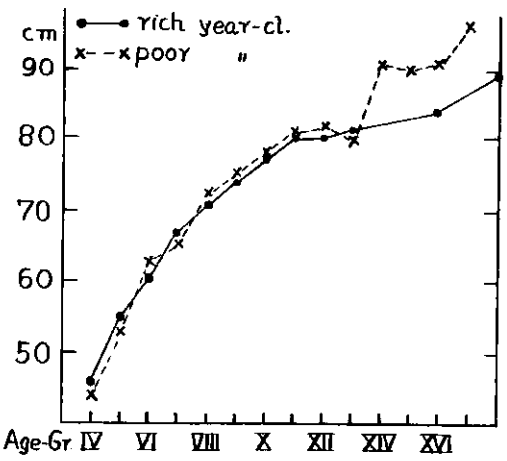

Fig. 3. Growth curves for rich and poor year-classes (Table 3).

The figures for length and weight refer to the summer following the spring in which the age-group stated was reached; the yearly increases of length and weight to the year preceding that summer.

Figure 2 shows yearly length and weight increase. Length increase is strongest in the first two years' of life (12 cm.); thereafter it decreases with ca. one cm. a year up to the eighth year of life, when the decrease gets stronger (maturity). From age-group XI the length increase is small, 2 - 1 cm. a year. The yearly increase in weight rises up to the seventh year of life, when it reaches 600 grams; from that year on it drops gradually, being only 100 grams in the 13th year.

3. Growth and and density of stock

It is a feature of the W. Greenland cod that the strength of the year-classes varies greatly, a feature probably due to the W. Greenland cod living under extreme conditions. Very rich year-classes make their appearance in some years, very poor year-classes in others. Rich year-classes were produced in 1934, 1936, 1942, 1945, 1947 and 1950. In order to study whether the rich year-classes grow more slowly than the poor year-classes, the mean growth of rich and poor year-classes have been compared (Table 3, Figure 3). It appears from Figure 3 that for age-groups IV-XIII (the age-groups for which the largest material is available) there is little difference in growth between rich and poor year-classes. It is understandable that no such difference should occur. On the Greenland banks cod of a considerable number of age-groups live together feeding on the same stock of food animals, and thus the individuals of a poor year-class compete for food not only with the few individuals of their own year-class but also with the many individuals of closely preceding or following rich year-classes.

To study possible variations in growth rate in connection with food competition one must in a case like this, study the growth rate of the whole population in an area over a number of years compared with the stock density variations in that area in the same period of years. Based on the mean lengths of the various age-groups for the summer of the years 1952, 53, 54, and 55 (all countries, whole Subarea 1), the following table is compiled, showing the differences in the mean size of the separate age-groups from the summer of one year to that of the following, and the averages of these differences for those age-groups (V-VI and IX-X) for which observations of mean lengths for all four years are available:

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Difference in cm. from one year to another:

Age-Group	1952 to 53	1953 to 54	1954 to 55
IV-V	10		9
V-VI	6	6	10
VI-VII	5	4	6
VII-VIII	2	3	6
VIII-IX	2	2	4
IX-X	5	1	3
X-XI	3		4
XI-XII		0	
M. V-VI to IX-X	4.0 cm.	3.2 cm.	5.4 cm.

The difference found varies considerably, and regarding this difference as growth, the growth for the period summer 1954 to summer 1955 was 70% higher than that from 1953 to 1954; the growth for the period 1952-53 is intermediary. Whereas little difference in growth between rich and poor year-classes can be found the difference in growth between years can be considerable.

TABLE 3

Mean length at various ages of rich and poor year-classes. (From the material in Table 1)

	YEAR-CLASS	AGE-GROUP IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII
RICH	1950	46	55													
	1947		54	60	64	70										
	1945				70	72	74	77								
	1942							77	80	80	81					
	1936													84		
	1934															89
	MEAN	46.0	54.5	60.0	67.0	71.0	74.0	77.0	80.0	80.0	81.0			84.0		89.0
POOR	1951	45														
	1949		53	63												
	1948	44	54	60	66											
	1946			62	67	70	74									
	1944					74	76	77	81							
	1943						73	78		82						
	1941								80			91				
	1940									81			90			
	1939										80			91		
	1938														96	
	MEAN	44.5	53.5	61.7	66.5	72.0	74.3	77.5	80.5	81.5	80.0	91.0	90.0	91.0	96.0	

The reasons for this difference may be manifold. First it could be caused by a difference in the sampling itself. In fact such a difference exists as far as a large number of Portuguese samples are included in the 1955 averages, but none in those for 1954. From the Danish research vessel "Dana" a number of samples were taken by the same gear in those two years and in 1953 (without any selection for commercial purposes). These samples give the following growth from one age-group to the next for the years 1953 to 1954 and 1954 to 1955; here only the age-groups V-VI to VIII-IX are represented, the figures for all countries for these age-groups are given for comparison:

Difference in cm. from one year to another:

Age-Groups	Denmark V-VI	VI-VII	VII-VIII	VIII-IX	Mean V-VI to VIII-IX Denmark	All countries
Year 1953 to 54	8	5	4	4	5.3	4.0
Year 1954 to 55	10	6	5	6	6.8	6.5

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Also for the Danish samples there is a considerable difference in growth between the two years, it is 28% higher in 1954-55 than in 1953-54; for all countries the difference is 63%; this larger difference may be due to the Portuguese samples from 1955 (the Portuguese fleet takes larger fish than any of the other countries apart from Norway). However, the still considerable difference found, where only Danish samples are considered, shows that the difference in growth is caused not only by differences in the sampling alone. However, in the few years considered here no connection between water temperature and growth can be established.

In 50-100 m's depth the temperatures on the banks in July (Fylla and Lille Hellefiske) are as follows:

1952	- 0-2°	1954	- 1-2°
1953	- 1-4°	1955	- 0-2°

The slowest growth was observed in the 1953-54 season with high temperatures, the fastest growth in 1954-55 with low temperatures. As we have no observations of variations in the total amount of food, the influence of such variations upon growth cannot be investigated.

It remains to be considered if variations in the degree of competition for food, i.e. variations in size of total stock on the the fishing grounds, can be connected with the variations in growth. Our knowledge of variations in the size of stock is limited to what can be acquired from the yields per unit of effort.

For Portugal and the United Kingdom, the former fishing mainly in the northern and central, the latter in the southern region, we have the following yields in tons per one hour's trawling:

	Portugal	U.K.	growth in cm.
1952	1.45	3.43	
1953	1.07	1.80	4.0 (1952-53)
1954	3.27	1.62	3.2 (1953-54)
1955	4.20	1.60	5.4 (1954-55)

The figures give no indication of a dense stock growing slower than a less dense one. The slowest growth is recorded for the period (1953/54) with on an average low yield per unit of effort.

Is it that the yield per unit is not and indication of density - at any rate when not a variety of fisheries are considered? Do other factors, f.i. weather conditions, influence the efficiency of the fishing to such a degree, that they may cover the influence of stock density upon the yield per unit? Or is it that variations in feeding conditions - when not too great - influence not so much the length growth of the cod as their increase in bulk (weight, fatness, compactness of flesh)?

There is evidence showing that differences in the condition of the cod exist between the years 1953, 54, and 1955. Norway has reported conversion factor experiments from W. Greenland waters for the years 1953-54 and 55 and by individual length measurements and weights. From these reports the average weights per cm. length have been calculated for the sizes 68-85 cm. (those most numerous in the material). Drawn together by 3 cm. groups we get the following mean weights in kg. The coefficient of condition ($k = \frac{100w}{l^3}$) are also shown in the table:

cm. group	Individual weight 1953	1954	1955	Coefficient of condition 1953	1954	1955
68-70	3.1	2.7	2.7	0.87	0.82	0.82
71-73	3.6	3.5	3.0	0.93	0.93	0.81
74-76	3.8	3.7	3.3	0.91	0.88	0.77
77-79	4.3	3.9	3.9	0.90	0.82	0.81
80-82	4.5	4.2	4.3	0.85	0.79	0.80
83-85	5.2	5.2	4.3	0.88	0.86	0.72
MEAN	4.1	3.8	3.6	0.89	0.85	0.79

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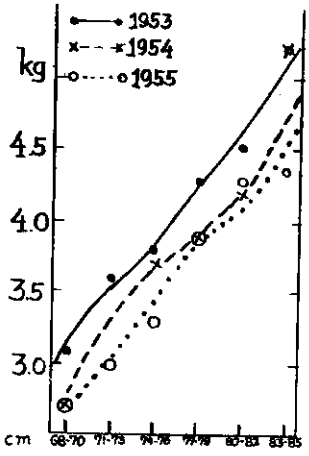

Fig. 4. Individual weight per 3 cm. groups of length 1953-55 calc. from Norwegian Conversion factor reports.

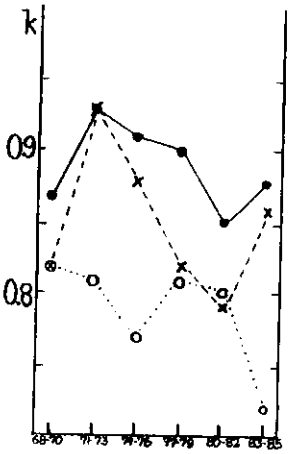

Fig. 5. Same material. Coefficient of condition (k).

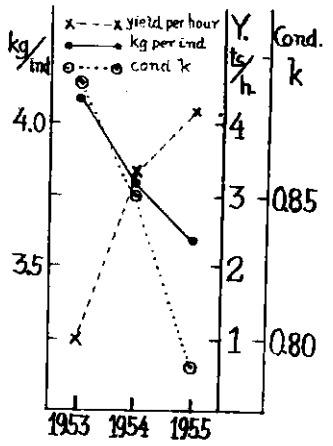

Fig. 6. Yield in tons per Portuguese trawler compared to mean individual weight and condition of fish, 1953, 54 and 55.

Figures 4 and 5 give these figures in graphic form. It is apparent that the condition of the fish was much better in 1953 than in 1954, and a little better in 1954 than in 1955. The measurements were taken on the following dates: 24-31 July 1953, 9 July 1954, and 5-6 July 1955, i.e. around three weeks earlier in 1953 than in 1954 and 1955. It might be argued that these three weeks closer to the spawning season (March-May) could account for the lower co-efficient of condition in 1954 and 1955. However, even the first half of July is at least a month and a half later than the main spawning season. Thus the difference found might well be ascribed to other reasons. The Norwegian Research Report for 1953 stresses the considerably better quality of the cod in 1953, compared to earlier years. The Research Report for 1954 says "in April the cod were in good condition ..... In July the fish had become thinner and were decidedly of inferior quality". For 1955 the report says "The cod in these localities (southern banks) was of rather good size, but otherwise the fish was in poor condition with a small liver content". These remarks agree well with the observed individual weights and bear evidence to the generally poorer condition of the cod in 1954 and 1955 than in 1953.

When comparing the mean individual weight per cm. length with the Portuguese yield per unit, it is seen that individual weight is highest when the yield is lowest (1953) and vice versa (1955) (Figure 6). When yield per unit is considered a measure of density of stock, this indicates that condition of the cod can be influenced adversely by high density of stock.

4. Growth in the separate subdivisions

One of the conclusions of the 1956 Symposium on Cod was that there are at least two stocks of cod in Subarea 1, one northern and one southern. It may be of interest to investigate if the average length of the age-groups show a different growth for these two stocks.

Based on the material from 1952-55 (Table 1) the average lengths of the age-groups IV-XVIII in the separate subdivisions have been calculated (Table 4). Growth curves for Subdivisions A + B (northern), C + D (central), and E + F (southern) are given in Figure 7 (only the age-groups IV-XIII considered).

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TABLE 4

Mean length at the different ages by subdivisions.
(From material in Table 1)

Age-Group	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII
1A				66		72	77	79	81	83			84		89
1B	45	53	61	67	71	74	78	81	82	81	91	90	89	96	
1C	47	55	60	67	72	73	77	77	79	80			83		
1D	47	54	62	67	72	75	78	78	80	77					
1E+F		55	60	66	70	75	76	78	78						

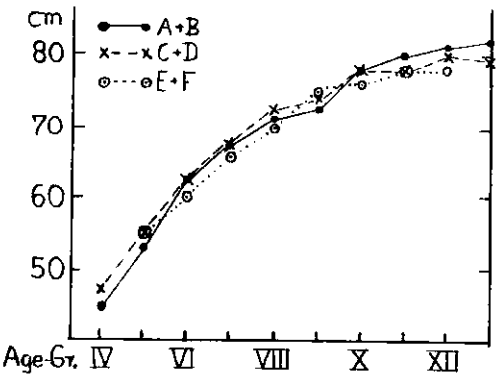

Fig. 7. Cod. Growth curves for the northern (A+B), central (C+D), and southern (E+F) subdivisions of Subarea 1 (after Table 4).

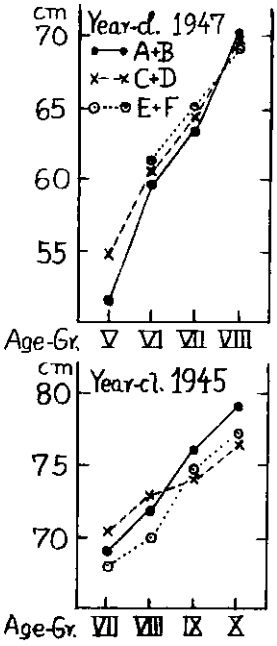

Fig. 8. Growth of the year-classes 1945 and 1947 in Subdivisions A+B, C+D and E+F of Subarea 1.

The curves for the three regions fall closely together. For the northern region the curve for the younger age-groups IV-VI runs about 1 cm. below the curve for the central and southern region, for the older age-groups X-XIII it runs 1-2 cm. above. In no case do the curves deviate more than 2-3 cm., in most cases much less or not at all.

The uniformity of growth through Subarea 1 appears also from Fig. 10 which shows the average lengths of the age-groups VII, IX, X and XI, taken together for the separate subdivisions (E and F united due to insufficient data). The corresponding means for Subdivision 2J (1952-55) and for the Grand Bank (1951) are also shown on the map; the figures for these latter regions are from Table 5 (attached). The age-groups used in the calculation are those for which length by age-groups are available for all the regions considered. The average length for 2J (Labrador) is ca. 18 cm. less, that for Subarea 3 (Grand Bank) 6 cm. above the means for Subarea 1.

Thus, the difference in growth between the regions is insignificant when the stock as a whole is considered. However, when year-classes are dealt with separately (Figure 8) a small difference can be traced from region to region. For the 1947 year-class growth has been somewhat slower up to age IX in the northern than in the central and southern region. The 1945 year-class shows up to age VIII a decidedly slower growth in the southern region than farther north. These differences may be due to food competition, as the 1947 year-class was especially rich in the north, the 1945 year-class in the south.

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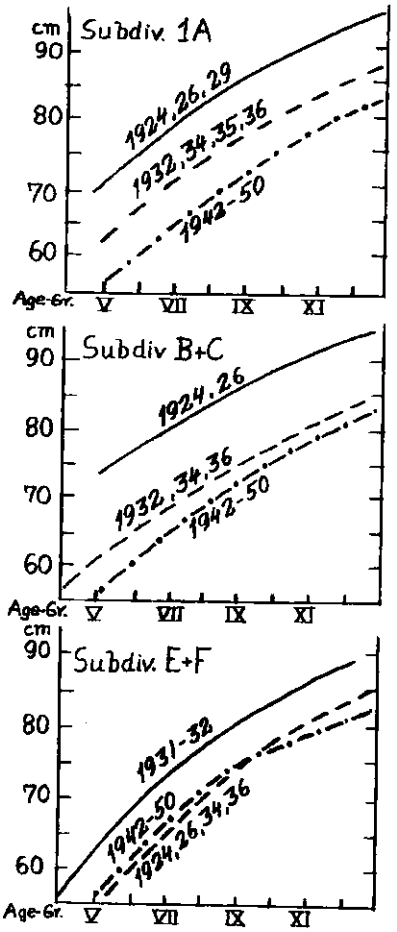

Fig. 9. Growth curves for the year-classes of the 'twenties, 'thirties and 'forties in various parts of Subarea 1.

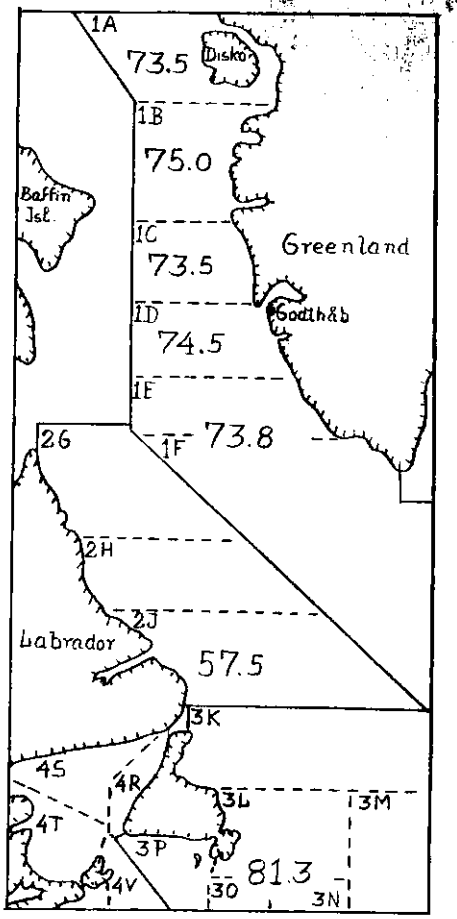

Fig. 10. Cod mean length in cm. of the age-groups VII, IX, X, XI, taken together in samples 1951-55 by subarea subdivisions. The age-groups considered are those for which data are available for all subdivisions (see Tables 4 and 5).

The sudden increase in growth rate of the 1945 year-class in Subdivisions E+F from 1953 to 1954 (age VIII to IX), can well be connected with the thinning of the stock of this year-class between 1953 and 1954 (through emigration or through fishery) as observed by Denmark and Iceland (cfr. corresponding Research Reports for 1954, Ann. Proc. Vol. 5).

5. Variations in Growth Rate of W. Greenland Cod over the Years

The growth rate of the W. Greenland cod has changed considerably since the late 'twenties, as Paul Hansen[1]) has shown by comparing the growth of the year-classes 1924-29 with that of the year-classes 1932-42. He found a considerable decrease in growth rate from the first to the second period in the northern and central region of the W. coast. Off the south coast there is no such regular change; some year-classes (1931 and 1932) have a faster growth than others (f.i. 1934 and 1936).

1) Paul M. Hansen: Studies on the Biology of the Cod in Greenland Waters. Rapp. et Proc. Verb. vol. CXXIII ICES, 1949 and: The Stock of Cod in Greenland Waters during the years 1924-52. Rapp. et Proc. Verb. vol. CXXXVI ICES, 1954.

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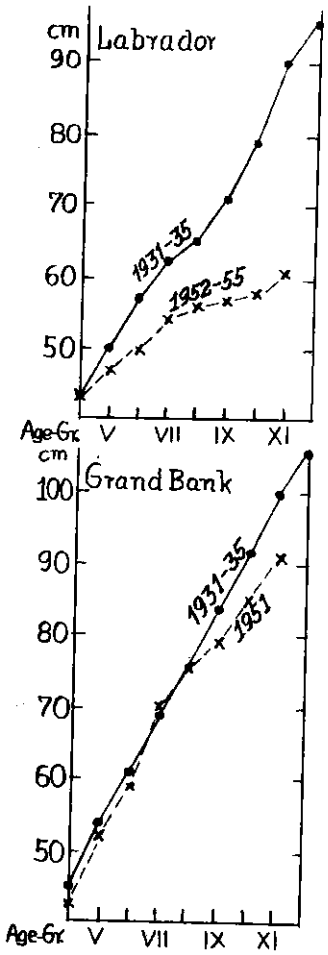

Fig. 11. Cod. Growth curves Subareas 2 and 3, 1931-35 and 1951-55.

Based on Paul Hansen's figures (1949) Fig. 9 shows a comparison of the growth in the two earlier periods with the growth of the recent 1942-50 year-classes (as reported to ICNAF). For the northern region there is a further decrease in growth from the year-classes of the 'thirties to those of the more recent years (1942-50). The difference in growth-rate is of considerable magnitude. In the late 'twenties a cod reached the length of 70 cm. at an age of 5-6 years; in recent years only at an age of 8-9 years.

For the central region (C and D) there is only a slight decrease in growth rate from the year-classes of the 'thirties to those of the 'forties, and for the southern region (E + F) no decrease at all.

The decrease in growth has been attributed to (1) overcrowding and lack of food, and (2) to the earlier inception of maturity in more recent years. The earlier inception of maturity might of course in itself also be a result of overcrowding.

6. Comparison of Growth of Cod from W. Greenland and from other Regions.

The map, Fig. 10, shows the average length in various subdivision of the age-groups VII, IX, X and XI (those for which age and length have been reported for each of the subdivisions concerned).

The mean lengths are much the same in all the subdivisions of the Subarea, perhaps just a bit higher in the central (74.3 cm.) than in the northern and the southern regions (73.5 and 73.8 cm. respectively).

In Subdivision 2J (Hamilton Bank area) the mean length of these age-groups is far below (57.5 cm.) In the Grand Bank area (3L, N and O) the mean length is somewhat higher-(81.3 cm.).

The growth decrease over the last 20-30 years may not be restricted to the W. Greenland stock. The data available also show a decrease in size of age-group for the Labrador cod; for the cod of the Grand Bank a very light decrease can be traced for the older age-groups. Figure 11 gives growth curves for the Labrador cod, years 1931-35 (H. Thompson, 1943[1]), and 1952-55 (J. Ancellin, 1954[2]) and (Mario Ruivo, 1956[3]), and for the Grand Bank 1931-35, (H. Thompson, 1943) and 1951 (J. Ancellin, 1954).

1) Harold Thompson: A Biological and Economic Study of Cod (Gadus callarias L.) in the Newfoundland Area, including Labrador. Newfoundland Government, Research Bull. No. 14 (Fisheries). St. John's 1943.
2) J. Ancellin: Observations sur la Morue de Terre-Neuve et du Labrador. Rapp. et Proc. Verb. vol. CXXXVI ICES, 1954.
3) Mario Ruivo: Portuguese Research Report for 1955. Ann. Proc. Vol. 6 ICNAF 1956.

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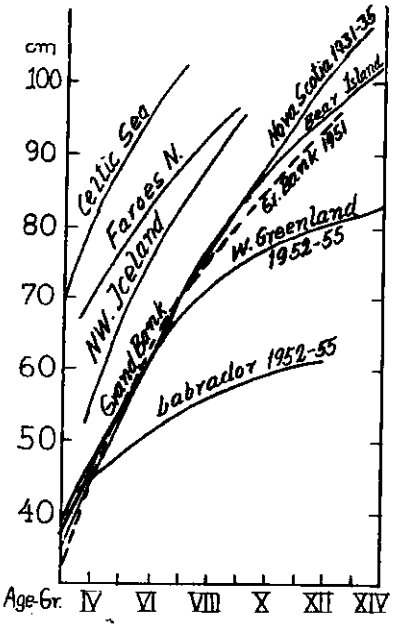

Fig. 12. Cod. Growth-curves for various regions of the N.W. Atlantic (from Table 5).

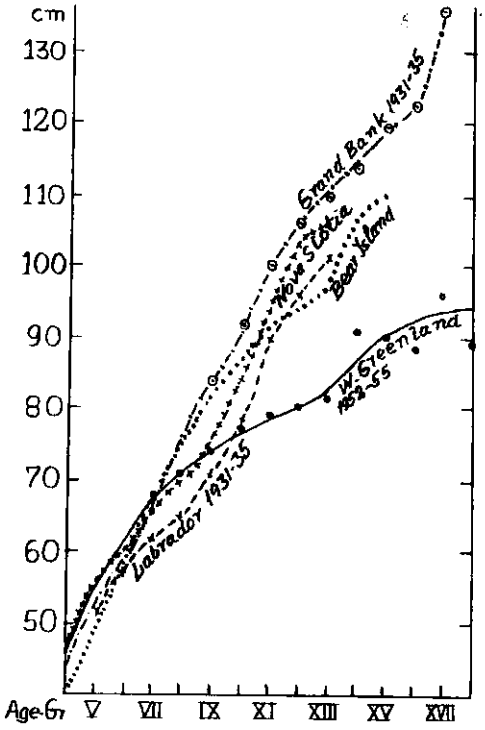

Fig. 13. Growth curves from regions from where comparatively larger numbers of older cod have been aged (from Table 5).

For Labrador the young year-groups, up to IV, had about the same growth in the two periods but from Group V on the growth rate is much slower in the recent period. For the Grand Bank there is an indication of a lesser growth for the older year-classes in the recent period. In evaluating these differences it must be borne in mind that Harold Thompson used scales for age-determinations, J. Ancellin and M. Ruivo otoliths.

In Fig. 12, smoothed growth curves (based on Table 5 - attached) for cod from various regions of the North Atlantic are given.

The slowest growth is found for the Labrador cod (IX-Gr. = 57 cm.), considerably faster is the growth of the W. Greenland cod (IX-Gr. = 74 cm.). The growth curves for the cod of the Grand Bank of Newfoundland, Nova Scotia and Bear Island follow one another very closely (IX-Gr. = 79, 81 and 83 cm. respectively). Far above again is the growth rate of the cod from Iceland and the Faroes (IX-Gr. = 95 cm.). The highest growth is found for the cod living in the Celtic Sea at the western entrance to the English Channel (VII-Gr. = 100 cm.).

These differences in growth rate are no doubt dependent on the water temperature. The cod growing slower in colder than in more temperate water. The following table gives the mean size reached at the age of seven years and (from ICES, Bull. Hydr. pour l'année 1951, and ICNAF Research Reports for 1954) the approximate mean summer temperature at 50 m's depth for a number of regions.

...../11.

	Length as VII-Gr.	Temp. 50 m., summer
Celtic Sea	ca. 100 cm.	10-13° C.
N. of Faroes	" 87 "	8-10 "
N.W. of Iceland	" 83 "	6-10 "
Grand Bank	" 70 "	1-4 "
Bear Island	" 69 "	2-5 "
W. Greenland	" 68 "	1-4 "
Nova Scotia	" 66 "	1-4 "
Labrador	" 53 "	0-2 "

It should be remembered that growth rate has little to do with the sizes of cod fished; in fact the sizes of cod landed from the various regions do not differ much (with the exception of Labrador). The sizes of salted cod landed from the N.W. Atlantic are on a whole just a little lower than of those landed from the N.E. Atlantic; the difference is, however, in no way comparable to the difference in growth rate. What differs is mainly the age of the cod when captured. It takes nature a longer time (this probably meaning also more food) to produce one ton of cod in the Labrador-Greenland area than elsewhere in the Atlantic. However, it costs the fishing industry less (in effort) to produce one ton of salt fish in W. Greenland waters than in the N.E. Atlantic, as the following figures of catch per unit of effort show:

German trawlers; yields per fishing day in tons.

	Cod	Total
W. Greenland 1)	26.8	31.1
Barents Sea 2)	4.2	22.0
Bear Island 2)	2.1	15.7

1) Statistical Bulletin, Vol. 4 (1954). ICNAF, 1956.
2) Bulletin Statistique, Vol.37 (1952). ICES, 1954.

The growth curves shown in Fig. 12 are smoothed curves. In Fig. 13 are given curves that follow more closely the observed mean lengths for the different age-groups. It appears from these curves relating to the regions from which an appreciable number of the older age-groups are included in the material, that we can trace for the Labrador, Grand Bank, Nova Scotia and Bear Island regions the same irregularity as that mentioned for W. Greenland, viz. that the observed mean length for the older age-groups are higher than those which would conform with a "natural" continuation of the smoothed curves; in other words the data indicate an increase in growth rate for the older age-groups.

In Fig. 14 growth curves are shown for the medium-aged and older cod from these regions, i.e. for the period of age in which growth is slowing down and for the period of the apparent new increase in growth rate. The stipled curve-parts are smoothed continuations of the curve observed for the period with decreasing growth, drawn as if this decrease continued, the bold curve is drawn following the actually observed mean lengths also for the older age-groups. It is apparent that for all four regions the bold curves display an upward bend for the older age-groups, and run far above the stipled curves.

Admittedly, the number of individuals of the old age-groups is rather small and therefore the high mean lengths found could be attributed to mere chance. However, the fact that the phenomenon can be found, or at any rate traced, for all the four regions, may justify a closer consideration of it.

The explanation of this phenomenon could be that spawning marks have obliterated or weakened the age rings in otoliths (and scales), thus causing the age reading to be too low. It is suggested that those reading ages pay special attention to this possibility.

...../12.

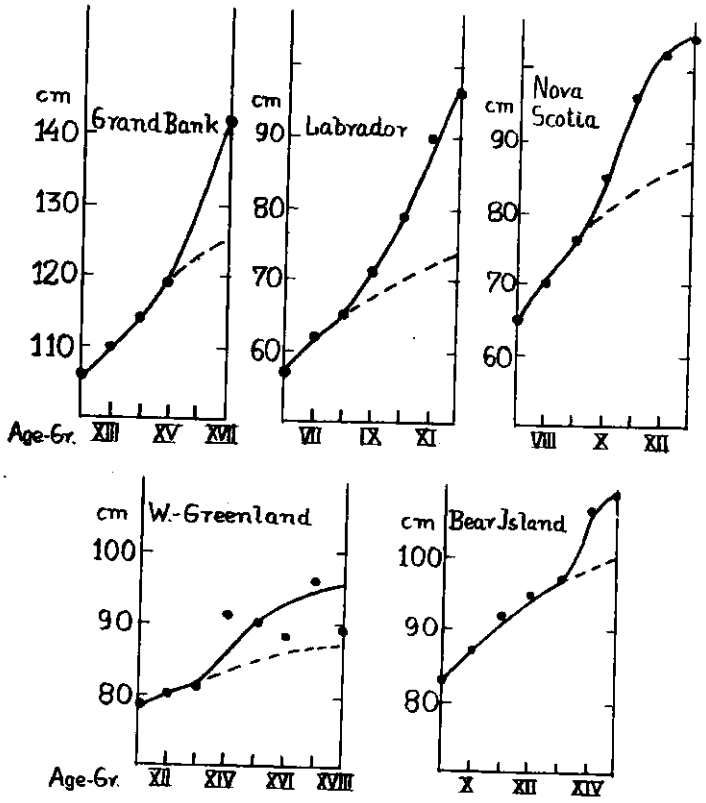

Fig. 14. Growth curves for cod of older age-groups, showing difference between lengths observed and those indicated by smooth continuation of the curves for the years with decreasing growth rate.

If this explanation is not admitted we are faced either with the fact of a new increase in growth rate with increasing age (caused f.i. by changes in diet or by a decrease in fecundity - (perhaps spawning only every second year) or with a change in pattern of migrations. It might be of interest to note that, judging from Fig. 2, it would appear that the increased growth rate for old fish is exhibited especially by the poor year-classes.

SUMMARY:

1. The four countries (Denmark, Iceland, Norway and Portugal) reporting age-length data of cod from Subarea 1 (years 1952-55) report fairly closely the same lengths for the same age-groups; their scientists read the otoliths in very much the same way (Table 2).

2. There is hardly any difference in growth rate between the rich and the poor year-classes when the whole Subarea is considered (Fig.3). However, a difference exists when separate year-classes are concerned for separate subdivisions (Fig.8).

3. The growth rate is nearly the same in all subdivisions (Fig. 7).

4. The decrease in growth observed from the late 'twenties to the 'thirties has continued in the 'forties and 'fifties for Subdivision A, and to only a small extent for Subdivisions B and C. In Subdivision E + F growth has been small too, equalling that of the slow growing year-classes of the 'twenties and 'thirties (Fig. 9).

...../13.

SUMMARY: (continued)

5. A similar decrease in growth rate from the early 'thirties to recent years is indicated for the Labrador area and the Grand Bank of Newfoundland. (Fig. 11).

6. The growth rate of the W. Greenland cod is considerably higher than that of the Labrador cod, somewhat slower than that of the cod from the Grand Bank, Nova Scotia and Bear Island, and much slower than the growth in more temperate seas: Faroes, Iceland, Celtic Sea (Fig. 12). Growth rate varies with the temperature of the water (table p. 11).

7. A special feature of the growth of the W. Greenland and Labrador cod, cod from cold regions, is the strong decrease in growth with increasing age, compared to the rather small decrease for cod from more temperate regions (Fig. 12).

8. The material available from various regions of the N. Atlantic indicates the possibility of an increase in growth rate for old cod (Figs. 13 and 14).

- THE END -

TABLE 1. Cod. Subarea 1. Mean lengths in cm. of age-groups – year-classes by subdivisions, years 1952-55. Denmark, Iceland, Norway and Portugal. The samples from Holsteinsborg Deep (border between B and C) are included in 1C.

SUMMER, 1952

AGE-GROUP	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XVI	XVIII
YEAR-CLASS	1948	1947	1946	1945	1944	1943	1942	1941	1940	1939	1936	1934
1A												
Off Disko, Den.				69			80					
Disko Deep, Nor.						72	75	78				
S. Disko B., Nor.						73	78	81		83	84	89
W. Disko B., Nor.						72	77	79	83			
1A, MEAN				69		72	77	79	83	83	84	89
1B												
St. Hellef. B., Den.		52		68			78					
" " " , Ice.	44	53	60	71	73	75	77					
" " " , Nor.					70	70	75			76	86	
1B, MEAN	44	53	60	70	72	73	77			76	86	
1C												
Holst., Ice.		56	63	72	78							
Holst., Nor.				69	72	73	76	77	79	79	83	
L. Hellef. B., Den.		52		69			79					
1C, MEAN		54	63	70	75	73	78	77	79	79	83	
1D												
Fylla B., Den.		55		70								
Fisken. B., Den.		55		71								
Fylla B., Ice.		55	63	72	76	76	80					
1D, MEAN		55	63	71	76	76	80					
1E												
Dana B., Den.				71								
1F												
Julianeh., Den.				65			75					
SUBAREA I, 1952 MEAN	44	54	62	70	74	73	75	79	81	80	84	89

SUMMER, 1953

AGE-GROUP	V	VI	VII	VIII	IX	X	XI
YEAR-CLASS	1948	1947	1946	1945	1944	1943	1942
1B							
St. Hellef. B., Den.	52	59	66	72			82
" " " , Por.		60					
1B, MEAN	52	60	66	72			82
1C							
Holst. D., Den.		56					77
" " , Nor.		60					77
L. Hellef. B., Den.		59		72			
Banana B., Den.		60					
1C, MEAN		59		72			77
1D							
Fylla B., Den.		61	66	73			
Fisken. B., Den.		62		72			76
Fylla B., Ice.	55	63	68	74	76	78	78
Fylla B., Por.		60					
Fisken. B., Por.							79
1D, MEAN	55	62	67	73	76	78	78
1E							
Dana B., Den.		61		70			
" " , Por.							78
1E, MEAN		61		70			78
SUBAREA I, 1953 MEAN	54	60	67	72	76	78	78

.....continued.....

TABLE 1 (continued):

SUMMER, 1954

AGE-GROUP	IV	V	VI	VII	VIII	IX	X	XI	XII
YEAR-CLASS	1950	1949	1948	1947	1946	1945	1944	1943	1942
1A									
Off Hisøy, Den.				63					79
1B									
St. Hellef. B., Den.	45	51	59	64	70	76	77		82
1C									
Holst. D., Nor.				64					77
L. Hellef. B., Den.			60	64		73			80
Ramsøe Bank, Den.	45			65		75			
1C, MEAN	45		60	64		74			79
1D									
Fylla B., Den.	47	52	61	65	71	73	76		80
Off Far. H., Den.				64		74			
Fiskem. B., Den.				65					
1D, MEAN	47	52	61	65	71	73	76		80
1E									
Dana B., Den.		54		66	69	73			76
Fredh. B., Den.		55		64		76	76		80
1E, MEAN		55		65	69	75	76		78
SUBAREA 1, 1954									
MEAN	46	54	60	64	70	75	76		79

SUMMER, 1955

AGE-GROUP	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII
YEAR-CLASS	1951	1950	1949	1948	1947	1946	1945	1944	1943	1942	1941	1940	1939	1938
1B														
St. Hellef. B., Den.	45	55	64	66	70		78							
" " " , Por.		56	61	67	71	75	80	81	82	85	91	90	91	96
1B, MEAN	45	56	63	67	71	75	79	81	82	85	91	90	91	96
1C														
Holst. D., Nor.					69									
" " , Den.		56		67	69		75			80				
L. Hellef. B., Den.		57		66	72									
" " " , Por.				67	71		77		77	80				
Held. B., Por.				67	70	72	77			82				
1C, MEAN		57		67	70	72	76		77	81				
1D														
Fylla B., Den.		55	62	65	70	76	78							
Fiskem. B., Den.					69									
Fylla B., Por.		53		65	70	72	76			77				
1D, MEAN		54	62	65	70	74	77			77				
1E														
Fredh. B., Ice.			59	65	69		77							
Dana B., Den.					70									
1E, MEAN			59	65	70		77							
SUBAREA 1, 1955														
MEAN	45	55	61	66	70	74	77	81	80	81	91	90	91	96

TABLE 5. Mean lengths in cm. of age-groups of cod in various regions of the North Atlantic, and at various periods.

REGION AND PERIOD	AGE-GROUP															
	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII
N.W. Greenland 1924-29 (Hansen, 1949)			70	75	79	83	87	89	91	93	96					
W. Greenland 1952-55 (ICNAF Reports)	34	45	55	61	68	71	74	77	79	80	81	91	90	88	96	89
Labrador 1931-35 (Thompson, 1943)	34	43	50	57	62	65	71	79	90	96	106					
" 1952 (Ancellin, 1954)		46	49	52	56	58	61	63	65							
" 1955 (Ruivo, 1956)	33	39	44	47	51	53	55	55	57							
Grand Bank 1931-35 (Thompson, 1943)	36	45	54	61	69	76	84	92	100	106	110	114	119	122	141	
" " 1951 (Ancellin, 1954)	31	42	53	59	70	76	79	85	91							
Off Nova Scotia 1931-35 (Thompson, 1943)	39	47	54	60	66	70	76	85	94	102	102					
N.W. Iceland (Jensen & Hansen, 1931[1])	41	55	66	76	83	90	98									
N. Norway (Jensen & Hansen, 1931)	31	35	52	56	62	66	74									
N. of the Faroes (Tåning, 1943[2])		69	77	83	87	93	95	93	95							
Bear Island (Trout, 1954[3])	29	38	48	51	69	77	83	87	92	95	98	107	109			
Celtic Sea (Letaconnoux, 1954[4])	69	80	89	96	101											

1) Ad. S. Jensen and Paul M. Hansen: Investigations on the Greenland Cod. Rapp. et Proc. Verb. LXXII, ICES, 1931.
2) Å. Vedel Tåning: Fiskeri-og Havundersøgelser ved Færøerne. Skr. udg. af Kom. f. Danmarks Fiskeri-og Havundersøgelser, No. 12, 1943.
3) G.C. Trout: Otolith Growth of the Barents Sea Cod. Rapp. et Proc. Verb. Vol. CXXXVI, ICES, 1954.
4) R. Letaconnoux: La Morue de la Mer Celtique et de l'Entrée de la Manche. Ibid. ICES, 1954.