COMPTES-RENDUS

DES TRAVAUX

LABORATOIRE CARLSBERG

18ME VOLUME

No. 6

Le No. 5 est sous presse.

COPENHAGUE

EN COMMISSION CHEZ H. HAGERUP

IMPRIMERIE DE THIELE

1930

Prix: 5 Kr.

LES COMPTES-RENDUS
DES TRAVAUX DU LABORATOIRE CARLSBERG

paraissent par livraisons à des époques indéterminées. A mesure qu'il en paraîtra un nombre suffisant pour faire un volume, les abonnés recevront un titre en même temps qu'une table des matières, avec l'indication de la période qu'embrasse le volume.

JOHS. SCHMIDT:

RACIAL INVESTIGATIONS.

X. THE ATLANTIC COD (*GADUS CALLARIAS* L.) AND LOCAL RACES OF THE SAME.

BY

JOHS. SCHMIDT.

I. Introduction.

The first treatise in this series, the object of which is to elucidate the racial characters in different organisms, was devoted to *Zoarces viviparus* L. This species of fish was exceptionally well suited for such studies. Thus one could in this viviparous species compare mother and offspring in respect of a whole series of characters which were already fully developed in the yet unborn progeny. Besides it appeared that *Zoarces*, even within relatively small areas, are capable of resolving into populations which by different characters are easily distinguished from one another. Thus it was striking that the *Zoarces* populations inside the Danish fjords were very different to those living outside, for instance as regards the number of vertebræ. There could, on an average, be even nine vertebræ more in the populations outside the fjords than in those at the inner end of the fjord and correspondingly these *Zoarces* were shorter and clumsier than those living outside. The middle parts of the fjords occupied an intermediate position in such respects.

This gradation could be observed everywhere in the Danish fjords.

I would refer to the first treatise issued in 1917[1]) where many examples were cited and to the fifth issued in 1920[2]) where

[1]) Johs. Schmidt: Racial investigations. I. *Zoarces viviparus* L. and local races of the same. Comptes-rendus des travaux du Lab. Carlsb. Vol. 13, No. 3. 1917.

[2]) Johs. Schmidt: Racial investigations V. Experimental investigations with *Zoarces viviparus* L. Comptes-rendus des travaux du Lab. Carlsb. Vol. 14, No. 9. 1920.

a single fjord area was treated separately *viz.* the Isefjord-Roskilde-fjord area.

I think that *Zoarces* was a lucky find because no closely investigated fish species shows such great differences from population to population, in other words, reacts so strongly to the influence of the external factors which are responsible for the differences. What these factors are, is another question which cannot be answered without further consideration. I have dealt with this in treatise V of this series issued in 1920 (pag. 10) and will come back to it later. That these factors have been able to manifest themselves to so high a degree in *Zoarces* must, I believe, be considered due particularly to the fact that this species is so exceedingly stationary, that it has even no pelagic stage as all our other Teleosts have, either as tiny larvæ or else as eggs. I have therefore considered it necessary to include other species with another biology in this investigation, for only when a series of such, with different biologies, have been more closely treated, as far as possible in connection with experimental investigations, can one hope to reach the heart of the matter and distinguish between the essential and the unessential.

Among the fish the laboratory has taken up for investigation in this connection, I will mention the genus *Anguilla*. This contains species such as the European eel which with its enormous migrations is, we know, diametrically the opposite of *Zoarces*. Later on, it is to be hoped, there will be an opportunity to give the result of the *Anguilla*-investigations. We have, besides, investigated *Gadus callarias* and several other species among which were pelagic as well, all with the object of getting as many biological types represented as possible.

I shall here discuss only *Gadus callarias*, a fish which, as we know, both as eggs and larvae leads a pelagic life and which besides is known, through marking experiments, to be able to migrate long distances, to wit a species whose biology is very different to that of *Zoarces*[1]).

For the present investigation a large material, kindly sent

[1]) A very short resumé of this treatise was submitted at the meeting of the International Council for the Exploration of the Sea in Copenhagen in June 1928 (printed subsequently in Rapports et Procés-Verbaux des Réunions du *Conseil Internat. pour l'Explorat. de la Mer.* Vol. LIV. Copenhague 1928).

to me by colleagues at home and abroad, has been at my disposal. Their names appear in the list pages 34—48 and here as well I beg them to accept my hearty thanks for the effective assistance they have contributed to my work. Thanks to Professor A. G. Huntsman, Ottawa, and Mr. O'Malley, U. S. Fish Commissioner, Washington, D. C., we have also been able to include the other side of the Atlantic in our investigations which has been of great importance for the interpretation of the results.

The material has as a rule been sent to the Carlsberg Laboratorium, fresh or preserved in formalin. The preparation was carried out by Mr. N. R. Poulsen and the investigation by Miss E. Hansen both of whom I must ask to accept my best thanks. My sincere thanks are also due to cand mag. Aa. Strubberg and Dr. Å. V. Tåning who assisted me with the arrangement of the material and of whom the former besides, through his particular connections, procured me a large material from Danish waters. The calculations were made by Dr. Kirstine Smith as in my previous papers of this series to which, in such respects, I refer.

II. The material investigated.

The present work is based on the investigation of a total of abt. 20.000 specimens of *Gadus callarias* distributed among 114 stations. Pl. I shows the position of these 114 stations which are distributed over the greater part of the region of the species in the Atlantic.

The two characters which have always been examined are the number of vertebræ and the number of rays in the 2nd dorsal fin (D_2).

As regards the number of vertebræ a distinction has been made between the præcaudal and the caudal vertebræ; here, however, only the total sum is considered.

That the 2nd dorsal fin has been selected for the counting of rays in preference to the other unpaired fins, is due to a preliminary examination made by cand. mag. Aa. Strubberg from which it appeared that the number of rays in D_2 displayed a greater difference between one population and another than the other unpaired fins did.

Occasionally we have also examined the number of pectoral

and branchiostegal rays. Particularly the former could reveal fairly considerable differences, but the investigation of these did not seem to give anything essential and was therefore not continued.

The treatment was extremely simple. The musculature on one side of the formolized, serially numbered specimens was removed exposing the vertebral column. Most often the specimens were then placed in a solution of alizarine in alcohol whereby the rays and vertebræ were stained red. This facilitated the counting, particularly in the small specimens, very considerably. All sizes of cod were used for the investigation, including specimens from a meter in length to small fry measuring two to three centimeters.

The samples investigated varied as to numbers. We generally endeavoured to get samples of about 200 specimens but sometimes we had to be content with much fewer on the other hand, in certain instances we examined samples consisting of a far larger number of individuals.

From certains areas, e. g. Denmark, the Faroes and Iceland we have, for a series of years, annually collected samples at the same places. The study of these samples shows that the average of the investigated characters may vary considerably from one year to another. This is quite in keeping with what I found in *Zoarces*[1]) and with what other authors have found in other species of fish. I shall not go further into this circumstance here where the task is first and foremost to describe the *Gadus callarias*-populations of the different areas and point out the differences between them, consequently a task of a geographical nature. I shall content myself with remarking that this annual variation of the characters in the same population can by no means cover the considerable geographical variation we have been able to prove in the Atlantic *Gadus callarias*.

To facilitate the survey the places from which the samples are derived ("the stations") are furnished with consecutive numbers. They can then, without difficulty, be found in the lists as well as on the charts.

A survey of the position of "the stations" is given, as mentioned, in the chart Pl. I which shows the whole of the investigated area.

[1]) This series II: Constancy investigations continued. Compt.-rend. d. trav. du Labor. Carlsberg, Vol. 14, No. 1. 1917.

From this it will be seen that in the main we are fairly well supplied with material from the entire Atlantic region, from the western as well as the eastern part of that ocean. Undoubtedly there are several places from which material was desirable, such as south-western Ireland and other places near the south limit for the cod in the eastern Atlantic ocean, likewise Shetland, Spitzbergen etc., but from where I have not yet succeeded in procuring it. I therefore entertain no doubt that the investigation of still larger material will bring forward circumstances of importance which I have not been able to include. On the other hand I hope that the present material, in spite of its deficiances, is capable of giving us a good preliminary survey of the Atlantic cod populations.

III. Variation of the characters investigated.

In order to procure a rapid survey of the most essential features in the variation of the two characters over the whole of the investigated region, I have had two charts made, one of which (Pl. II) gives the values for vertebræ, the other (Pl. III) the values for D_2.

These charts contain no details — the following charts will be found to contain these — but by means of curves and hatchings of different densities it has been attempted to present the variations of the values in a way which permits of a rapid survey.

1. Vertebræ.

The region is divided into four sections with different densities of hatching, in accordance with the size of average number of vertebræ, so that the greatest density corresponds to the greatest number of vertebræ. In the four sections the average numbers of vertebræ fall into four classes[1]):

Class: I	54.00—55.46
— II	52.41—53.99
— III	52.00—52.40
— IV	51.47—51.99

[1]) As we know, our species is found only at comparatively slight depths which do not generally exceed 200 to 300 m. This has not been taken into consideration in the hatchings of the sections which are uniformly hatched between the curves, also over the areas where the depths are too great for the occurrence of cod.

If we regard the open waters, we see that the number of vertebræ increases from south to north in the eastern part of the Atlantic ocean, the values being lowest west of the British Isles and highest in northern Norway.

The same is the case in the western Atlantic where the lowest values are found off the coast of U. S. A., the highest off northern Newfoundland and Labrador.

We see further that the figures increase from east to west, from the west of Scotland where the lowest value, 51.47, was found at Rockall, over the Faroes, Iceland, East Greenland, West Greenland to Labrador and northern Newfoundland where the highest value, 55.46, was found.

The shallow waters like the North Sea and the western part of the Baltic belong to intermediate class III with an average figure from 52.00 to 52.40 but it is a striking fact that the figures again increase when we move eastward from there into the deeper eastern part of the Baltic which then comes into class II with a maximal value of 53.36. I shall come back to this circumstance later on.

2. *Dorsal rays (D_2).*

The chart, Pl. III, which shows the main features of the variations of D_2, has been drawn in just the same way as Pl. II for the vertebræ. The four classes are as follows:

I..... $D_2 > 20$
II..... D_2 19.0—19.9
III..... D_2 18.0—18.9
IV..... $D_2 < 18$

As is the case with the vertebræ, the average values for D_2 show an increase from south to north in both sides of the Ocean, and furthermore an increase from the sea west of the British Isles over the Faroes, Iceland and Greenland to Newfoundland. Here and there values for D_2 were found which differed from the rest within the same area, such as at the stations 31 and 55.

The eastern Baltic also occupies a peculiar position in respect of D_2. East of Bornholm, this island included, the average value of D_2 decreases below 18.

IV. Characteristics of the populations of the different areas.

On closer investigation it has proved that to a certain extent it is possible to characterize the different areas by the average values for vertebræ and D_2.

Between the populations of America and Europe there is thus no slight difference, both the values for the vertebræ and D_2 being higher in the American than in the European populations.

In the European waters the average number of vertebræ does not exceed 54.00 and values above 53.5 were found only in northern and western Norway. In the American waters, on the contrary, it is the rule to find values over 54.00, the only exceptions being the most southerly population off U. S. A. (St. 1) and a couple of inshore populations in the St. Lawrence area.

The values for D_2 are also higher in America than in Europe. Whereas, as regards Europe, D_2 practically never reaches the figure 20, average values above 20 are the rule in the investigated American populations.

In the following I will endeavour to briefly characterize the different areas by the average values for the two characters, referring besides to the charts Pl. IV and V.

1. *America (Pl. IV).*

Labrador and the north coast of Newfoundland exhibit the highest known average values for vertebræ *viz.* about 55 or more, thus 55.46 in the Belle Isle Strait (St. 10) which is the highest figure found in any population. D_2 is also very high, about 20.5 or more, on an average.

In the stretch from St. John's, Newfoundland (St. 8) to Nantucket Shoals, U. S. A. (St. 1) the number of vertebræ decreases no less than $1^3/_4$ on an average, *viz.*, from 54.61 to 52.90 which is the lowest average value found in the western side of the Atlantic. It is worthy of remark that the figures inside St. Lawrence Bay (St. 5 and 6) are below 54 and thus lower than at the stations that lie outside (No. 4 and 7) which have 54.29 and 54.16 respectively.

2. *Greenland (Pl. IV).*

Both from West- and East-Greenland there are good large samples. While the average values for D_2 were high as in America, namely 20 or more, they were as regards vertebræ somewhat lower, most often about 53.5 in West-Greenland, in one sample from 1929 from South-Greenland, however only about 53.2.

It has been suggested that the cod stock of West-Greenland did not breed on the spot but was recruited through immigration from the banks on the American side. A glance at the chart Pl. IV will show that this, apparently, cannot be the case. On the other hand, the average values found at Iceland (see Pl. VI and Tables, Section X) do not seem to exclude the possibility of an exchange taking place, at any rate periodically or occasionally, between the cod populations of Greenland and those of Iceland. That this actually has been the case recently, appears from the latest results of the marking experiments with Greenland cod which have been made every year since 1924 by the Danish Commission for the Exploration of the Sea, a total of 2091 cod having been marked till the end of 1929.

Whereas, to begin with, there was no evidence of any marked cod leaving Greenland, the last years and, more particularly, the spring of 1930 decidedly brought such evidence as shown by the chart Fig. 1 and the Table p. 10. Till now ($^1/_8$ 1930) 7 cod marked at Greenland have been recaught at Iceland all of them off the northwestern part of this island. It is a remarkable fact that six out of the seven were caught in the spring of 1930. This may mean a large *départ* of Greenland cod which, in search of more favourable breeding conditions than those actually available in the Greenland waters in question, have migrated to Iceland. It would hardly be worth while, however, to discuss this or other possible explanations at the present stage of the investigation. We must content ourselves with pointing out that our samples of West-Greenland cod from 1924, 1925 and 1927 showed higher average values than those found in any of the numerous samples of Iceland cod examined by us.

As regards East-Greenland I succeeded — contrary to expectation, I may say — in getting a good sample of cod from the fjord at the Danish colony Angmagssalik, which showed that in 1927 there were many small cod at that place. The investigation

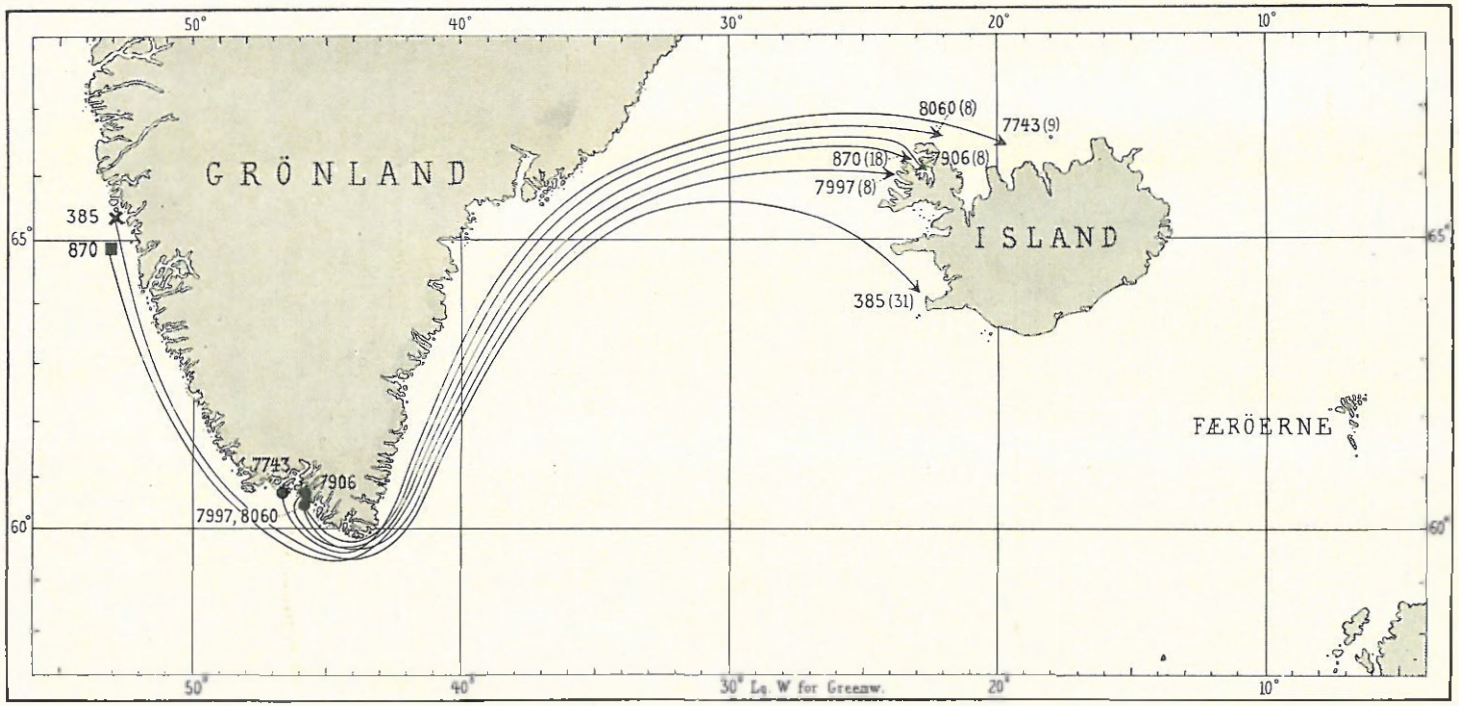


Fig. 1. Cod marked at Greenland recaught at Iceland (see Table p. 10).

× Marked in 1924, ■ in 1928, ● in 1929. The figures in brackets give the numbers of months between liberation and recapture of the cod in question. The migration of cod no. 3116 (see Table p. 10) is not shown in the above figure.

Cod marked at Greenland, recaught at Iceland.

No.	cm	Liberated	Date	Recaught	Date	Growth cm
385	70	Sukkertoppen	27/8 1924	Faxe Bay	28/8 1927	8
870	77	L. Hellefiske Bank	3/10 1928	Isafjordsdyb	5/4 1930	?
3116	55	Kapisigdlit, Godthaabfjord	26/6 1926	Off Patriksfjord	8/5 1930	32
7743	82	Off Julianehaab	24/8 1929	Siglufjord	15/5 1930	2
7907	74	Unartok Fjord	3/10 1929	Isafjordsdyb	26/5 1930	?
7997	66	Off Sydprøven	5/10 1929	S. of Onundarfjord	31/5 1930	0
8060	70	» »	» »	N.E. of Cape North	10/8 1930	?

gave abt. 20 for D_2, which is a high figure, very nearly the same as for the American cod. The average value for vertebræ in 1927, on the other hand, was a little lower than in the West-Greenland populations, viz. 53.08.

We are not yet certain where the East-Greenland cod spawns nor whether there is any connection with the populations living to the north-west of Iceland.

The elucidation of this and, on the whole, of the occurrence of cod in the sea between Iceland and Greenland is one of the most important fishery biological problems in this part of the North Atlantic region.

3. Iceland (Pl. V and VI).

Although by far the most cod of Iceland are produced off the south- and west-coast[1]), a closer investigation shows that there is no difficulty in indicating differences within the Icelandic populations. The average for D_2 lies as a rule between 19.5 and 20, and as regards vertebræ between about 52.3 and about 53.3, so that the highest values for vertebræ are decidedly found off the east- and north-east-coasts, the lowest at the south-western part of Iceland. Besides, a closer consideration of the positions shows that the populations living in the deepest water,

[1]) Johs. Schmidt: Fiskeriundersøgelser ved Island og Færøerne i Sommeren 1903. Published by »Kommissionen for Havundersøgelser«. »Skrifter« Nr. 1. Copenhagen 1904.
ibid.: The distribution of the Pelagic Fry and the Spawning Regions of the Gadoids in the North Atlantic from Iceland to Spain. Rapp. et Proc.-Verb. du Cons. Intern. pour l'Explor. de la Mer. Vol. X. Copenhagen 1909.

farthest away from the coasts, generally have somewhat higher values than those living in more shallow water closer to the coasts. At station 24 in the Seydis Fjord on the east-coast samples were examined for a series of years from 1924 to 1927 and from this it appeared that the average values at the same place can vary considerably from year to year, thus, as regards vertebræ from about 52.6 in 1924 to about 53.1 in 1925.

The marking experiments with Greenland cod mentioned above (see Fig. 1 and Table p. 10) are of considerable interest bringing as they do the first evidence of cod having migrated to Iceland from other regions. It is too early, however, to say, whether this immigration of Greenland cod is of any material importance the Iceland stock of cod.

4. The Faroes (Pl. VII).

From the Faroes there is a large material, from a couple of stations (37 and 34) even several samples collected in the years from 1924 to 1927 and showing no inconsiderable variations from one year to another.

The values are somewhat lower than at Iceland and as regards the vertebræ the value can decrease from scarcely 52.5 to about 52.0[1]). In this area as well, there seems to be a difference in the samples which are derived from deeper water and those that are taken close to the coasts or in the fjords, the former giving a slightly higher average value for the vertebræ (for this vide section V, later on).

The Faroe Bank south-west of the Faroes (St. 31) is dealt with under the next area: — the sea west of the British Isles.

5. The sea west of the British Isles (Pl. V).

This area which includes the Faroe Bank (St. 31) and the Rockall Bank (St. 51) is well characterized by the low average for the vertebræ which is less than 52, and decreases to the lowest value found in any population viz. 51.47 at Rockall Bank (St. 51).

The Irish Sea belongs to this area and it appears that the north coast of Scotland with the Orkneys must also be reckoned

---

[1]) I take no notice of the sample from St. 35 as it consists of only ten specimens and cannot therefore be considered as giving a reliable average.

in it. Unfortunately I have not yet succeeded in getting material from the west and south coasts of Ireland. Here, where we approach the south limit for the regular occurrence of the species, there might possibly be reason to expect still lower average values for the number of vertebræ than further north.

The values for D_2 are not identical over the whole of the area; they appear to decrease as we move southward just as they do in the North Sea as may be seen from the chart.

It was surprising to ascertain that the Faroe Bank (St. 31) which lies near the Faroes, is, in respect of the average number of vertebræ, so divergent from these islands and in this respect belongs decidedly to the more southern area which we have here under consideration. The low value for D_2, 18.74, on the Faroe Bank is a somewhat incomprehensible fact which I shall not attempt to explain, but will merely point out that this character very rarely seems to appear with values so divergent from what might be expected after an examination of the population of the neighbouring stations. The Faroe Bank, however, is beyond comparison the most striking example, and the circumstance seems all the more remarkable as in this case it is a question of the open sea. It is desirable, when opportunity offers, to have a fresh sample from these waters investigated for D_2.

6. Norway (Pl. V).

In consideration of the differences between populations, which geographically are not far from each other, we have found in other areas, one might be warranted in expecting considerable differences within so large and varied a sea area as the Norwegian which stretches from the Skager Rack to beyond the Arctic Circle. And this expectation has been verified. Although the material to hand is scarcely sufficient for a description of the cod populations of Norway it yet furnishes several particulars of considerable interest. I shall first occupy myself with the open water populations and then with the relation between these and the inshore populations.

A. Open water populations.

In the whole of northern and western Norway, toward the south in any case as far as St. 55, in Nordmør (ca. 63° lat. N.) and thus, inter alia, including Lofoten the populations are characterized by high average values, both as regards vertebræ and

D_2, varying between ca. 53.4 and 53.8 and between ca. 19.5 and ca. 20, respectively. Such high values for vertebræ were not found anywhere else in the European area and according to the available evidence there is scarcely any prospect of finding populations with higher average numbers of vertebræ at other places in the East Atlantic region, Spitzbergen and the White Sea perhaps excepted.

From St. 55 in Nordmør (ca. 63° N. lat.) to St. 57 at Haugesund in West-Norway (ca. 59° 24' N. lat.) the picture is greatly altered, the average number of vertebræ falling more than 1 to 52.44, a value about equal to that of the populations on the outer banks at the Faroes.

Finally we have material from the southern part of Norway, from the Skager Rack (Stt. 66 and 67). Here the values have decreased still further. Thus the average number of vertebræ is only 52.1 to 52.2 and the values for D_2 are likewise lower.

Our journeying from northernmost to southernmost Norway has therefore revealed great differences between the cod populations, which show that the average values for vertebræ and D_2 fall from north to south. But the fall is not uniform as the values in the whole of the enormous stretch from Finmark to Nordmør (St. 55, ca. 63° N. lat.) remain practically identical and subsequently fall only when we move further in a southerly direction. This result, arrived at exclusively through variational statistics, seems to coincide well with those regarding the biology and migrations of the Norwegian cod which Joh. Hjort arrived at some years ago through marking experiments and the study of the occurrence of the "skrei" and the younger year classes[1]).

B. Inshore populations.

No less interesting is the comparison of the inshore populations with those living in open waters.

The best material comes from the Trondhjem Fjord. My attention was drawn by Fiskerikonsulent Oscar Sund to the fact that there were spawning "skrei" in the innermost part of that large fjord system. Through the kind offices of Dr. Sund I received a sample from Beistad Fjord in the innermost part of the Trond-

[1]) Joh. Hjort: Fiskeri og Hvalfangst i det nordlige Norge. Bergen. 1902. *id.*: Fluctuations in the great Fisheries of Northern Europe. Rapp. et Proc.-Verb. du Cons. Intern. pour l'Explor. de la Mer. Vol. XX. Copenh. 1914.

hjem Fjord (St. 53) and another from Dr. Nordgaard, Trondhjem, consisting of small cod taken at the Biological Station at Trondhjem. For comparison I had the sample from the open coast at Nordmør (St. 55). The position of the stations in question will be seen from the chart Pl. V and Fig. 3 p. 25. The investigation gave a very clear result; the values, particularly for the vertebræ, were much lower inside the fjord than outside of it. Whereas the samples from the open coast had an average of 53.76 vertebræ the figures for the two inshore samples were only 52.40 and 52.35.

It is probable that the same phenomenon viz. that the average values for vertebræ and D_2 inside the fjords differ from those outside of them, could be found in other places. I am thus inclined to interpret the figures that resulted from an investigation of a couple of samples from Tromsø in northern Norway (Stt. 50 and 51), and which are essentially lower than those usually found in this area, as belonging to cod of a local inshore population. (Vide chart and tables).

7. *The North Sea (Pl. V).*

From this area, so complicated from a hydrographical point of view, I have hardly sufficient material for a complete description of the cod populations. Yet there are certain features which come into prominence. Thus it appears to be a rule that the average values for D_2 fall from north to south, as north of 50° N. lat. we find figures above 19 and south of this latitude figures below 19.

As regards the second of the characters investigated, the vertebræ, the state of things does not appear to be so simple. Thus, in the eastern part of the North Sea, along the peninsula of Jutland, the average number of vertebræ increases from north to south from 52.06 to ca. 52.3—52.4.

As regards the western part of the North Sea matters are possibly the same. For a glance at the chart, Pl. V will show that if we exclude station 59 in the innermost part of the Firth of Forth — and this we are possibly justified in doing as quite specially local conditions may prevail here — we shall here also find a slight increase from the lowest value 51.91 at Orkney (St. 58) to the highest: 52.09 at St. 60 N. N. E. of Lowestoft. Another couple of stations, for instance, one at Aberdeen and

another off the mouth of the Thames might possibly settle the matter and, on the whole, there is hardly a doubt that in future it would pay to investigate a larger number of populations from the North Sea.

We considered, above, the variations of the investigated characters from north to south in the North Sea. From west to east we find — always excluding the station in the innermost part of the Firth of Forth (St. 59) — an increase in the average values for vertebræ.

8. The Cattegat including the Limfjord (Pl. VIII).

The Cattegat is characterized by low average values of D_2 which here seem to be below 19. As regards vertebræ there appears to be a difference between the western part on one hand and the eastern and most northerly part on the other, the values in the former being lower, less than ca. 52.2 and a little higher in the latter, more than ca. 52.4.

The Limfjord (Pl. VIII) is particularly remarkable for low values for vertebræ which, here, lie close up to 52.0, indeed they decrease even as far down as abt. 51.8. At the 11 stations investigated in the Limfjord, the average value, at four of them, was below 52. The values for D_2 in the Limfjord are below 19 and thus correspond most closely to what we find in the Cattegat, while they differ from what we have found in the nearest parts of the North Sea, at St. 65, where the average was 19.5. The statistical method is of considerable interest for the determination of the question as to the independence of the Limfjord cod population.

9. The Belt Sea and the Western Baltic (Pl. VIII).

The average values for vertebræ lie between ca. 52.1 and ca. 52.25, for D_2 between ca. 18.2 and ca. 18.75 and thus correspond to what we found in the western part of the Cattegat.

10. The Eastern Baltic (Pl. V).

None of the areas investigated is better characterized than the Eastern Baltic, particularly through the values for D_2. While the western Baltic showed values of about 18.5 we find that these decrease if we move eastward so that when we have passed longitude 14° east of Greenwich, they lie below 18.

We have investigated twelve population samples from the Baltic east of this meridian, and in all of them, without exception, the average number of rays in D_2 was below 18[1]), the average varying from 17.24 to 17.92.

The other character investigated, the number of vertebræ, also shows interesting conditions. We saw that the average figure in the western Baltic was low, ca. 52.1 to 52.25. If we move eastwards we find that it increases. Already when the above mentioned meridian, 14° E. long., is passed the average figure has reached up to above 52.5, i. e. to values which are found neither in the Cattegat nor the North Sea, and to find the like of which one must go right up to western Norway or Iceland. Further east in the Baltic the values increase still more, more rapidly in the eastern than in the western side, until a maximum is reached in the Gulf of Finland (St. 113) with the value 53.36, an average figure which even off eastern Iceland we have not found so high, and which in Europe is surpassed only by the values that occur in the Bank-cod, off western and northern Norway.

In the west side of the inner Baltic, in the Gulf of Bothnia, we have found the highest value: 53.02 at St. 114, which lies at abt. 63° N. lat.

By the low average values for D_2 the cod of the eastern Baltic are characterized as distinct from those of other areas. In a biological and practical respect the establishment of this fact signifies that the eastern Baltic has an indigenous cod population which is independent of the waters outside.

That it has been possible to arrive at so clear a result with regard to the Baltic cod is due to the excellent material which was sent to us by our Baltic colleagues, particularly by Dr. K. A. Andersson in Stockholm but also by Prof. Järvi in Helsingfors, Dr. V. Miezis in Riga and Dr. Lundbeck in Königsberg.

Several instances of fish species are known to have spread into the Baltic from the North Sea and the Danish waters, which presently as we proceed further east appear, in a more or less pronounced degree, as dwarf forms, most frequently with a re-

[1]) Only once has an average value under 18 been encountered outside this area, to wit, at St. 87 a in the Isefjord (a fjord in the Cattegat) where the figure was 17.85; but the investigation of a fresh population sample from this place (St. 87 b) two years later, gave the value 18.81.

duced number of vertebræ as well. I must therefore say that I was surprised to find that the sample sent to me by Dr. K. A. Andersson in Stockholm from the Swedish side of the Gulf of Bothnia (Station 114) consisted of fine large cod of about 70 cm in length, that is to say, such as the Norwegians call "skrei". In the literature on the subject[1]) the Swedish biologists have called attention to the occurrence of these large cod and their pelagic eggs have been found in several deep basins of the Baltic. The larval stages on the other hand have, as far as I am aware, been hitherto met with quite exceptionally.

In this connection it is as well to remember that a hypothesis has been advanced that these large Baltic cod are individuals that have immigrated from waters outside the Baltic[2]). According to the results of the present investigation this hypothesis cannot be maintained, as cod with the characters established in the Baltic populations do not occur in the waters outside the Baltic.

V. Significance of external factors.

In the foregoing section we have got a knowledge of the populations of the several waters and have seen how they differ from one another. In other words we have become acquainted with a whole range of facts. It is now time to see if it is possible to show a rule for the grouping of these facts.

A glance at the chart Pl. II will show that the number of vertebræ, at any rate in the open waters, decreases as we proceed from north to south. This applies both to the western part of the area from Labrador and southward to U. S. A., and in the eastern part from northern Norway to the North Sea and from Iceland to western Scotland and England.

One is most inclined to think that the temperature of the water is the factor which primarily is of significance for the distribution of the values and a consideration of the course of the isotherms drawn on the chart seems also to put it beyond

[1]) Andersson, K. A.: Fiskeribiologiska Undersökningar i Östersjön och bottniska Viken. Inledning och allmän Översikt. Medd. från Kungl. Lantbruksstyrelsen. Nr. 243. Stockholm. 1923. Hessle, Chr.: *ibid.*: Undersökningar röranda Torsken *(Gadus callarias* L.*)* i mell. Östersjön och Bottenhavet.

[2]) Strodtmann: Mitteilungen des Deutschen Seefischereivereins, Bd. 42, No. 8, p. 21, 1926.

doubt that this factor in some way or other, direct or indirect, so influences the populations that the lowest temperatures give the highest values and vice versa.

Even in a landlocked sea like the Baltic, this rule seems to hold good; for the values were highest in the interior eastern Baltic, but then the temperature here was also the lowest, at any rate at the depths where the spawning and the earliest larval development of the cod seem to take place.

Furthermore it is possible, indeed probable, that in the shallower waters such as the North Sea, the Cattegat, the Belt Sea and the western Baltic the values found may also be traced to the variations in the temperature.

The comparatively high values for vertebræ in the south-eastern part of the North Sea (Pl. V) might suggest this, for the temperatures here during the spawning period of the cod are comparatively at their lowest. The fact that the average number of the vertebræ in the western Cattegat with the Limfjord, seem decidedly lower than in the eastern Cattegat (Pl. VIII) may also be due to the distribution of the temperatures which, as we know, are lower towards the east than towards the west in these waters. That other factors besides the temperature (e. g. the depth) may intervene here cannot, however, be ignored (vide thus section VI on the relation between the inshore and the open water populations).

As regards the second character investigated, the number of rays in D_2, matters stand thus, that the rays are not formed till at a somewhat later stage of the individual's life than the vertebræ. It is therefore very probable that the so called "critical period" i. e. the period in the life of the individual, when the influence of external factors can be brought to bear on the number of elements like those with which we are occupied, occurs later in the case of D_2 than that of vertebræ[1]). From this again it follows that we are not justified in expecting quite a parallel variation of the two characters. On comparing Pl. II and Pl. III we see, in fact, that although the curves for D_2 run, in the main, in the same manner as those for vertebræ, there are, however, certain divergences, primarily as regards the Baltic, where the values of D_2 are distinctly on the decrease towards east while

[1]) I have experimentally shown this in the common trout (*Salmo trutta* L.). This series, No. VII in C.-R. Laboratoire Carlsberg. Vol. 14, No. 15—1921).

the average number of vertebræ increases, as a matter of fact, as we proceed in an easterly direction.

No experimental investigations in respect of the temperature are available as concerning the cod. In so emphatically bringing to light in this paper the importance of this factor for the average value of the characters with which we are concerned, I have been actuated inter alia by the fact that in other species of fish I have by direct experiments been able to establish the importance of the temperature for the number of vertebræ and fin-rays. In this connection I would refer to previous treatises in this series where the results of my experiments with the common trout *(Salmo trutta)* and with the million fish *(Lebistes reticulatus)* are described[1]).

It would, however, not be right to assume that the temperature is the only factor capable of influencing the average values of the number of vertebræ and fin-rays, but with our present knowledge of the physics and chemistry of the seas in question, it is hardly possible to define precisely or chart other factors as completely as the temperature, this might possibly be done only with the salinity. As regards the latter I have by investigations not found anything indicating that experimental alterations of it are able to affect the average values. Nor did I succeed by a comprehensive comparative study of the *Zoarces* populations in the north European region to trace any directly determinative influence of the varying salinities from one area to another[2]). Thus we might find the same average number of vertebræ in the North Sea as in the eastern Baltic where the salinity of the water barely reaches $^1/_9$ of the value found in the North Sea. And on the other hand populations living in waters of about the same salinity might have an extremely different average number of vertebræ[3]).

[1]) II: Johs. Schmidt: Constancy investigations continued. Comptes-rendus du Laborat. Carlsberg, Vol. 14, No. 1. 1917.
III: Johs. Schmidt: Experiments with *Lebistes reticulatus* (Peters) Regan. *Ibid.*, Vol. 14, No. 5. 1919.
VII: Johs. Schmidt: Annual fluctuations of racial characters in *Zoarces viviparus* L. *ibid.*, Vol. 14, No. 15. 1921.

[2]) Johs. Schmidt: *Zoarces viviparus* L. and local races of the same. C.R. Laborat. Carlsberg. Vol. 13, No. 5. 1917.

[3]) Thus in the interior of the Roskilde Fjord where the average number of vertebræ was 107—108 and the Kjeldsnor Lagoon at Langeland, where the corresponding figure was found to be 119—120 (No. I of this series, page 327).

Nor does a comparison of the charts Pl. II and III with one showing the salinity in the North Atlantic area, seem to point to any closer connection between the variations of this factor and of the characters investigated, as was the case in respect of the temperature. I shall therefore here leave the salinity, but in section VIII there will be occasion to again say a few words about it.

Inshore and open water populations.

There is, however, reason at this juncture, where the influence of external factors on population characters is being discussed, to consider the relation between the populations which, within the same area, live in more open and deeper water and those who live in shallower more inshore places like fjords; in short, between the populations in inshore water and in open water in the same area.

Therefore on a basis of what we have learned from the description of the populations of the various waters and by a consideration of the charts Pl. IV—V we will compare the average values of the inshore and open water populations while omitting shallow waters such as the North Sea and the Danish waters.

We find then that there is an unmistakeable difference between the values, particularly as regards vertebræ, the inshore or shallower waters having lower figures than the open or deeper waters. The most marked instance has already been mentioned viz., Trondhjem Fjord in Norway, where in the innermost part (in Beistadfjord St. 53) we found an average number of vertebræ of 52.35, while the value at the nearest station outside the fjord (St. 55) was 53.76 (vide chart Fig. 3, p. 25).

Among other deeper waters which admit of a comparison between inshore and open water populations, may be mentioned the Faroes and Iceland.

On looking at the chart Pl. VII of the Faroes we find that northern island samples from seven stations have been investigated; of these four were taken inshore and three in open water off the coast. At the southern island, Suderø, one inshore and one outside sample have been investigated. The proportion between the average numbers of vertebræ in the inshore and open water samples appears from the following:

Faroes.

Inshore	Open water
52.17 (St. 36)	*52.49* (St. 40)
52.29 (St. 37)	*52.41* (St. 41)
52.16 (St. 38)	*52.41* (St. 33)
52.10 (St. 39)	*52.39* (St. 32)
52.25 (St. 34)	

Even though the differences are not great it is, however, incontestable that there is a difference between the two groups.

We next come to Iceland. As the temperatures vary so very greatly at the different coasts of the country it is necessary to deal with each of these by itself. We arrive then at the following table:

Iceland.

	Inshore	Open water
S. W. coast	*52.29* (St. 18)	*52.75* (St. 17)
—	—	*52.79* (St. 16)
—	—	*52.61* (St. 15)
N. W. coast	*52.62* (St. 16)	*52.96* (St. 20)
E. coast	*52.86* (St. 24)	*53.29* (St. 22)
—	*52.79* (St. 25)	*53.16* (St. 23)
—	—	*53.26* (St. 28)

As may be seen from the tables there can be no doubt that within each of the three groups of water, the fjord populations have lower average values than those living outside.

As regards the American side, the temperatures vary so greatly over comparatively short stretches that a deal of caution must be exercised in comparing the inside with the outside populations. We must therefore restrict ourselves to a comparison of Stt. 5 and 6, which lie in the Gulf of St. Lawrence with Stt. 4 and 7, the two nearest stations lying outside the gulf, as shown in the following:

In the Gulf of St. Lawrence	Outside the Gulf of St. Lawrence
53.58 (St. 6)	*54.16* (St. 7)
53.86 (St. 5)	*54.29* (St. 4)

The same, therefore, as we found in the populations on the otherside of the Atlantic: lower values in inshore than in open waters.

From what we have seen in the immediately preceding pages

the slightest doubt cannot be entertained as to the fact that inshore, shallow waters contain one or more factors, not found in the deeper, more open waters in the vicinity, which have the effect of decreasing the average numbers of vertebræ. What these factors are and in what way they affect the average figures we have, as yet, no means of determining. Whether the temperature intervenes here also, whether the lesser depth, as such, or the vicinity of the land or whether other, including unknown, factors make their influence felt, would hardly be worth while discussing at the present stage of the investigations. It would not, however, be out of place to compare our results touching the cod, a little more closely with those available as to other, thoroughly investigated species of fish from the North Atlantic.

VI. Comparison with other species.

Among species of which we have a thorough analysis covering large areas, as in the case of the cod, only two need really to be taken into consideration, viz. *Zoarces viviparus* L. and the herring, *Clupea harengus* L. The first has been investigated by myself[1]), the second by quite a number of authors who have expatiated on Heincke's classical work on races of the herring of North and West Europe[2]).

I will first deal with *Zoarces*. As mentioned in the introduction, the *Zoarces* populations of the Danish fjords presented a very characteristic picture. It was manifest everywhere that while the populations living outside the fjords had a high average number of vertebræ this decreased inshore until a minimum was reached in the vicinity of the innermost part of the fjord. In extreme cases there could be an average difference of nearly ten vertebræ between the innermost part of the fjord and the waters outside and a corresponding difference in form. While the populations outside the fjord consisted of elongated, slim individuals, those in the base of the fjord were short and heavily built, so that at a first glance they appeared dissimilar to the former. I here reproduce a figure (Fig. 2, p. 24) from one of my publications in this series, showing the average number of vertebræ in *Zoarces*

[1]) Johs. Schmidt: Comptes-rendus du Laboratoire Carlsberg, Vol. 13, No. 3. 1917.

[2]) F. Heincke: Naturgeschichte des Herings. Teil I. Abhdl. d. Deutschen Seefischerei-Vereins. II. Bd. Hf. 1. Berlin 1898.

viviparus in the Ise Fjord—Roskilde Fjord area, a fjord in the north of Zealand, Denmark, opening out into the Cattegat[1]).

This figure gives an excellent illustration of how the number of vertebræ is reduced in the short stretch from the mouth and inwards into the fjord. Now so great a variation cannot be expected in other fish species — for, as we know, *Zoarces* occupies a peculiar position both as to the wide range of variations and its localization which presumably must be due to the fact, inter alia, that this viviparous species has no pelagic stage whatever — but it will, however, be of interest to make comparison with what we have found in the cod.

In the figure (Fig. 3) p. 25 a reproduction is given of the results of our already mentioned investigations of the populations in the Trondhjem fjord area.

A comparison of the two figures shows that both in the cod and in the *Zoarces* we are confronted with the same phenomenon: a decrease in the average number of vertebræ from the open waters inwards into the inshore area.

As regards the herring I have no observations of my own but must confine myself to the literature on the subject on the basis of which cand. mag. Aa. Strubberg has prepared a list of the most important data for average nos. of vertebræ. From this list I shall quote a couple of examples partly from western Norway, partly from the North Sea, all bearing on winter or spring spawning herring.

West Norway[2]).

Inside the Fjord:		Off the coast:	
Beistad Fjord ..... (the innermost part of the Trondhjem Fjord).	*56.48*	66°—67° N.	*57.36*
		62° 30′ N.	*57.51*

The North Sea, Holland[3]).

Inshore water:		Off the coast:	
Zuidersee	*55.35*	50 miles N. W. of Ymuiden (ca. 53° 5′ N. Lat., 3° 30′ E. Long.).....	*56.62*
do., near Uik island.	*55.13*		
do., Marsdiep near Helder.....	*54.78*		

[1]) Johs. Schmidt: Comptes-rendus Laboratoire Carlsberg, Vol. 14, No. 9, Pag. 8.

[2]) Investigated by Hj. Broch: Norwegische Heringsuntersuchungen während der Jahren 1904—1906. Berg. Mus. Aarbog 1908.

[3]) J. J. Tesch: Invest. on herring in the Southern North Sea. Rapp. et Proc.

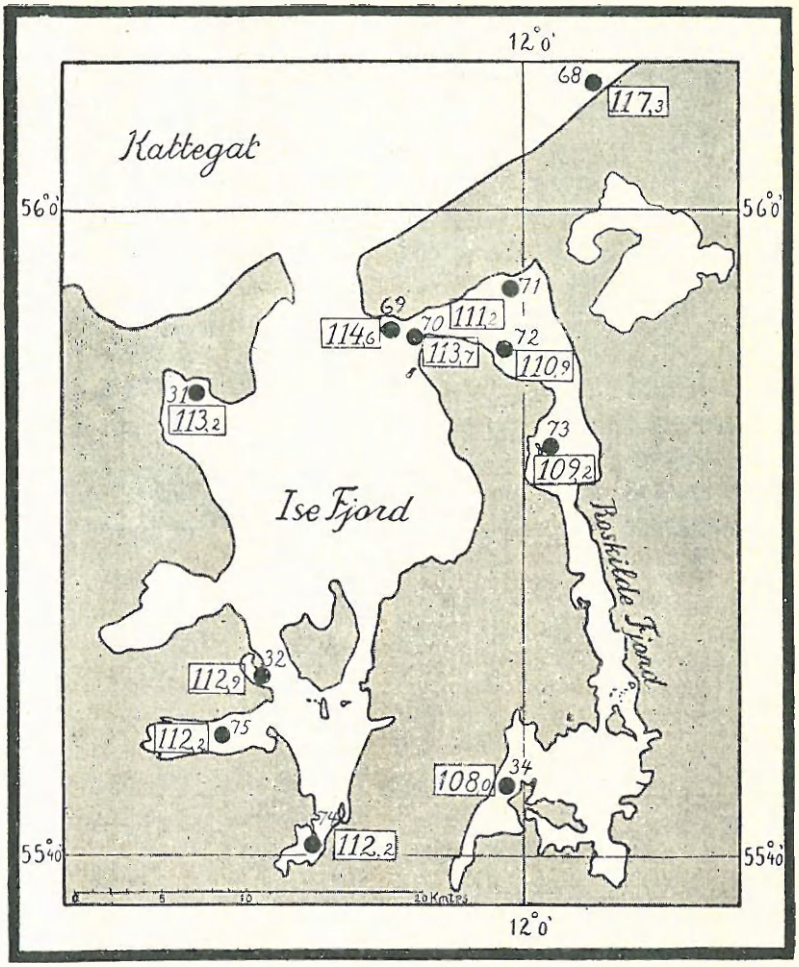


Fig. 2. Average no. of vertebræ in 11 *Zoarces* populations from the Ise Fjord—Roskilde Fjord area.
The figures by the black spots are station numbers; those in the squares indicate the average no. of vertebræ for the population in question.

In both instances we see that the average number of vertebræ decreases from the open in towards the inshore waters.

These examples could be supplemented with many others but this is hardly necessary. We have already seen the same phenomenon

---

Verb. du Cons. Intern. p. l'Explor. de la Mer. Vol. LIV. 1929.
H. C. Delsman: Ueber das Wachstum von Nordsee-Hering und Zuidersee-Hering. Rap. u. Verh. Rijksinst. v. Vischerijonderz. Deel 1. 1914.

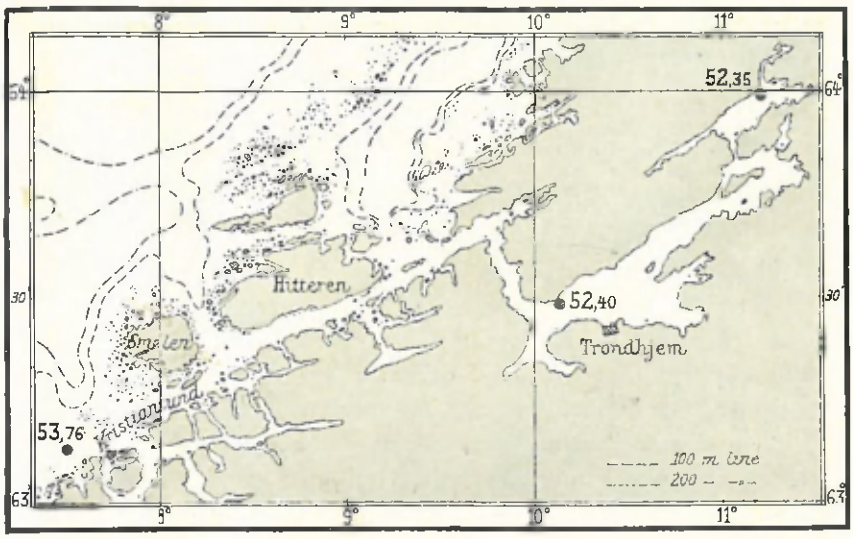


Fig. 3. Average no. of vertebræ in 3 cod populations inside and outside the Trondhjem Fjord.

repeated in three species of fish so dissimilar systematically as the cod, *Zoarces* and the herring and which biologically also belong to three different types: pelagic eggs (the cod), viviparous, without pelagic stages *(Zoarces)* and demersal eggs (the herring). There is therefore no reason whatever to doubt that we are here confronted with a phenomenon of general significance, when we discern that the average number of vertebræ within the same area is lower inshore than in the open water off the coast. And it is likely that the more localized a species is in its youngest stages (eggs and larvæ) the greater will — given the same conditions — the fluctuation be.

In this section we have, so far, concerned ourselves only with a comparison of populations in open waters and in land-locked fjords and bays. It seems, however, possible to carry this consideration further, to imagine the shallow waters such as the North Sea, the Danish waters and the Western Baltic as being an inshore area in comparison with the Norwegian Sea and the Atlantic, a consideration which seems possible both as regards the cod and the herring (vide p. 21 and 23), but which, to be sure, is not yet able to carry us nearer to the solution of the question as to what these "inshore" factors are that have the effect of decreasing the average number of vertebræ, and which does not thus

exclude the possibility that, in the end, it is nevertheless the temperature that is the determining factor.

VII. A Summary of the most important results.

In this work a description is, for the first time, given of the populations of cod (*Gadus callarias* L.) occurring in the North Atlantic region.

The description of the populations and how to distinguish them are based on a large material, abt. 20.000 individuals derived from 114 stations distributed over the greater part of the area of the species in the Atlantic and tributary seas (Pl. I).

The characters employed are the number of vertebræ and of the rays in the 2nd dorsal fin (D_2).

The result of the investigation is that the North Atlantic cod, in contrast to the eel (*Anguilla vulgaris*[1]), but like *Zoarces* consists of a mosaic of populations dissimilar to one another. Some of these, particularly those belonging to the open seas, are distributed to a considerable extent, while others are far more local and, on the whole, it would appear from the facts collected that the cod, generally speaking, is a more local species than we were previously justified in assuming.

The American cod differs from the European in having higher average values, from 52.9 to 55.5, as regards vertebræ while the European varies from 51.5 to 53.8. The values for D_2 are also higher at America than at Europe, being as a rule above 20 at America, while this figure is very seldom reached in European waters.

The values for the cod in West-Greenland are such that they can hardly originate from the American banks. Marking experiments with Greenland cod have shown that cod, at any rate in certain years, migrate from Greenland to the north-western parts of Iceland, but up to the present, however, no populations have been found at Iceland having values exactly identical with those of the Greenland cod.

Concerning the populations in the rest of the areas I may

[1]) Johs. Schmidt: First report on eel investigations (Rapp. et Procés-Verbaux du Conseil Internat. p. l'Explor. de la mer. Vol. XVIII. Copenhagen 1913). Johs. Schmidt: Second report on eel investigations (ibidem Vol. XXII. 1915).

refer to the descriptions in section IV. In this place prominence must be given only to the eastern part of the Baltic, where the populations differ from all others in the low average value of D_2, which east of abt. 15° Long. E. sinks below 18. It is therefore certain that the populations living here are indigenous to the Baltic and that an immigration from outside, which was supposed to have taken place, is out of the question.

The cod in the inner Baltic (the Gulf of Bothnia, for instance) is no dwarf race; its individuals reach "skrei" size and the average number of vertebræ increases from west to east in the Baltic.

There is a distinct correlation between the values and the temperature in the open sea particularly as regards the vertebræ which may be seen immediately from Pl. II and III. A similar correlation can besides be shown in respect of the herring in the open waters (Pl. IX and Pl. X). In both species the average number of vertebræ increases with a falling temperature.

In *Zoarces* it has with great clearness been demonstrated that the average number of vertebræ decreases very greatly from the outlet in towards the base of the fjord. In the present material of the Cod it has been possible to show a similar, though perhaps not so marked a difference, between the inshore and open water populations, this being so both in Norway, at Iceland and the Faroes (vide page 21), and from the literature on the subject it is seen that something similar is the case as regards the herring (vide page 23). There is therefore no doubt that this is a circumstance of a general nature though we cannot yet with certainty point out what factors are at work to decrease the number of vertebræ. It is possible that the shallow areas such as the North Sea and the Danish waters are in this connection to be considered as inshore waters.

VIII. Concluding remarks.

It may I presume be useful in concluding this work to offer a few remarks of a more general nature.

Fishery biologists are evidently unanimous that external factors are capable of altering the average characters by which races in the fishes are determined. This has been proved directly by

experiment in the common trout (*Salmo trutta* L.) and in the million fish (*Lebistes reticulatus* (Peters) Regan) by varying the temperatures during which the development in the "critical period" took place (cf. my papers, No. II, III and VII in this series).

It would, however, be quite wrong to ignore the fact that the differences in the average characters by which the races are determined may also be of a hereditary, genotypical nature, which, as far as I can see, several of the researchers occupied in the study of races in fishes, seem inclined to do. I have myself, in my first treatises on *Zoarces* (1917), strongly defended the opinion that the hereditary moment is of great significance, and later on I have considered this to be confirmed to no small extent by my experiments in diallel crossings with the common trout *(Salmo trutta)*[1]).

It is then certain that external factors can alter the average values of both vertebræ and fin rays. It was likewise perfectly evident from my experiments[2]) with *Salmo trutta* and *Lebistes* that a change of the temperature in the critical period is capable of producing great instant alterations as has often been witnessed in other fields of experimental biology and genetics. I emphasize this as it seems to show that in our views regarding the races of fishes we need not take refuge in the secular influences of external factors which do not admit of being checked experimentally.

How the action of the external factors results in an alteration of the average values has, however, not yet been established with certainty and the question is far from being a simple one. The action may be of a more or less direct nature and may conceivably take place either at a very early stage of development particularly in the "critical" or "sensitive period" or even later in the life of the individual. We will consider each case by itself.

A. Early influence.

Here again there may be a question of two essentially different processes viz., either a direct impression of the single

[1]) Johs. Schmidt: La valeur de l'individu a titre de générateur appréciée suivant la méthode du croisement diallèle. Comptes-rendus du Laborat. Carlsberg. Vol. 14. No. 6. 1919.

[2]) Johs. Schmidt: Racial studies in fishes, III. Diallel Crossings with trout *(Salmo trutta* L.). Journal of Genetics. Vol. IX. No. 1. Cambridge. 1919.

individuals as a consequence of *e. g.* changes of temperature or it may be that owing to a change of this kind a choice, a selection takes place, through the death of certain variates.

I am inclined to think that what happened in the case of my experiments with *Salmo trutta* and *Lebistes*, perhaps *Zoarces* as well, was a direct impression caused by the change of temperature. It would, however, not be easy to give a decided proof of this, and theoretically, perhaps impossible, when, as in the case of *Lebistes* and *Zoarces*, the matter hinges on viviparous species, the embryonic development of which takes place in an environment which cannot be controlled as H. M. Kyle has emphasized in his "Biology of Fishes".[1]) It will, however, be within the range of possibility to settle this if one works with oviparous species as for instance *Salmo trutta*. Let us imagine that we have a number of eggs from the same female, fertilized with sperm from the same male, and without any selection take out two lots each consisting of say 50 eggs which are developed, one by a higher and the other by a lower temperature which, according to my experience, can make a great difference in the average number of vertebræ in the two lots of fry. If the mortality during the experiment can be reduced to a minimum of a very few per cent, which would seem possible, and if the great average difference between the number of vertebræ of the two lots of progeny still appears, why, then the alteration of the average values caused by the variation of temperature cannot depend on a selection but must be due to a direct impression of the individuals.

B. Late influence.

If the external factors in question do not assert themselves till a later period in the life of the individual the effect on the population may take the form of a rearranging or regrouping of its individuals whereby certain variates are segregated and disappear from the main body say by emigration. Should this be the case we again have a question of selection but one which occurs later in the life of the individual and which is of a more active character. To get a clearer insight into the matter let us imagine that the offspring of some population, during the pelagic larval

[1]) H. M. Kyle: Biology of Fishes, p. 192, London 1926.

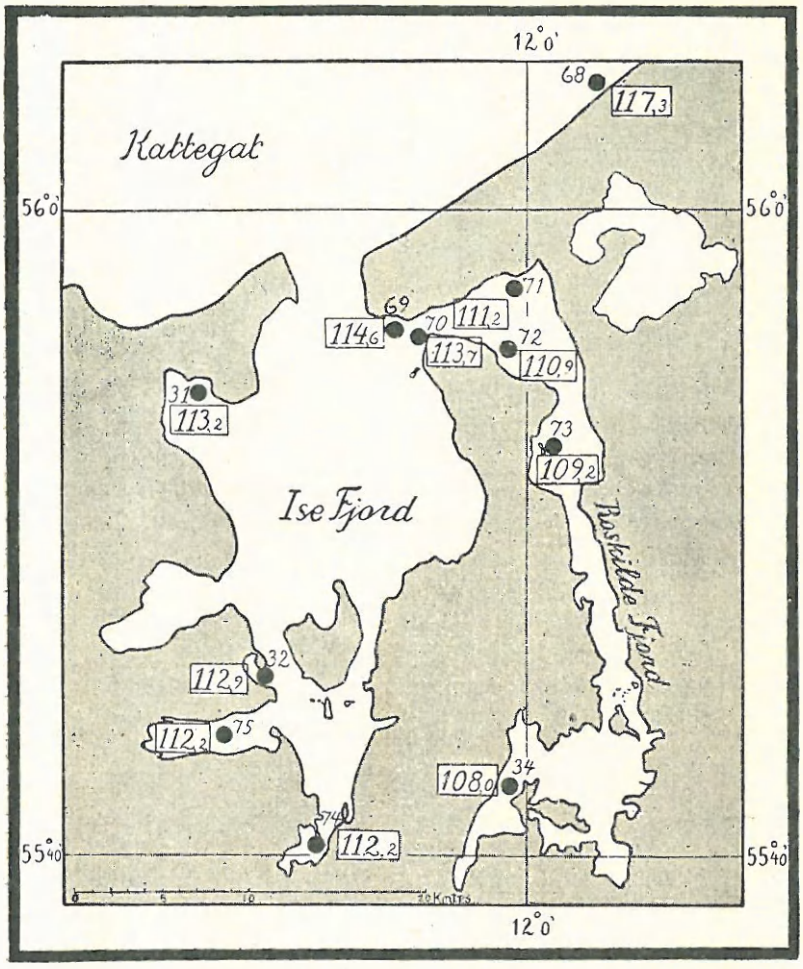


Fig. 4. — Average number of vertebrae in 11 *Zoarces* populations from the Ise Fjord - Roskilde Fjord area, Sealand, Denmark.
The figures at the black spots indicate station numbers, those within the rectangles the average number of vertebrae of the population concerned.

and postlarval development, spreads over a rather large area with highly varying external conditions. Furthermore, that the population — and its offspring — consists of individuals which with respect to a temperature optimum or the exigencies of temperature group themselves in accordance with the usual variation curve in such a way that the lowest part of the curve contains the variates which require a lower temperature than the

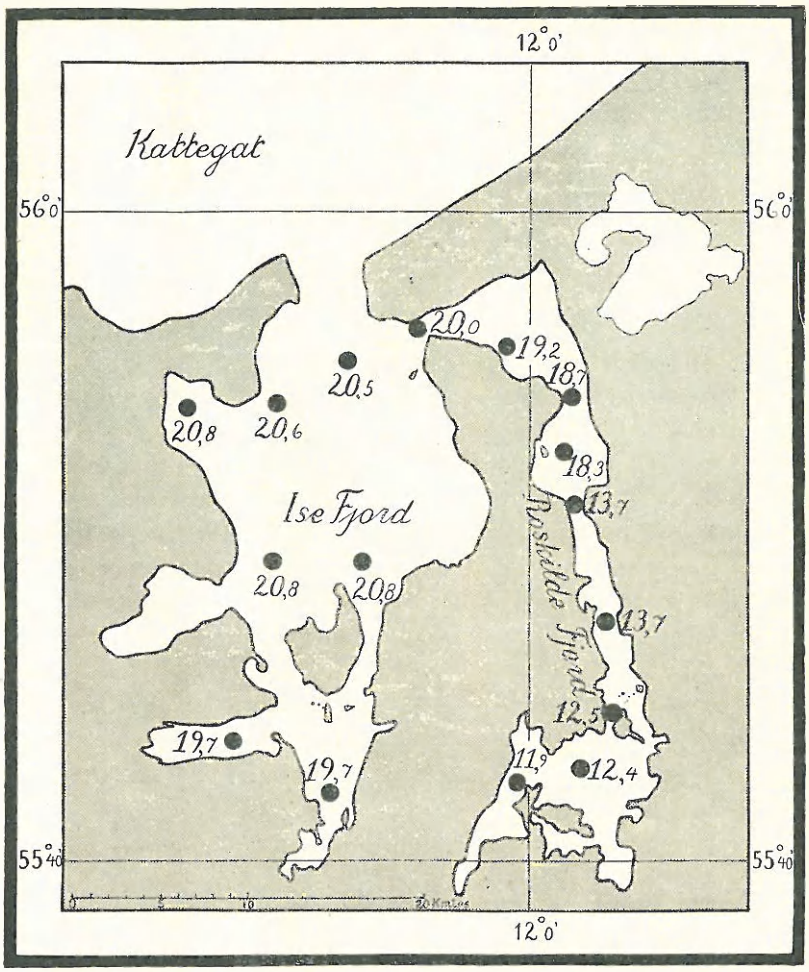


Fig. 5. — Ise Fjord - Roskilde Fjord area, Sealand, Denmark. Showing the salinity of the water in per mille (‰) at the end of November 1919.

main body of them and particularly lower than those that belong to the uppermost part of the curve.

Should the offspring of this population get into an area with a lower temperature the majority of these individuals would then emigrate from this area whereby it would be inhabited by a population having another, lower average value as to the exigencies of temperature than the original one. Provided the "altered" population can propagate in the "new" colder

area, the "new" lower average value will be fixed by inheritance and contingently by further emigration of the higher variates from the area.

If this view is to be applied to those characters of the population with which we are generally concerned, for instance, the number of vertebræ, there must be a correlation between the low vertebral figure and an optimum for the external factor in question. The idea that such a correlation can exist will perhaps occur to many as being improbable. It would, however, not seem unconceivable that two or more such characters may be interdependent or coupled as it is called in genetics and several instances might possibly be found where differences between populations were explainable in this way.

Duncker has emphasized the possibility of such a selective alteration of the plaice populations in the North Sea.[1])

In my work on the populations of the common eel (*Anguilla vulgaris* Turt.) I have found no suggestion of this as all eel-populations, even those from the most far-away corners of Europe displayed identical average values as regards the number of vertebræ.

On the other hand I don't suppose it would be unreasonable to explain the distribution of the average values of the number of vertebræ in *Zoarces* in the Danish fjords as being due to a late selection, where the conditions had been fixed in the course of time by inheritance and emigration of unfit variates. I reproduce here two figures from an earlier treatise on *Zoarces* in the Isefjord-Roskilde area. In one (Fig. 4, p. 30) is given the average number of vertebræ at a series of stations, in the other (Fig. 5) the salinity of the water at these stations. There is, as may be seen, a distinct correlation between the two series of values, thus the number of vertebræ decreases with a diminishing salinity. A phenomenon like this would, I suppose, be explained by many as a direct effect of the salinity. This I find difficult to accept both because I have not, experimentally, been able to prove the direct significance of the salinity[2]), and because we have learned

---

[1]) Duncker: Ueber einige Lokalformen von *Pleuronectes platessa* L. Mitt. Naturhist. Museum. XXX. Hamburg 1913.

[2]) Even though the salinity may possibly not have any direct significance it may of course have a regulative or selective effect. It should not be forgotten, however, that, apart from the salinity, other factors having a direct influence may exist in inshore waters.

from the investigations of *Zoarces* that populations with the same average number of vertebræ can live in water of extremely different salinity just as, vice versa, water of the same salinity can contain populations with an extremely different number of vertebræ.

On the other hand both this phenomenon and others of a similar nature (cf. sections V and VI on open water and inshore populations of cod and herring) might be explained as being due to a selection which would naturally manifest itself very distinctly in a species so localized and variable as *Zoarces*.

There is, however, a possibility of testing this matter more thoroughly and of coming to a final decision, namely, in such areas where the species occurs but does not spawn. If, for instance, we could prove that the early (postlarval) individuals presented an average figure different from that of the older fish we would thereby have a basis for a decision[1]).

The above remarks will give an idea of how complicated and difficult a question we have to deal with in the study of the races of fish, at any rate as soon as we attempt to go even slightly into details in any particular case. At present we are, as far as understanding is concerned, only at the beginning but there can hardly be any doubt that by experiments and a thorough, comparative study of a series of biologically different types we shall be able to attain to clearness.

---

[1]) It is, however, possible that such a proof is already available through Duncker's work on the Elbe-Flounder (Variation und Verwandschaft von *Pleur. flesus* and *Pleur. platessa L.* Wiss. Meeresuntersuchungen. N. F. I. 1894), which was found to have lower average figures than the North Sea flounders. The presumption would be that it is certain that the propagation does not take place in the Elbe from which the populations investigated were derived.

IX. List of the populations investigated.

St. 1. U. S. A. Massachusetts, Nantucket Shoals, abt. { 41° 18' N. 70° 02' W.
May—June and Sept.—Oct. 1927.
From W. C. Schroeder, Field Assistant, Bureau of Fisheries, Washington D. C., U. S. A.

St. 2. Gulf of Maine, off Mount Desert, abt. { 43° 59' N. 68° 08' W.
1926 and May—June 1927.
From W. C. Schroeder, Field Assistant, Bureau of Fisheries, Washington D. C., U. S. A.

St. 3. Canada, New Brunswick, Bay of Fundy, between Grand Manon and Campobello. abt. { 44° 50' N. 66° 47' W.
January and April 1926.
From Professor A. G. Huntsman, Canada.

St. 4. Canada, Nova Scotia, abt. { 43° 36' N. 62° 18' W.
From trawlers on the west side of Sable Island Bank. Spring 1927. Halifax.
From Professor A. G. Huntsman, Canada.

St. 5. Canada, Cape Breton Island, Port Hood N. S. abt. { 46° 00' N. 61° 35' W.
January 1928.
From Professor A. G. Huntsman, Canada.

St. 6. Canada, Gulf of St. Lawrence, Paspebiac P. Q. abt. { 48° 03' N. 65° 14' W.
January 1928.
From Professor A. G. Huntsman, Canada.

St. 7. New Foundland, Port aux Basques near Cape Ray, abt. { 47° 35' N. 59° 10' W.
January 1928.
From Mr. W. A. Munn, St. John's, New Foundland.

St. 8. New Foundland, St. John's, abt. { 47° 34' N. 52° 42' W.
August 1927.
From Mr. W. A. Munn, St. John's, New Foundland.

St. 10. Belle Isle Straits: Flower Cove, St. Barbe Harbour. 4 Sept. 1923. Seine. abt. 6 August 1923. Seine. { 51° 15' N. 57° 00' W.
From Professor A. G. Huntsman, Canada.

St. 11. Labrador, Sandy Islands: Flat Island, Black Bear Bay, abt. { 53° 20' N. 55° 46' W.
Depth 10 fathoms. 40 fathoms from the coast. 6 August 1927. In traps.
From Mr. F. S. Munn at the request of Mr. W. A. Munn, St. John's, New Foundland.

St. 12. West Greenland, Sukkertoppen, abt. { 65° 23' N. 52° 54' W.
1924.
From Dr. Å. V. Tåning.
1925, July and August.
From Fiskemester Nielsen.
1927.
From Professor Ad. S. Jensen, Copenhagen.

St. 13. West Greenland, Julianehaab, abt. { 61° 00' N. 47° 00' W.
1928.
From the Royal Danish Greenland Department.

St. 13a. West Greenland, Lichtenaufjord, abt. { 60° 29' N.B. 45° 35' V.L.
2—3 Octobre 1929.
From Mag. P. Hansen.

St. 14. East Greenland, Angmagssalik 1926 and 1927, abt. { 65° 40' N. 37° 10' W.
25 caught 19 July—21 July 1927 in Kolonifjorden (in the innermost part of the fjord).
From Kolonibestyrer Hedegaard.

St. 15. Iceland. West of Portland, abt. { 63° 25' N. 19° 20' W.
R/S. »Dana«. Station 3066. Depth 20—50 m. 6 July 1927. Ottertrawl.

St. 16. Southwest Iceland, off Landeyjasandur, abt. { 63° 34' N. / 20° 26' W.
R/S. »Explorer«. Station 40. 27—28 June 1925. Ottertrawl.

St. 17. South Iceland, between Vestmannaeyar and Reykjanes, abt. { 63° 44' N. — 63° 16' N. / 22° 57' W. — 20° 30' W.
R/S. »Dana«. Stations 3159, 3161, 3163, 3164 and 3165. Depth 68—143 m. 31 July and 1 Aug. 1927. Hooks.

St. 18. West Iceland, Faxe Bay, Havnefjord, abt. { 64° 04' N. / 21° 57' W.
R/S. »Dana«. Station 2130. Depth 11—0 m. 13—14 June 1924. Eel hand-seine.

St. 19. Northwest Iceland, Isafjord, abt. { 66° 04' N. / 23° 08' W.
R/S. »Dana«. Station 3219. Depth 8—0 m. 8 August 1927. 0 + 1 gr. Eel hand-seine.

St. 20. Off Northwest Iceland, Djupállsrif (Hali), abt. { 66° 53' N. / 24° 42' W.
R/S. »Dana«. Stations 3220 and 3223. Depth 190—180 m. 9 August 1927. Hooks.

St. 21. North Iceland, Skialfandi, abt. { 66° 01' N. / 17° 30' W.
R/S. »Dana«. Stations 2458 and 2459. Depth 7—10 m. 10 and 11 August 1925. Stations 3265. Depth 15—35 m. 16 August 1927. Ottertrawl.

St. 22. East Iceland, Hjeradsfloi, abt. { 65° 40' N. / 14° 10' W.
R/S. »Dana«. Station 3089. Depth 30—40 m. 12 July 1927. Ottertrawl.

St. 23. East Iceland, Glettinganesgrunn.
R/S. »Dana«. Station 3292. Depth 100 m. 18 August 1927. Cod hooks. Abt. { 65° 31' N. / 13° 10' W.
R/S. »Dana«. Station 3293. Depth 124—134 m. 20 August 1927. Ottertrawl. Abt. { 65° 33' N. / 12° 56' W.

St. 24. East Iceland, Seydisfjord, abt. { 65° 16,7' N. / 13° 58,7' W.
R/S. »Dana«. St. 2095. Depth 6—0 m. 3 June 1924.
— St. 2220 and 2221. Dept 24—0 m. 29 July 1924.
— St. 2468. Depth 23—0 m. 13 August 1925.
— St. 2604. Depth 24—0 m. 12 and 13 June 1926.
— St. 2956. Depth 14—0 m. 1 and 2 August 1926.
— St. 3287. 18 August 1927. Eel hand seine.
— St. 3291. 18 August 1927. 3 m stramin nets. 65 m wire.

St. 25. East Iceland, Nordfjord, abt. { 65° 08,8' N. / 13° 42' W.
R/S. »Dana«. Station 2224. Depth 10—0 m. 30 July 1924. Eel hand seine.

St. 26. South east Iceland, Lonsvik, abt. { 64° 20' N. / 14° 39' W.
R/S. »Dana«. Station 3075. 9 July 1927. Ottertrawl with 300 metres wire out.

St. 27. South east Iceland, off Hornafjord, abt. { 64° 13' N. / 15° 28' W.
R/S. »Explorer«. Station 48. Haul Nr. 999. Depth 31 m. 2 July 1925. Ottertrawl.

St. 28. South east Iceland, Hvalsbak, abt. { 64° 35' N. / 13° 15' W.
Icelandic S/T. »Skallagrimur«. May 1928.
From Fiskerikonsulent, Dr. B. Sæmundsson, Reykjavik.

St. 29. South Iceland, S. E. of Ingolfshöfdi, abt. { 63° 46' N. / 16° 25' W.
R/S. »Dana«. Station 3072. Depth 65 m. 8 July 1927. Ottertrawl.

St. 30. South Iceland, Ingolfshöfdi, abt. { 63° 5' N. / 16° 33' W.
R/S. »Explorer«. Station 47. Haul Nr. 998. Depth 24 m. 1 July 1925. Ottertrawl.

St. 31. Faroe Bank, abt. { 60° 52' N. / 8° 12' W.

R/S. »Dana«. Station 3030. Depth 160 m. 24 June 1927. Ottertrawl; also from Grimsby S/T. 24 June 1927.

St. 32. Faroe Islands, S. W. of Suderø, abt. { 61° 15' N. / 6° 55' W.

R/S. »Dana«. Station 3060. Depth 150 m. 3 July 1927. Ottertrawl.

St. 33. Faroe Islands, Husagrynna, abt. { 62° 03' N. / 6° 11' W.

R/S. »Dana«. Station 3052. Depth 115—118 m. 29 June 1927. Ottertrawl.

St. 34. Faroe Islands, Vaag Fjord, abt. { 61° 28' N. / 6° 48' W.

R/S. »Dana«. St. 2062. Depth 10—0 m. 23 May 1924.
- — St. 2293. — 6—0 m. 22 May 1925.
- — St. 2479. — 12—0 m. 19 August 1926.
- — St. 2561. — 1 June 1926.
- — St. 2996. — 6—0 m. O-Gr. 9 August 1926.
- — St. 3013. — 4—0 m. I-Gr. 20—21 June 1927.
- — St. 3340. — 12—0 m. O-Gr. 3 September 1927.

Eel hand seine.

St. 35. Faroe Islands, Trangisvaagfjord, bottom of the Fjord, abt. { 61° 33,5' N. / 6° 49' W.

R/S. »Dana«. Station 2073. Depth 11—0 m. 26 May 1924. Eel hand seine.

St. 36. Faroe Islands, Vestmanhavn, abt. { 62° 09' N. / 7° 10' W.

R/S. »Dana«. Station 2077. Depth 12—0 m. 28 May 1924. Eel hand seine.

St. 37. Faroe Islands, Sandegærde, abt. { 62° 00' N. / 6° 46' W.

R/S. »Dana«. St. 2247. Depth 5—0 m. 7 August 1924.

R/S. »Dana«. St. 2475. Depth 6—0 m. 17 and 18 August 1925.

— St. 2983. Depth 6—0 m. 5 August 1926.

Eel hand seine.

St. 38. Faroe Islands, Kollefjord, abt. 62° 06' N. 6° 55' W.

R/S. »Dana«. Station 2082. Depth 10—0 m. 31 May 1924. Eel hand seine.

St. 39. Faroe Islands, Fuglefjord, abt. 62° 14,5' N. 6° 48,3' W.

R/S. »Dana«. Station 2080. Depth 10—0 m. 30 May 1924. Eel hand seine.

St. 40. Faroe Islands, north of Viderø, abt. 62° 27' N. 6° 26' W.

R/S. »Dana«. Station 2505. Depth 80—90 m. 23 May 1926. Ottertrawl.

St. 41. Faroe Islands, north of Fuglø, abt. 62° 27' N. 6° 20' W.

R/S. »Dana«. Station 3054. Depth 90 m. 30 June 1927. Ottertrawl.

St. 42. The Rockall area, abt. 57° 00' N. 14° 00' W.

May 1929.

From Mr. Davis, Fisheries Laboratory, Lowestoft.

St. 43. Irish Sea, Morecambe Bay, Liverpool Bay, abt. 53° 24' N. 2° 58' W.

Received December 1925 and January 1926.

From Professor J. Johnstone, Dept. of Oceanography, University of Liverpool.

St. 44. Firth of Clyde, Kilbrennan Sd. abt. 55° 25' N. 5° 30' W.

abt. 55° 22' N. 5° 26' W. 55° 30' N. 5° 31' W.

19 May and 5 Sept., 1927.

From Dr. Bowman, Fishery Board for Scotland.

St. 45. Hebrides, Broad Bay, abt. { 58° 14' N. / 6° 18' W.
27 September 1927.
From Dr. Bowman, Fishery Board for Scotland.

St. 46. Barents Sea, abt. { 71° 03' N. — 33° 30' E. / 71° 00' N. — 33° 30' E.
R/S. »Poseidon«. Station LXIV. Depth 243—242 m.
21 Aug. 1927.
From Dr. A. Bückmann, Biol. Anstalt, Heligoland.

St. 47. Barents Sea, abt. { 69° 37,5' N. — 33° 11,5' E. / 69° 39' N. — 33° 20,5' E.
R/S. »Poseidon«. Station LXIX. Depth 175—218 m.
26 Aug. 1927. Trawl.
From Dr. A. Bückmann, Biol. Anstalt, Heligoland.

St. 48. Barents Sea, abt. { 69° 36' N. — 33° 12,5' E. / 69° 38,5 N. — 33° 14' E.
R/S. »Poseidon«. Station LXIX. Depth 225—218 m.
26 Aug. 1927. Trawl.
From Dr. A. Bückmann, Heligoland.

St. 49. Finmark Sea, off Vaidagub on the Fisker peninsular, on the bank about 25—30 miles east of Vardø, abt. { 70° 24' N. / 32° 00' E.
June 1927.
From Fiskerikonsulent O. Sund, Bergen.

St. 50. Near Torsvaag at Tromsø. 1928. Abt. { 70° 15' N. / 19° 30' E.
From Bestyrer A. Dannevig, Arendal.

St. 51. Tromsø Sound. November 1925. Abt. { 69° 42' N. / 18° 56' E.
From Tromsø Museum.

St. 52. Lofoten. March 1927. »Skrei«-grop. Abt. { 68° 00' N. / 14° 00' E.
From Fiskerikonsulent O. Sund, Bergen.

St. 53. Trondhjemsfjord, in the innermost part of the fjord Verran in the Beistadfjord. April 1928. »Skrei«-group. Abt. { 64° 00' N. / 11° 12' E.
From Fiskerikonsulent O. Sund, Bergen.

St. 54. Trondhjemsfjord, near the Biological Station, abt. 63° 29' N. 10° 08' E.
2—10 November 1927. Eel seine.
From Dr. O. Nordgaard, Trondhjem.

St. 55. West-Norway, at Veiholmen in Nordmør, abt. 63° 08' N. 7° 30' E.
March 1928. »Skrei«-group.
From Fiskerikonsulent O. Sund, Bergen.

St. 56. West-Norway, at Bergen, abt. 60° 23' N. 5° 20' E.
1926. 0 gr.
From Fiskerikonsulent O. Sund, Bergen.

St. 57. West-Norway, Haugesund, abt. 59° 24' N. 5° 17' E.
April 1928.
From Fiskerikonsulent O. Sund, Bergen.

St. 58. Orkney Islands, Inganess Bay, abt. 58° 59' N. 2° 53,5 W.
Depth 14 m. 17 September 1928. Eel seine.
From Dr. Alex. Bowman, Fishery Board for Scotland.

St. 59. Firth of Forth, in the innermost parts of the fjord, abt.
56° 01' N. 3° 22' W.
56° 03' N. 3° 05' W.
56° 05' N. 3° 01' W.
56° 05' N. 3° 22' W.
Depth 16—28 m. 24—26 May 1928. Ottertrawl and eel seine.
From Dr. Alex. Bowman, Fishery Board for Scotland.

St. 60. The southern North Sea, abt. 35 miles N. N. E. of Lowestoft. 14 November 1928. Ottertrawl. Abt. 53° 03' N. 2° 07' E.
From Mr. Davis, Fisheries Laboratory, Lowestoft.

St. 61. The North Sea, Inner Herring trawling Ground, abt 54° 46' N. 0° 28' E.

Depth 79 m. 13 Sept. 1925. Ottertrawl.
From the Fisheries Laboratory, Lowestoft.

St. 62. At Helder, abt. { 53° 00' N. / 4° 45' E.
From Dr. H. C. Redeke, Rijksinstituut voor Biologisch Vischerijonderzoek, Helder.

St. 63. The North Sea, at Heligoland, abt. { 54° 12' N. / 7° 53' E.
1925.
From Professor E. Ehrenbaum, Hamburg.

St. 64. The North Sea, south of Horn Reef, abt. { 55° 28' N. / 7° 55' E.
R/S. »Dana«. Depth 10—43 m. 16—20 October 1925.

St. 65. West-Jutland, west of Thyborøn, 8 miles W by S off Thyborøn light-buoy, abt. { 56° 39' N. / 7° 58' E.
15 November 1928. Danish seine. I-Gr.
From Havnebetjent K. Buus, Thyborøn.

St. 66. Skagerak, off Trømøen at Arendal, abt. { 59° 33' N. / 10° 27' E.
5—7 May 1928. Large Cod.
From Bestyrer A. Dannevig, Arendal.

St. 67. Skagerak, Holmsbue at the mouth of the Drammen fjord, abt. { 59° 33' N. / 10° 27' E.
15 May 1928.
From Bestyrer A. Dannevig, Arendal.

St. 68. Limfjorden, western part of Nissum Bredning, at Stenodden, abt. { 56° 37,5' N. / 8° 17' E.
Depth 50—56 m. 22 April 1929. Stake net. I-Gr.
From Fiskerikontrollør Jørgensen, Aalborg.

St. 69. Limfjorden, Venø Sund, off the coast from Oddesund south to Gibbel Næs, abt. { 56° 34' N. / 8° 35' E.
Depth 50—56 m. 20 October 1928. Eel traps.
From Fiskerikontrollør Jørgensen, Aalborg.

St. 70. Limfjorden, Venø Sund at Thorsodden, north end of Venø, abt. { 56° 35,5' N. / 8° 39' E.

Depth 6 m. Medio April 1929. Stake net. I-Gr.
From Fiskerikontrollør Jørgensen, Aalborg.

St. 71. Limfjorden, the northern Vildsund and the western part of Thisted Bredning, abt. 56° 53,5' N. 8° 39' E.
Depth 10—14 m. 8 June 1929. Eel seine.
From Fiskerikontrollør Jørgensen, Aalborg.

St. 72. Limfjorden, western part of Thisted Bredning, abt. 56° 54,5' N. 8° 40' E.
Depth 9—11 m. 22 November 1928. Bait seine.
From Fiskerikontrollør Jørgensen, Aalborg.

St. 73. Limfjorden, Livø Bredning, at Boxer-odde, east coast of Mors, abt. 56° 52' N. 8° 52' E.
Depth 6 m. October 1928. Eel traps.
From Fiskerikontrollør Jørgensen, Aalborg.

St. 74. Limfjorden, Livø Bredning, east coast of Mors, abt. 56° 45' N. 8° 50' E.
Depth 6 m. April 1929. In eel traps. I-Gr.
From Fiskerikontrollør Jørgensen, Aalborg.

St. 75. Limfjorden, Løgstør Bredning, east of Holmetange, abt. 57° 01' N. 9° 05' E.
Depth 4 m. 22 April 1929. Eel traps. I-Gr.
From Fiskerikontrollør Jørgensen, Aalborg.

St. 76. Limfjorden, Hauerslev Bredning, abt. 57° 01,5' N. 9° 23' E.
Depth 5—6 m, May 1929. Eel traps. I-Gr.
From Fiskerikontrollør Jørgensen, Aalborg.

St. 77. Limfjorden, between Bredhage and Storvorde, abt. 57° 03,5' N. 10° 03' E.
Depth 11 m. 5 November 1928. Cod-seine. I-Gr.
From Fiskerikontrollør Jørgensen, Aalborg.

St. 78. Limfjorden, at Stranderholm, abt. 57° 02' N. 10° 06' E.
Depth abt. 11 m. 5 April 1929. Cod-seine. I-Gr.
From Fiskerikontrollør Jørgensen, Aalborg.

St. 79. Kattegat, north of Frederikshavn, abt. { 57° 26' N. / 10° 36' E.
17 August 1925. Stake-nets.
From Fiskerikontrollør Jørgensen, Aalborg.

St. 80. Kattegat, at Frederikshavn, south of the harbour, abt. { 57° 25,5' N. / 10° 32,5' E.
Depth 7 m. 20 June 1929. Stake nets. I-Gr.
From Fiskerikontrollør Jørgensen, Aalborg.

St. 81. Kattegat, between Hals and Jyngerhuse, close to the coast, abt. { 57° 01' N. / 10° 22' E.
4 December 1928.
From Fiskerikontrollør Jørgensen, Aalborg.

St. 82. Kattegat, at Dokkedal, near the coast, abt. { 56° 54,5' N. / 10° 18' E.
April 1929. I-Gr.
From Fiskerikontrollør Jørgensen, Aalborg.

St. 83. Western Kattegat, mouth of the Randers Fjord. abt. { 56° 36,5' N. / 10° 23' E.
May 1928.
From Fiskeribetjent Skaaning, Randers.

St. 84. Kattegat, ½ mile south of Grenaa harbour, near the coast, abt. { 56° 24' N. / 10° 55,5' E.
18 November 1928. I-Gr.
From Fiskerikontrollør Jørgensen, Aalborg.

St. 85. Kattegat, south-east of Anholt, at Røde Banke N. of Store Middelgrund, abt. { 57° 09' N. / 12° 17' E.
Depth abt. 24 m. 28 March 1927.
From Bureauchef, Dr. K. A. Andersson, Stockholm.

St. 86. Kattegat, Lysekil between Hållö and Väderöarne, abt. { 58° 19' N. / 11° 10' E.
4 April 1917. *Long-lines.*
From Bureauchef, Dr. K. A. Andersson, Stockholm.

St. 87 a. Southern Kattegat, off the mouth of the Isefjord, abt. { 55° 57' N. / 11° 50' E.
27 June 1925.
From Fiskeribetjent Frederiksen, Lynæs.

St. 87 b. Southern Kattegat, the mouth of the Isefjord, W. of Lynæs harbour. abt. { 55° 57' N. / 11° 50' E.
Depth 4 m water. 1 May 1927. Eel seine.
From Fiskeribetjent Frederiksen, Lynæs.

St. 88. Kattegat, western part of Holbæk Fjord, abt. { 55° 43,5' N. / 11° 40,5' E.
Depth 1,5 m. 22 November 1928. Eel drift seine.
From Fiskerifoged N. S. Jensen, Holbæk.

St. 89. Belt Sea:
Horsens Fjord off Gyllingnæs, abt. { 55° 50' N. / 10° 09' E.
13 July 1925.
Horsens Fjord, north east side of Sælgrunden, abt. { 55° 51' N. / 10° 01' E.
20 April 1927.
Horsens Fjord, west side of Hjarnø, abt. { 55° 49' N. / 10° 04' E.
April 1927. Eel seine.
From Fiskerikontrollør Trolle Thomsen, Nyborg.

St. 90. Belt Sea, at Samsø, abt. { 55° 49' N. / 10° 39' E.
7 July 1925.
From Fiskerikontrollør Trolle Thomsen, Nyborg.

St. 91. Belt Sea, western part of Kalundborg Fjord, abt. { 55° 40' N. / 11° 03' E.
Depth 15 m. 9 December 1928. Purse seine. O-Gr.
From Fiskerikontrollør Trolle Thomsen, Nyborg.

St. 92. Great Belt, at Nyborg, abt. { 55° 21' N. / 10° 49' E.
May 1928.
From Fiskerikontrollør Trolle Thomsen, Nyborg.

St. 93. Smaalandshavet, Karrebæksminde, abt. { 55° 11' N. / 11° 37' E.
25 June 1925.
From Fiskeribetjent Bagger Jensen, Karrebæksminde.

St. 94. Belt Sea, off the west end of Lolland, 1—3 miles s. of Albu light house, abt. { 54° 48,5' N. / 10° 57' E.

16 November 1928. Eel stake nets. I-Gr.
From Fiskerikontrollør Trolle Thomsen, Nyborg.

St. 95. Little Belt:
Horne Bugt at Faaborg, abt. { 55° 05' N. / 10° 09' E.
25 June 1925.
North of Faaborg, abt. { 55° 05,5' N. / 10° 14' E.
20 August 1925. Stake nets.
From Fiskeribetjent Gerhardt, Svendborg.

St. 96. Little Belt, Aabenraa Fjord, abt. { 55° 02,5' N. / 9° 30' E.
1 May 1928.
From Fiskeriassistent Erichsen, Aabenraa.

St. 97. Kiel Fjord, abt. { 54° 25' N. / 10° 13' E.
January 1929.
From »Oberfischmeister-Amt«, Kiel.

St. 98. At Warnemünde, abt. { 54° 12' N. / 12° 00' E.
October 1928.
From Fischmeister Ebert, Wismar.

St. 99. Køge Bugt, off Bøgeskov Ladeplads, abt. { 55° 23' N. / 12° 25' E.
1—8 December 1926. Traps.
From Fiskerikontrollør Tr. Thomsen, Nyborg.

St. 100. At Klintholm, south coast of Møen, east of the harbour, abt. { 54° 57' N. / 12° 28' E.
Depth 3,5 m. 5 October 1928. Stake nets.
From Fiskerikontrollør Trolle Thomsen, Nyborg.

St. 101. East coast of Falster, at Hesnæs, north-west of Præstbjerg Reef, abt. { 54° 49' N. / 12° 9' E.
9 May 1928. Stake nets.
From Fiskeribetjent Chr. Larsen, Masnedsund.

St. 102. East coast of South Falster, between Gjedser Odde and Bötögaard, abt. { 54° 36' N. / 11° 59' E.
Depth 3—4 m. 24 October 1928.
From Fiskerikontrollør Trolle Thomsen, Nyborg.

St. 103. West coast of South Falster, between Kroghage and Stavreby, abt. { 54° 37' N. / 11° 54' E.
Depth 2,5 m. 24 October 1928.
From Fiskerikontrollør Trolle Thomsen, Nyborg.

St. 104. Eastern Baltic, at Nexø, Bornholm, abt. { 55° 04' N. / 15° 08' E.
December 1925 and 28 February 1928.
From Fiskeribetjent Christiansen, Rønne.

St. 105. Eastern Baltic, at Rønne, Bornholm, abt. { 55° 07' N. / 14° 43' E.
May 1928.
From Fiskeribetjent Christiansen, Rønne.

St. 106. Eastern Baltic, at Ystad, abt. { 55° 27' N. / 13° 50' E.
May 1928.
From Bureauchef, Dr. K. A. Andersson, Stockholm.

St. 107. Eastern Baltic, at Karlskrona, abt. { 56° 13' N. / 15° 35,5' E.
30 April 1928.
From Bureauchef, Dr. K. A. Andersson, Stockholm.

St. 108. Off Kolberg in Pommern, abt. { 54° 11' N. / 15° 35' E.
May 1928. Hooks.
From Dr. Kändler, Hamburg.

St. 109. At Neukuhren, East Prussia, abt. { 54° 58' N. / 20° 12' E.
July—October 1927.
From Dr. Lundbeck, Seefischereistation des Fischerei-Instituts der Universität Königsberg in Pr. Neukuhren.

St. 110. S. S. W. of Libau, 15 miles S. S. W. of Libau, abt. { 56° 27' N. / 21° 00' E.
Depth 30 m. 28 January 1928.
From Dr. V. Miezis, Riga.

St. 111. Near Stockholm, abt. { 58° 51' N. / 18° 07,5' E.
15 December 1923.
From Bureauchef, Dr. K. A. Andersson, Stockholm.

St. 112. Gulf of Finland, Lappvik-trakten at Hangö, abt. { 59° 51' N. 23° 00' E.
February 1928.
From Professor T. H. Järvi, Helsingfors.

St. 113. Gulf of Finland, at Lovisa, south of the islet Wâtskär, abt. { 60° 20' N. 26° 17' E.
31 March 1928.
From Professor T. H. Järvi, Helsingfors.

St. 114. Gulf of Bothnia, at Örnsköldsvik, Norrland, abt. { 63° 08' N. 18° 42' E.
5 March 1927.
From Bureauchef, Dr. K. A. Andersson, Stockholm.

X. Tables showing results of population analyses.

In the following tables the results of the population analyses are given.

The localities where the cod samples were taken are provided with serial numbers whereby their positions may easily be ascertained from the list in section IX, page 34, and by means of the chart, Pl. 1.

The tables give detailed information of the total number of vertebræ and the number of rays in the second dorsal fin, D_2. The figures in the extreme left hand column of each page, indicate the scale of variates. In respect of each sample, there will be found the total number of individuals examined (n), the average value of the counts made (a), the standard deviation (σ) and the fluctuation of average (Fl.). (Vide also: Racial Investigations, Comptes-rendus du Lab. Carlsb., Vol. 13, No. 3, 1917, page 360 and Vol. 14, No. 11, page 5).

With regard to the methods employed in counting, reference is made to previous papers on Racial Investigations at the Carlsberg Laboratorium. Staining with alizarine was employed in all cases where this method could further the execution of the investigation. The number of fused vertebræ was determined according to the number of neural and hæmal arches; a fusion of two vertebræ is not rare between the third and fourth vertebra from the end of tail (about the 47—55 vertebra); on the contrary there is rarely a fusion of three vertebrae and an alteration in the numerical position of the fusions of the vertebræ of the vertebral column is also rare. The vertebra which has fused with the greatly extended hæmal arch has been counted as the last vertebra. To make it possible to count the rays of the dorsal fin, specimens under abt. 30 cm. long were stained; the skin was carefully removed from one side of the fin. Clearing with glycerine or xylol was used in counting of all small individuals.

No. of vertebræ	East coast of U. S. A.				Atlantic coast of Canada								W. Greenland			
	1	2			3	4	5	6	7	8	10	11	12			13
	Nantucket Shoals	Gulf of Maine			Bay of Fundy	Nova Scotia	Cape Breton Island	Gulf of St. Lawrence	Port aux Basques	St. John's	Flower Cove St. Barbe Harbour	Labrador	Sukkertoppen			Julianehaab
		1926	1927	Total									1924	1925	1927	1928
57										5	11	10				
56					2	5	2		3	13	50	19			2	
55	1	14	3	17	27	32	14	13	13	24	52	22	6	4	30	7
54	10	17	9	26	28	41	33	39	22	17	14	7	59	60	100	85
53	40	5	6	11	14	15	19	45	11	6		6	69	70	40	92
52	19	3	1	4			3	4					5	11	11	16
51							1	1								
50																
n	70	39	19	58	71	93	72	102	49	65	127	64	139	145	183	200
a	**52.90**	**54.08**	**53.74**	**53.97**	**54.24**	**54.29**	**53.86**	**53.58**	**54.16**	**54.91**	**55.46**	**55.31**	**53.47**	**53.39**	**53.85**	**53.42**
σ	± 0.63	± 0.90	± 0.81	± 0.88	± 0.80	± 0.80	± 0.92	± 0.80	± 0.85	± 1.07	± 0.80	± 1.15	± 0.64	± 0.67	± 0.80	± 0.69
Fl.	± 0.28	± 0.49	± 0.62	± 0.39	± 0.32	± 0.28	± 0.37	± 0.27	± 0.41	± 0.45	± 0.24	± 0.49	± 0.18	± 0.19	± 0.20	± 0.17
No. of rays (D 2)																
25										1	1					
24		1		1						—	3	1	1		14	
23	1	1	2	3	3	3	2	3		3	11	4	2	5	13	3
22	6	8	3	11	5	9	2	8	7	11	30	8	13	11	38	17
21	7	6	4	10	19	19	11	23	12	17	33	20	30	31	33	47
20	24	13	3	16	20	26	25	28	10	20	29	16	40	48	50	65
19	25	8	5	13	11	19	24	30	14	9	18	14	34	30	21	48
18	6	—	1	1	10	12	9	8	6	6	5	2	10	22	9	16
17	1	2		2	2	5		2			1		3	2	1	3
16															1	
15																
14																
n	70	39	18	57	70	93	73	102	49	67	131	65	133	149	180	199
a	**19.74**	**20.38**	**20.50**	**20.42**	**20.01**	**19.87**	**19.71**	**19.96**	**20.00**	**20.48**	**20.86**	**20.52**	**20.02**	**19.92**	**20.88**	**20.01**
σ	± 1.16	± 1.48	± 1.50	± 1.48	± 1.40	± 1.45	± 1.12	± 1.27	± 1.27	± 1.41	± 1.46	± 1.30	± 1.28	± 1.31	± 1.62	± 1.12
Fl.	± 0.47	± 0.79	± 1.20	± 0.66	± 0.56	± 0.51	± 0.45	± 0.42	± 0.61	± 0.58	± 0.43	± 0.54	± 0.37	± 0.36	± 0.41	± 0.29

No. of vertebræ	W. Gr.	E. Greenland		Iceland										
	13a	14		15	16	17	18	19	20	21			22	23
	Lichtenau	Angmagssalik		West of Portland	Off Landeyjasandur	Between Vestmannaeyar and Reykjanes	Faxe Bay	Isafjord	Djupallsrif	Skialfandi			Hjeradsfloi	Gletting-ganes-grunn
	1919	1926	1927							1925	1927	Total		
57														
56														
55	9									3		3	3	1
54	58	13	44	5	11	8	5	6	23	45	9	54	71	47
53	119	11	85	23	46	23	69	82	69	104	59	163	113	97
52	35	1	27	18	27	21	131	59	28	34	29	63	18	18
51	1		2	3	1		16	2		1	3	4		2
50														
n	222	25	158	49	85	52	221	149	120	187	100	287	205	165
a	**53.18**	**53.48**	**53.08**	**52.61**	**52.79**	**52.75**	**52.29**	**52.62**	**52.96**	**53.08**	**52.74**	**52.96**	**53.29**	**53.16**
σ	± 0.75	± 0.59	± 0.70	± 0.76	± 0.67	± 0.71	± 0.63	± 0.59	± 0.65	± 0.71	± 0.66	± 0.71	± 0.64	± 0.67
Fl.	± 0.17	± 0.40	± 0.19	± 0.36	± 0.25	± 0.33	± 0.14	± 0.16	± 0.20	± 0.18	± 0.22	± 0.14	± 0.15	± 0.18
No. of rays (D 2)														
25	1													
24	3		1						1	2		2		3
23	12		1		1		1	1	2	2	1	3	2	4
22	40	1	14	2	8	4	11	3	2	11	5	16	15	13
21	44	8	36	7	16	9	31	16	28	45	17	62	48	38
20	61	12	61	21	27	19	71	44	45	50	33	83	65	64
19	46	3	34	16	21	13	56	47	32	41	37	78	49	65
18	14	—	11	4	10	5	38	27	12	26	21	47	24	16
17	4	1	4		2	4	10	12	4	7	7	14	7	7
16	1							1					1	
15														
14														
n	226	25	162	50	85	54	218	151	126	184	121	305	211	210
a	**20.38**	**20.16**	**20.02**	**19.74**	**19.86**	**19.67**	**19.51**	**19.23**	**19.79**	**19.82**	**19.42**	**19.66**	**19.82**	**19.86**
σ	± 1.50	± 0.99	± 1.20	± 0.94	± 1.20	± 1.29	± 1.23	± 1.23	± 1.20	± 1.37	± 1.26	± 1.34	± 1.28	± 1.32
Fl.	± 0.35	± 0.66	± 0.32	± 0.45	± 0.46	± 0.59	± 0.28	± 0.34	± 0.36	± 0.34	± 0.38	± 0.26	± 0.30	± 0.31

No. of vertebræ	Iceland														
	24 Seydisfjord									25 Nord-fjord	26 Lons-vik	27 Off Horna-fjord	28 Hvals-baki	29 South east of Ingolfs-höfdi	30 Ingolfs-höfdi
	1924	1924	1925	1926	1926	1927	1927	1927	Total						
57															
56															
55			4	2					6	3	1	3	1		
54	5	23	81	18	15	14	2	3	161	32	11	63	27	15	22
53	67	85	212	127	61	49	8	4	613	102	51	231	35	34	82
52	48	66	50	42	26	43	6	2	283	62	18	80	10	23	30
51	4	3	2	2	3	4			18	10		3		2	
50															
n	124	177	349	191	105	110	16	9	1081	209	81	380	73	74	134
a	**52.59**	**52.72**	**53.10**	**52.87**	**52.84**	**52.66**	**52.75**	**53.11**	**52.865**	**52.79**	**52.94**	**52.96**	**53.26**	**52.84**	**52.94**
σ	± 0.63	± 0.70	± 0.66	± 0.62	± 0.70	± 0.75	± 0.68	± 0.78	± 0.694	± 0.81	± 0.64	± 0.66	± 0.71	± 0.78	± 0.62
Fl.	± 0.19	± 0.18	± 0.12	± 0.15	± 0.23	± 0.24	± 0.58	± 0.88	± 0.071	± 0.19	± 0.24	± 0.11	± 0.28	± 0.30	± 0.18
No. of rays (D a)															
25															
24										1					
23	2	4	4	1	1				12	3		1	2	4	
22	7	18	14	10	5	6			60	22	4	27	7	9	6
21	13	30	51	23	13	21			151	50	11	58	12	13	14
20	43	53	103	49	26	38			312	47	34	119	25	21	35
19	33	53	109	56	39	25			315	55	21	101	17	18	43
18	23	17	50	44	14	18			166	20	11	47	8	5	29
17	4	4	13	13	7	1			42	9	4	13	1	4	5
16			1	2					3			2			1
15				1					1						
14															
n	125	179	345	199	105	109	—	—	1062	207	85	368	72	74	133
a	**19.54**	**19.88**	**19.53**	**19.25**	**19.41**	**19.72**			**19.545**	**19.93**	**19.58**	**19.65**	**19.94**	**20.04**	**19.29**
σ	± 1.25	± 1.28	± 1.22	± 1.36	± 1.25	± 1.15			± 1.269	1.39	± 1.16	± 1.25	± 1.28	± 1.48	± 1.20
Fl.	± 0.38	± 0.32	± 0.22	± 0.32	± 0.41	± 0.37			± 0.131	0.32	± 0.42	± 0.22	± 0.51	± 0.58	± 0.35

No. of vertebræ	Faroe Islands													
	31 Faroe Bank	**32** S. W. of Suderø	**33** Husagrynna	**34** Vaag Fjord 1924	1925	1925	1925	1926	1926	1927	1927	Total	**35** Trangisvaag Fjord	**36** Vestmanhavn
57														
56														
55							1					1		
54	2	4	5				2	2		3	5	12		
53	8	49	29	8	6	26	37	54	55	81	47	314	1	7
52	70	66	38	41	13	67	83	97	96	132	101	630	6	21
51	40	8	7	8		8	9	6	11	23	16	81	3	2
50														
n	120	127	79	57	19	101	132	159	162	239	169	1038	10	30
a	**51.77**	**52.39**	**52.41**	**52.00**	**52.32**	**52.18**	**52.27**	**52.33**	**52.27**	**52.27**	**52.24**	**52.250**	**51.80**	**52.17**
σ	± 0.64	± 0.66	± 0.74	± 0.53	± 0.48	± 0.55	± 0.64	± 0.57	± 0.58	± 0.64	± 0.66	± 0.611	± 0.63	± 0.53
Fl.	± 0.20	± 0.20	± 0.28	± 0.24	± 0.37	± 0.18	± 0.19	± 0.15	± 0.15	± 0.14	± 0.17	± 0.064	± 0.67	± 0.32
No. of rays (D 2)														
25														
24								1			1	2		
23		2	1			1	2	—	1	4	1	9		
22		5	3	3	1	5	6	7	10	7	9	48		
21	9	20	14	6	3	18	9	18	32	44	32	162	2	6
20	17	44	29	20	5	35	40	49	53	77	49	328	3	6
19	45	45	24	18	6	24	32	50	43	66	48	287	2	10
18	36	19	6	6	3	14	25	33	16	36	26	159	3	6
17	13	4	2	2	1	4	5	4	2	3	1	22		1
16	—		1				1	2	1	3		7		
15	1													
14														
n	121	140	80	55	19	101	120	164	158	240	167	1014	10	29
a	**18.74**	**19.57**	**19.71**	**19.56**	**19.47**	**19.67**	**19.38**	**19.39**	**19.81**	**19.63**	**19.72**	**19.600**	**19.40**	**19.34**
σ	± 1.11	± 1.17	± 1.18	± 1.12	± 1.26	± 1.23	± 1.29	± 1.24	± 1.17	± 1.23	± 1.21	± 1.232	± 1.17	± 1.14
Fl.	± 0.34	± 0.33	± 0.45	± 0.51	± 0.98	± 0.41	± 0.40	± 0.33	± 0.31	± 0.27	± 0.31	± 0.131	± 1.25	± 0.73

No. of vertebræ	Faroe Islands								West of Scotland	West coast of England and Scotland					Norwegian Sea
	37 Sandegærde				38 Kolle-fjord	39 Fugle-fjord	40 North of Viderø	41 North of Fuglø	42 The Rockall area	43 Morecambe Bay, Liverpool Bay			44 Kil-brennan Sound	45 Broad Bay	46-47-48 Barents-Sea
	1924	1925	1926	Total						1925	1926	Total			
57															
56															
55															10
54	6	1	3	10	1		5	5		1		1			34
53	195	7	77	279	17	37	39	109	3	5	6	11	4	26	22
52	386	28	108	522	41	127	50	124	40	48	66	114	44	185	
51	37	6	8	51	8	18	2	16	45	23	39	62	25	61	
50									3	3	2	5	2		
n	624	42	196	862	67	182	96	254	91	80	113	193	75	272	66
a	**52.27**	**52.07**	**52.38**	**52.288**	**52.16**	**52.10**	**52.49**	**52.41**	**51.47**	**51.72**	**51.67**	**51.69**	**51.67**	**51.37**	**53.82**
σ	± 0.58	± 0.64	± 0.59	± 0.589	± 0.64	± 0.54	± 0.63	± 0.64	± 0.62	± 0.69	± 0.60	± 0.64	± 0.62	± 0.55	± 0.68
Fl.	± 0.08	± 0.33	± 0.14	± 0.068	± 0.26	± 0.13	± 0.22	± 0.13	± 0.22	± 0.26	± 0.19	± 0.16	± 0.24	± 0.11	± 0.28
No. of rays (D a)															
25															
24															
23			1	1		1		2							1
22		1	11	12	2	8		17	1	1	2	3		4	6
21		6	43	49	14	20	11	33	13	9	6	15	8	31	12
20		13	52	65	20	51	31	72	32	20	19	39	13	71	21
19		11	61	72	21	59	30	82	28	23	41	64	30	88	17
18		7	27	34	9	36	17	42	17	17	30	47	19	68	9
17		3	2	5	2	11	3	6	1	13	7	20	8	17	1
16		1		1			2				2	2	1	2	
15															
14															
n	—	42	197	239	68	186	94	254	92	83	107	190	79	281	67
a		**19.29**	**19.73**	**19.65**	**19.60**	**19.33**	**19.25**	**19.56**	**19.46**	**18.98**	**18.88**	**18.92**	**18.89**	**19.13**	**19.84**
σ		± 1.31	± 1.17	± 1.21	± 1.13	± 1.23	± 1.12	± 1.22	± 1.02	± 1.28	± 1.13	± 1.19	± 1.15	± 1.17	± 1.26
Fl.		± 0.58	± 0.28	± 0.26	± 0.47	± 0.30	± 0.39	± 0.26	± 0.36	± 0.47	± 0.37	± 0.29	± 0.44	± 0.23	± 0.52

No. of vertebræ	West coast of Norway									North Sea (western)					
	49 Finmark Sea	**50** Tromsø	**51** Tromsø Sound	**52** Lofoten	**53** Trond-hjemsfjord, innermost part	**54** Trond-hjemsfjord, near Biol. St.	**55** Veiholmen Nordmør	**56** Bergen	**57** Hauge-sund	**58** Inganess Bay	**59** Firth of Forth	**60** 35 miles N. N. E. of Lowestoft	**61** Inner Herring trawling ground 1925	1925	Total
57															
56															
55	5			15		1	7								
54	33	18	44	75		9	47	7	7			3			
53	34	38	96	52	29	30	24	83	34	28	27	20	23	14	37
52	9	18	48	6	29	51	1	94	45	127	51	54	50	47	97
51		2	1		3	9		13	7	44	5	16	12	19	31
50					2	1				1	1	1			
n	81	76	189	148	63	101	79	197	93	200	84	94	85	80	165
a	**53.42**	**52.95**	**52.97**	**53.67**	**52.35**	**52.40**	**53.76**	**52.43**	**52.44**	**51.91**	**52.24**	**52.09**	**52.13**	**51.94**	**52.04**
σ	± 0.77	± 0.76	± 0.71	± 0.71	± 0.72	± 0.85	± 0.62	± 0.67	± 0.74	± 0.61	± 0.61	± 0.74	± 0.63	± 0.64	± 0.64
Fl.	± 0.29	± 0.30	± 0.18	± 0.20	± 0.31	± 0.30	± 0.24	± 0.16	± 0.26	± 0.15	± 0.23	± 0.26	± 0.23	± 0.24	± 0.17
No. of rays (D 2)															
25															
24															
23		2	2	3			1		2			1			
22	5	4	17	12	1	7	12		2	3	1	1	4	4	8
21	16	14	37	31	4	11	16		17	21	8	7	15	10	25
20	24	18	38	37	20	18	24		27	52	22	22	25	21	46
19	21	24	64	37	26	39	20		27	65	27	26	29	28	57
18	16	12	30	22	8	22	5		17	40	20	29	11	14	25
17	2	1	7	4	4	4	1		3	14	4	8	2	5	7
16		—				1				1		2			
15		1													
14															
n	84	76	195	146	63	102	79		95	196	82	95	86	82	168
a	**19.61**	**19.63**	**19.65**	**19.80**	**19.24**	**19.27**	**20.13**		**19.55**	**19.16**	**19.16**	**18.92**	**19.60**	**19.35**	**19.48**
σ	± 1.23	± 1.38	± 1.34	± 1.34	± 1.03	± 1.28	± 1.24		± 1.24	± 1.16	± 1.09	± 1.27	± 1.13	± 1.22	± 1.18
Fl.	± 0.45	± 0.54	± 0.32	± 0.37	± 0.44	± 0.42	± 0.47		± 0.43	± 0.28	± 0.42	± 0.44	± 0.41	± 0.46	± 0.31

No. of vertebræ	North Sea (eastern)								Skagerak		Limfjord				
	62 Helder			63 Heligo-land	64 South of Horn Reef			65 West of Thyborøn	66 Off Tremøen	67 Drammen fiord	68 Nissum Bredning	69 Venø Sound	70 Venø Sound	71 Vildsund and Thisted Bredning	72 Thisted Bredning
	Okt. 1928	Nov. 1928	Total		1925	1925	Total								
57														1	
56															
55															
54				4		1	1		2	1	2	1	4	2	1
53	20	9	29	67	40	23	63	35	6	24	46	59	58	30	19
52	44	14	58	121	95	32	127	90	10	56	123	123	123	104	43
51	3	6	9	12	7	2	9	24	6	16	37	39	38	45	8
50		1	1	1				1			1	2	2	5	1
n	67	30	97	205	142	58	200	150	24	97	209	224	225	187	72
a	**52.25**	**52.03**	**52.19**	**52.30**	**52.23**	**52.40**	**52.28**	**52.06**	**52.17**	**52.10**	**52.05**	**52.08**	**52.01**	**51.90**	**52.15**
σ	± 0.53	± 0.81	± 0.63	± 0.63	± 0.53	± 0.59	± 0.55	± 0.65	± 0.92	± 0.67	± 0.67	± 0.70	± 0.73	± 0.77	± 0.68
Fl.	± 0.22	± 0.50	± 0.22	± 0.15	± 0.15	± 0.26	± 0.13	± 0.18	± 0.63	± 0.23	± 0.16	± 0.16	± 0.17	± 0.19	± 0.27
No. of rays (D 2)															
25															
24															
23											2				1
22				5	2		2	9	1	4	3	1	4	1	—
21	2	3	5	24	20	3	23	19	2	5	11	25	23	7	2
20	11	6	17	42	34	14	48	48	9	34	43	51	43	36	8
19	16	2	18	58	50	14	64	45	7	33	65	74	52	45	22
18	20	8	28	52	22	18	40	21	3	18	53	46	58	55	27
17	12	6	18	19	17	6	23	7	1	5	25	19	37	33	12
16	8	5	13	7	1	1	2	1	1	1	6	8	10	15	1
15	2		2											1	
14															
n	71	30	101	207	146	56	202	150	24	100	208	224	227	193	73
a	**18.14**	**18.23**	**18.17**	**18.97**	**19.14**	**18.77**	**19.01**	**19.50**	**19.33**	**19.25**	**18.81**	**18.96**	**18.73**	**18.39**	**18.48**
σ	± 1.41	± 1.63	± 1.47	± 1.35	± 1.25	± 1.16	± 1.24	± 1.23	± 1.31	± 1.15	± 1.33	± 1.26	± 1.41	± 1.33	± 1.16
Fl.	± 0.56	± 1.01	± 0.49	± 0.32	± 0.35	± 0.52	± 0.29	± 0.34	± 0.90	± 0.39	± 0.31	± 0.28	± 0.32	± 0.32	± 0.46

No. of vertebræ	Limfjord						Cattegat							
	73 Live Bredning	**74** Live Bredning	**75** Løgstør Bredning	**76** Hanerslev Bredning	**77** Bredhage and Storvorde	**78** Strander-holm	**79** North of Frederiks-havn	**80** Frederiks-havn	**81** Between Hals and Jyngerhuse	**82** Dokke-dal	**83** Off Randers Fjord	**84** South of Grenaa harbour	**85** S. E. of Anholt	**86** Lysekil
57														
56														
55														
54	5	1	3	1			8	3		8	2	3	6	5
53	55	42	49	39	23	67	64	42	12	79	62	41	38	36
52	100	86	85	154	71	136	64	74	37	128	98	85	53	48
51	36	39	29	74	24	31	13	21	11	46	24	29	5	6
50	1	3	8	10	1	1	1			1	1	1	1	
n	197	171	174	278	119	235	150	140	60	262	187	159	103	95
a	**52.14**	**51.99**	**52.06**	**51.81**	**51.97**	**52.14**	**52.43**	**52.19**	**52.02**	**52.18**	**52.21**	**52.10**	**52.42**	**52.42**
σ	± 0.75	± 0.76	± 0.84	± 0.73	± 0.66	± 0.63	± 0.75	± 0.71	± 0.62	± 0.76	± 0.69	± 0.73	± 0.72	± 0.69
Fl.	± 0.18	± 0.20	± 0.21	± 0.15	± 0.20	± 0.13	± 0.21	± 0.20	± 0.27	± 0.16	± 0.17	± 0.20	± 0.24	± 0.24
No. of rays (D 2)														
25														
24														
23	1		1							1				
22	1	3	—	2		3	1	1		1	3	2		1
21	5	11	9	12	7	10	5	7	7	14	10	12	5	16
20	32	23	34	39	20	39	21	26	15	34	29	26	19	22
19	67	45	48	77	36	56	43	34	14	62	64	55	32	33
18	54	53	50	77	44	78	41	43	15	81	54	37	30	19
17	30	22	34	51	10	42	35	23	7	53	26	18	15	6
16	11	15	7	20	3	8	4	5	2	15	3	8	2	1
15		2	2	5		1		1		1		1		
14				1		1								
n	201	174	185	284	120	238	150	140	60	262	189	159	103	98
a	**18.51**	**18.45**	**18.51**	**18.31**	**18.68**	**18.47**	**18.41**	**18.54**	**18.90**	**18.36**	**18.70**	**18.72**	**18.64**	**19.23**
σ	± 1.23	± 1.42	± 1.32	± 1.38	± 1.11	± 1.29	± 1.20	± 1.28	± 1.32	± 1.32	± 1.18	± 1.32	± 1.14	± 1.21
Fl.	± 0.29	± 0.36	± 0.33	± 0.28	± 0.34	± 0.28	± 0.33	± 0.36	± 0.58	± 0.27	± 0.29	± 0.35	± 0.38	± 0.41

No. of vertebræ	Cattegat				Samsø Sea				Great Belt				Little Belt		
	87 a	87 b	87 a & b	88	89			90	91	92	93	94	95		
		Isefjord		Holbæk Fjord	Horsens Fjord			Samsø	Kalundborg Fjord	Nyborg	Karrebæksminde	West of Lolland	Faaborg		
	1925	1927	Total		1925	1927	Total						1925	1925	Total
57															
56															
55													1		1
54	22	3	25	3	6	3	9	2	1	3	3	1	16	4	20
53	140	67	207	44	44	57	101	25	68	66	40	29	68	71	139
52	210	81	291	96	103	118	221	51	113	95	80	74	155	160	315
51	60	20	80	26	29	24	53	17	35	22	12	17	48	36	84
50				4	2		2	1	1	2	1				
n	432	171	603	173	184	202	386	96	218	188	136	121	288	271	559
a	**52.29**	**52.31**	**52.29**	**52.09**	**52.13**	**52.19**	**52.16**	**52.10**	**52.15**	**52.24**	**52.24**	**52.12**	**52.19**	**52.16**	**52.18**
σ	± 0.77	± 0.70	± 0.75	± 0.75	± 0.75	± 0.65	± 0.70	± 0.75	± 0.70	± 0.72	± 0.67	± 0.64	± 0.79	± 0.66	± 0.73
Fl.	± 0.12	± 0.18	± 0.10	± 0.19	± 0.18	± 0.16	± 0.12	± 0.26	± 0.16	± 0.18	± 0.19	± 0.20	± 0.15	± 0.13	± 0.10
No. of rays (D 2)															
25															
24		1	1												
23		--	--												
22		4	4	1	3	4	7	2	1	2	1	1	4	3	7
21	3	9	12	9	5	10	15	8	7	15	6	6	8	13	21
20	33	33	66	21	25	30	55	13	26	28	16	15	38	33	71
19	90	61	151	47	55	69	124	23	52	53	39	35	89	81	170
18	148	54	202	47	61	60	121	25	68	58	39	30	79	75	154
17	99	19	118	35	31	19	50	21	47	27	32	23	51	52	103
16	45	4	49	15	4	9	13	4	14	4	4	8	14	12	26
15	14		14	2		1	1		2	1	1	2	5	2	7
14															
n	432	185	617	177	184	202	386	96	217	188	138	120	288	271	559
a	**17.85**	**18.81**	**18.13**	**18.28**	**18.51**	**18.67**	**18.59**	**18.54**	**18.22**	**18.66**	**18.36**	**18.35**	**18.39**	**18.43**	**18.41**
σ	± 1.22	± 1.25	± 1.31	± 1.36	± 1.16	± 1.26	± 1.21	± 1.41	± 1.26	± 1.27	± 1.24	± 1.37	± 1.30	± 1.29	± 1.29
Fl.	± 0.20	± 0.31	± 0.18	± 0.35	± 0.29	± 0.30	± 0.21	± 0.15	± 0.29	± 0.31	± 0.36	± 0.42	± 0.26	± 0.26	± 0.19

No. of vertebræ	Little Belt	Western Baltic		Eastern Baltic												
	96	97	98	99	100	101	102	103	102 + 103	104			105	106	107
	Aabenraa Fjord	Kiel Fjord	Warnemünde	Køge Bugt	Klintholm	Hesnæs	East coast of South Falster	West coast of South Falster	Total	Nexø, Bornholm 1925	1928	Total	Rønne, Bornholm	Ystad	Karlskrona
57															
56															
55										1	1	2			
54	4	5		5	2	1	1		1	4	23	27	12	4	15
53	64	44	44	64	53	22	38	15	53	42	84	126	78	44	60
52	116	113	62	101	100	41	84	28	112	44	78	122	96	59	42
51	29	30	25	25	38	9	23	8	31	5	8	13	8	13	3
50	2	2	1	1	1		1		1						
n	215	194	132	196	194	73	147	51	198	96	194	290	194	120	120
a	**52.18**	**52.10**	**52.13**	**52.24**	**52.09**	**52.21**	**52.10**	**52.14**	**52.11**	**52.50**	**52.64**	**52.60**	**52.48**	**52.33**	**52.73**
σ	± 0.72	± 0.72	± 0.74	± 0.72	± 0.73	± 0.67	± 0.68	± 0.66	± 0.67	± 0.71	± 0.76	± 0.75	± 0.68	± 0.70	± 0.71
Fl.	± 0.17	± 0.18	± 0.22	± 0.18	± 0.18	± 0.26	± 0.19	± 0.31	± 0.16	± 0.25	± 0.19	± 0.15	± 0.17	± 0.22	± 0.22
No. of rays (D a)															
25															
24				1											
23	1			—											
22	3		2	4	2		1		1	1		1	2		
21	12	14	7	12	13	4	7	1	8	2		2	2	10	4
20	35	36	21	34	26	23	30	6	36	10	12	22	13	16	8
19	69	48	43	60	66	21	42	11	53	23	37	60	32	27	25
18	66	62	33	56	50	14	39	21	60	26	64	90	54	26	40
17	24	30	21	22	29	11	24	8	32	24	65	89	58	28	30
16	5	5	5	8	9	3	8	4	12	11	18	29	29	17	15
15		1	1		1	1				3	7	10	4	2	1
14													1		
n	215	196	133	197	196	77	151	51	202	100	203	303	195	126	124
a	**18.73**	**18.61**	**18.60**	**18.75**	**18.59**	**18.77**	**18.58**	**18.20**	**18.48**	**17.98**	**17.70**	**17.79**	**17.69**	**18.17**	**17.92**
σ	± 1.22	± 1.25	± 1.30	± 1.33	± 1.29	± 1.34	± 1.28	± 1.15	± 1.26	± 1.39	± 1.15	± 1.24	± 1.33	± 1.53	± 1.25
Fl.	± 0.28	± 0.30	± 0.38	± 0.32	± 0.31	± 0.51	± 0.35	± 0.54	± 0.30	± 0.47	± 0.27	± 0.24	± 0.32	± 0.46	± 0.38

No. of vertebræ	Eastern Baltic						Gulf of Bothnia		
	108	109			110	111	112	113	114
	Off Kolberg	Neukuhren, East Prussia			S. S. W. of Libau	Stockholm	Hangö	Lovisa	Örnsköldsvik
		29/7 1927	4/10 1927	Total					
57									
56					1				
55	1	3	1	4	6	2		8	2
54	7	16	8	24	35	13	6	42	20
53	55	24	37	61	36	43	13	63	55
52	50	6	19	25	17	27		11	20
51	8		5	5	2	10		1	1
50									
n	121	49	70	119	97	95	19	125	98
a	**52.53**			**52.97**	**53.27**	**52.68**	**53.32**	**53.36**	**53.02**
σ	± 0.74			± 0.85	± 0.90	± 0.91	± 0.48	± 0.77	± 0.73
Fl.	± 0.23			± 0.26	± 0.31	± 0.32	± 0.37	± 0.23	± 0.25
No. of rays (D a)									
25									
24									
23									
22					1				
21	1	1		1	1	1		1	1
20	5	—	1	1	6	4	1	3	8
19	27	5	9	14	9	13	3	24	12
18	32	13	27	40	29	29	7	51	31
17	42	18	22	40	33	27	6	33	29
16	13	10	11	21	11	20	1	13	15
15	5	4	3	7	7	5	1	4	3
14		2	1	3	2			1	
n	125	53	74	127	99	99	19	130	99
a	**17.66**			**17.24**	**17.43**	**17.41**	**17.68**	**17.68**	**17.63**
σ	± 1.21			± 1.23	± 1.42	± 1.26	± 1.16	± 1.14	± 1.26
Fl.	± 0.36			± 0.37	± 0.48	± 0.43	± 0.28	± 0.34	± 0.42

XI. The Herring (*Clupea harengus* L.). Average nos. of vertebræ.

By Cand. mag. Aa. Strubberg.

Locality	Date	Nos.	Vert.	V or S[1]	Publication	Investigator
Iceland.						
Off Eyja Fjord, N. Iceland	Sept. 1915	192	57.36	V	K. Medd. V	A. C. Johansen
Off Eyja Fjord, N. Iceland	12. Sept. 1924	49	57.49	V	Rap. Pr. V. 39	A. C. Johansen
At Malmey, N. Iceland	22. July 1924	143	57.48	V	Rap. Pr. V. 39	A. C. Johansen
Selvogs Bank, S. W. Iceland ...	Feb., Mar., April 1924	84	57.49	V	Rap. Pr. V. 39	A. C. Johansen
Off Eyja Fjord, N. Iceland	12. Sept. 1924	47	56.98	S	Rap. Pr. V. 39	A. C. Johansen
Køgur Huk, N. W. Iceland	6. Sept. 1924	36	57.08	S	Rap. Pr. V. 39	A. C. Johansen
Eldey Bank, S. W. Iceland	May 1919	297	57.07	S	K. Medd. VI	A. C. Johansen
Drangar (near the Westmanna Isles), S. Iceland	14. Aug. 1919	180	57.01	S	K. Medd. VI	A. C. Johansen
The Faroes.						
At Kongshavn	10. Sept. 1915	207	57.47	V	K. Medd. V	A. C. Johansen
At Kongshavn	Apr. 1920	160	57.33	V	K. Medd. VI	A. C. Johansen
At Kongshavn	16. Aug. 1919	124	56.90	?[2]	K. Medd. VI	A. C. Johansen
West of Scotland.						
12 miles west of Cap Wrath, N. W. Scotland.....	5. Mar. 1923	270	57.13	V	K. Medd. VII	A. C. Johansen
At Barra, The Hebrides	7. July 1891	30	56.97	V	Abh. D. S. V.	Fr. Heincke
Ballantrae Bank, S. W. Scotland	Febr. 1892	30	56.80	V	Abh. D. S. V.	Fr. Heincke
Stornoway.....	Jan. 1926	58	56.78	V	D. W. K. N. F. III/2	Schnakenbeck
Klondyke Gr., Malinhead, N. of Ireland.....	Aug. 1925	49	56.86	S	D. W. K. N. F. III/2	Schnakenbeck
Tarbert, Loch Fyne, W. Scotland	Dec. 1925	85	56.96	?	D. W. K. N. F. III/2	Schnakenbeck
West of England.						
The Smalls.....	(Aug.-Oct. 1925) (July-Nov. 1926)	1372	56.88	V	J. M. B. A. 1928	E. Ford
S. E. of Ireland	Apr.-July 1926	760	56.76	V	J. M. B. A. 1928	E. Ford
Padstow	Nov.-Dec. 1925 & 26	1367	56.75	V	J. M. B. A. 1928	E. Ford

[1]) V = winter- or spring spawners.
S = summer- or autumn spawners.

[2]) Probably S.

Locality	Date	Nos.	Vert.	V or S	Publication	Investigator
White Sea.						
Kandalaksha Bay	2. Oct. 1925	326	57.18	?	W.M.D.K.XV	Awerinzew
Kandalaksha	14. Apr. 1924	366	53.76	V	W.M.D.K.XV	Awerinzew
Onega Gulf	28. Mar. 1925	102	53.14	V	W.M.D.K.XV	Awerinzew
Archangel Bay	10. Jan. 1925	810	53.35	V	W.M.D.K.XV	Awerinzew
Norwegian Sea. **West coast of Norway.**						
Traena Bank and Traena Deep (abt. 66°—67° N. Lat.)	Sept., Nov. 1905	143	57.36	V	Berg. M. Aarb.	H. Brock
Sklinna Bank and Sklinna Deep (abt. 65° – 66° N. Lat.)	Sept.-Nov. 1905	30	57.37	V	Berg. M. Aarb.	H. Brock
Halten Bank and Halten Deep	Sept., Oct. 1905	20	57.45	V	Berg. M. Aarb.	H. Brock
Beistadfjord, at the innermost part of Trondhjemsfjord	Apr. 1905	100	56.55	V	Berg. M. Aarb.	H. Brock
Aalesund (abt. 62° 30′ N. Lat.)	Jan. 1905	100	57.55	V	Berg. M. Aarb.	H. Brock
		100	57.46	V		
S. W. coast of Norway.						
Solsvik (abt. 60° 30′ N. Lat.)	15. Feb. 1905	30	57.43	V	Berg. M. Aarb.	H. Brock
Haugesund (abt. 59° 25′ N. Lat.)	Mar. 1905	70	57.67	V	Berg. M. Aarb.	H. Brock
	Mar. 1906	100	57.60	V	Berg. M. Aarb.	H. Brock
		170	57.63			
Utsire (abt. 59° 20′ N. Lat.)	Feb. 1888	52	57.52	V	Abh. D. S. V.	Fr. Heincke
The North Sea.						
9 miles N. of Flugga (Shetland)	21. Mar. 1923	300	57.07	V	K. Medd. VII	A. C. Johansen
Abt. 61° 51′ N. — 0° 45′ E.	13. Sept. 1904	32	56.94	S	Berg. M. Aarb.	H. Broch
Viking Bank	Oct., Nov. 1904 / Aug.-Oct. 1905	128	57.24	V	Berg. M. Aarb.	H. Broch
Abt. 60° – 62° N. Lat. — 1° – 3° E. Lang.	Sept-Nov 1904 / Sept-Oct. 1905	135	56.73	S	Berg. M. Aarb.	H. Broch
Abt. 60° 37,5′ N. — 0° 41′ E.	23. June 1906	50	56.70	S	R. en V.R.V.I.	Redeke
20 miles S. E. of Balta Sound (abt. 60° 35′ N. — 0° 13′ W.)	1. Sept. 1921	363	56.50	S	K. Medd. VII	A. C. Johansen
Abt. 59° 14′ N. — 0° 38′ W.	10. Sept. 1904	29	56.52	S	Berg. M. Aarb.	H. Broch
At Fair Isle	June 1887	75	56.45	S	Abh. D. S. V.	Fr. Heincke
Moray Firth	June 1906	50	56.56	S	R. en V.R.V.I.	Redeke
Abt. 56° 08′ N. — 0° 05′ E.	Sept. 1904	31	56.45	S	Berg. M. Aarb.	H. Broch
Firth of Forth	Jan. 1892	30	56.83	V	Abh. D. S. V.	Fr. Heincke
Abt. 56° 16′ N. — 5° 16′ E.	5. Sept. 1904	31	56.32	S	Berg. M. Aarb.	H. Broch
Abt. 57° 20′ N. — 7° 56′ E.	12. Sept. 1889	29	56.55	S	Abh. D. S. V.	Fr. Heincke

Locality	Date	Nos.	Vert.	V or S	Publication	Investigator
Off Thyborøn	16. July 1918	200	56. 40		K. Medd. VII	A. C. Johansen
Abt. 55° 20'. N.—7° 20' E.	19. Sept. 1922	65	56. 32	S	K. Medd. VII	A. C. Johansen
Abt. 55° 23' N.—8° 12' E.	30. Nov. 1922	50	56. 40	S	K. Medd. VII	A. C. Johansen
Abt. 55° 26' N.—6° 50' E.	13. Sept. 1890	11	56. 45	S	Abh. D. S. V.	Fr. Heincke
W. of Sylt. Abt. 54° 55' N.—6° 34' E.	4. Aug. 1889	30	56. 53	?	Abh. D. S. V.	Fr. Heincke
Abt. 54° 47' N.—1° 18' E.	6. Sept. 1904	31	56. 58	S	Berg. M. Aarb.	H. Broch
Abt. 54° 30' N.—1° 25' E.	3. Oct. 1911	106	56. 43	S	R. en V. R. V. I.	Delsman
Abt. 54° 35' N.—1° 32' E.	14. Sept. 1912	50	56. 54	S	R. en V. R. V. I.	Delsman
Fladen Ground	Aug., Sept. 1924 1925	152	56. 49	S	D. W. K. N. F. III/2	Schnakenbeck
Brucey's Garden	Sept.-Oct. 1923-25	264	56. 55	S	D. W. K. N. F. III/2	Schnakenbeck
Abt. 55° 30' N.—0° 10' E.	Aug., Sept. 1906	40	56. 50	S	R. en V. R. V. I.	Redeke
Abt. 54° 30' N.—2° 40' E.	Oct. 1906	25	56. 44	S	R. en V. R. V. I.	Redeke
		65	56. 48			
Abt. 52° 39' N.—2° 30' E.	Nov. 1905	100	56. 56	V	R. en V. R. V. I.	Redeke
Abt. 52° 43,5' N.—2° 50' E.	Nov. 1905	100	56. 63	V	R. en V. R. V. I.	Redeke
Yarmouth	Oct. 1910	50	56. 50	V	R. en V. R. V. I.	Delsman
Lowestoft	Nov., Dec. 1923	100	56. 55	S	D. W. K. N. F. III/2	Schnakenbeck
	Oct., Nov. 1925	98	56. 71	S	D. W. K. N. F. III/2	Schnakenbeck
Abt. 54° 55' N.—6° 34' E.	Aug. 1889	30	56. 53		Abh. D. S. V.	Fr. Heincke
N. of Terschelling (abt. 53° 40' N.—4° 47' E.)	10. Sept. 1890	17	56. 29	S	Abh. D. S. V.	Fr. Heincke
Ditzum, Dollart	May 1888	79	56. 18	V	Abh. D. S. V.	Fr. Heincke
Zuiderzee	Apr. 1888	127	55. 35	V	Abh. D. S. V.	Fr. Heincke
Zuiderzee, Marsdiep, near Helder	May 1912	50	54. 78	V	R. en V. R. V. I.	Delsman
Zuiderzee, near Isl. Uik	Dec. 1912	40	55. 13	V	R. en V. R. V. I.	Delsman
Limfjorden, off Struer	7. Apr. 1887	50	55. 90	V	Abh. D. S. V.	Fr. Heincke
Limfjorden, off Lemvig	27. May 1915	270	55. 73	V	K. Medd. VI	A. C. Johansen
Limfjorden, off Nykøbing, Mors	8. May 1916	143	55. 73	V	K. Medd. VI	A. C. Johansen
Limfjorden, off Hals	20. May 1916	210	55. 77	V	K. Medd. VII	A. C. Johansen
Limfjorden, off Hals	May 1918	135	55. 85	V	K. Medd. VII	A. C. Johansen
Ringkøbing Fjord, W. Jylland	Apr. 1915	165	55. 56	V	K. Medd. VII	A. C. Johansen
Limfjorden, Nissum Bredning	Oct. 1915	171	56. 37	S	K. Medd. VII	A. C. Johansen
The Channel.						
Cap d'Antifer	Winter 1901—02	125	56. 57	V	Ann. St. B.-s.-M. I.	Cligny
Off Plymouth	Dec. 1914 Jan. 1915	1021	56. 77	V	J. M. B. A. 1916.	I. H. Orton

Locality	Date	Nos.	Vert.	V or S	Publication	Investigator
Off Plymouth	Nov.-Dec. 1924 Jan.-Mar. & Oct.-Dec. 1925 Jan. 1926	5468	56.78	V	J.M.B.A. 1928.	E. Ford
Off Brixham	Nov., Dec. 1925. Jan., Oct., Dec. 1925	787	56.73	V	J.M.B.A. 1928	E. Ford
Off Sussex coast	Dec. 1924 Oct.-Dec. 1925 Dec. 1926 June 1927	964	56.70	V	J.M.B.A. 1928	E. Ford
The Skagerak.						
Bohuslän	15. Apr. 1878	25	56.56	V	Abh. D. S. V.	Fr. Heincke
N. W. of Hirshals (abt. 57° 45' N. - 9° 15' E.	6. Mar. 1923	120	56.33	S	K. Medd. VII	A. C. Johansen
N. of Skagen	17. Mar. 1915	181	56.54	S	K. Medd. VII	A. C. Johansen
W. by S. of Vinga	10. Feb. 1915	64	56.22	V	K. Medd. V	A. C. Johansen
N. of Skagen	5. Jan. 1924	107	56.50	S	K. Medd. VII	A. C. Johansen
N. of Skagen	5. Jan. 1924	39	55.92	V	K. Medd. VII	A. C. Johansen
N. W. of Skagen	26. Jan. 1924	137	56.35	S	K. Medd. VII	A. C. Johansen
W. by S. of Vinga	10. Feb. 1915	49	56.47	S	K. Medd. VII	A. C. Johansen
The Kattegat.						
Near Kobbergrund	23. Oct. 1915	178	56.35	S	K. Medd. VII	A. C. Johansen
Near Kobbergrund	23. Oct. 1915	43	56.05	V	K. Medd. V	A. C. Johansen
Near Kobbergrund	Oct. 1915	40	56.78	V	K. Medd. VII	A. C. Johansen
Off Frederikshavn	23. Apr. 1918	213	55.63	V	K. Medd. V	A. C. Johansen
Off Varberg	Oct. 1887	67	56.37	S	K. Medd. VII	A. C. Johansen
E. of Læsø	13. Oct. 1914	116	56.47	S	D. Fisk. Tid. 15	A. C. Johansen
Off Udbyhøj	26. Apr. 1915	285	55.77	V	D. Fisk. Tid. 16	A. C. Johansen
East of Læsø	Oct. 1922	120	56.12	S	K. Medd. VII	A. C. Johansen
East of Læsø	9. Oct. 1922	71	56.75	V	K. Medd. VII	A. C. Johansen
Groves Flak, 57° 08' N. - 10° 35' E.	Oct. 1922	400	56.11	S	K. Medd. VII	A. C. Johansen
The Belt Sea.						
Aarhus Bay, at Hou	27. Mar. 1915	66	55.95	V	K. Medd. V	A. C. Johansen
Mouth of Kalundborg Fjord	2. May 1914	166	55.87	V	K. Medd. V	A. C. Johansen
Kalundborg Fjord	20. Sept. 1916	203	55.77	S	W. M. D. K. XV	A. C. Johansen
Kalundborg Fjord	15. Dec. 1914	102	55.80	V	D. Fisk. Tid. 15	A. C. Johansen
E. of Taasinge	9. June 1915	222	55.81	V		
At Masnedsund	5. Oct. 1915	215	55.54	S	K. Medd. VII	A. C. Johansen

Locality	Date	Nos.	Vert.	V or S	Publication	Investigator
Western Baltic.						
Off Rødby	20. Oct. 1915	185	55.48	S	K. Medd. VII	A. C. Johansen
Guldborgsund	May 1916	211	55.94	V	K. Medd. VII	A. C. Johansen
Prokner Wick	28. May 1888	46	56.04	V	Abh. D. S. V.	Fr. Heincke
Dassower See	Apr. 1925	128	55.42	V	D. W. K. N. F. IV/2	Altnöder
	May 1926	130	55.48			
		258	55.45			
Nordostseekanal	May 1927	114	55.65	V	D. W. K. N. F. IV/2	Altnöder
Die Schley	Mar. 1926	112	55.62	V	D. W. K. N. F. IV/2	Altnöder
		48	55.65	V		
Die Schley	Mar. 1878 / May 1885	161	55.45	V	Abh. D. S. V.	Fr. Heincke
Wohlenberger Wick	May 1926	50	55.66	V	D. W. K. N. F. IV/2	Altnöder
Kiel Bay		49	55.5	S	Abh. D. S. V.	Fr. Heincke
Fehmarn		21	55.8	S	Abh. D. S. V.	Fr. Heincke
Eckernförde	Aug. 1926	86	55.54	S	D. W. K. N. F. IV/2	Altnöder
Haffkrug	Oct. 1926	111	55.45	S	D. W. K. N. F. IV/2	Altnöder
		73	55.67			
Heiligenhafen (Caught on Flügge-sand, Fehmarn)	May 1926	84	55.95	V	D. W. K. N. F. IV/2	Altnöder
The Sound						
N. E. of Gilleleje	30. Aug. 1913	118	55.58	S	D. Fisk. Tid. 15	A. C. Johansen
Near Skovshoved	23. Sept. 1914	48	55.54	S	D. Fisk. Tid. 15	A. C. Johansen
Kalvebodstrand	Oct. 1916		55.60	S	D. Fisk. Tid. 16	A. C. Johansen
The true Baltic.						
E. of Bornholm	30. Sept. 1915	227	55.45	S	K. Medd. VII	A. C. Johansen
Off Rønne Bornholm	7. Oct. 1914	99	55.55	S	K. Medd. VII	A. C. Johansen
N. W. of Nordpeerd, Rügen	3. Oct. 1891	30	55.53	S	Abh. D. S. V.	Fr. Heincke
Gulland Bank	18. Sept. 1887	35	55.51	S	Abh. D. S. V.	Fr. Heincke
Hanøbukten	22. May 1924	28	55.46	V	Public. de Circonstance 1925	Chr. Hessle

Locality	Date	Nos.	Vert.	V or S	Publication	Investigator
Store Rör (fjord-herring)	22. June 1923	30	55. 30	V	Public. de circonstance 1925	Chr. Hessle
W. coast of Gotland (Kappelshamn, Visby-Klintehamn)	Feb., May 1920 1923	87	55. 46	V	»	»
Oskarshamn	1. Dec. 1924	53	55. 43	V	»	»
Sladö	23. Oct. 1923	27	55. 37	V	»	»
Emtö	8. Apr. 1924	49	55. 73	V	»	»
Nynäshamn	Sept. 1921 / Apr., May 1923	107	55. 56	V	»	»
Sandhamn	17. May 1923	48	55. 48	V	»	»
The inner parts of the archipelago of Stockholm (fjord-herring)	Apr. 1920-23	50	55. 12	V	»	»
Gudingen	6. June 1923	50	55. 18		»	»
Hudiksvall	12. June 1924	68	55. 70	V	»	»
Norrfällsviken	29. Sept. 1924	23	55. 74	V		
Hanöbukten	May 1924	58				
	Nov. 1924	63				
		121	55. 51	S	»	»
Östergarn	July 1923	61				
	Aug. 1924	34				
		95	55. 62	S	»	»
Sladö	23. Oct. 1923	35	55. 77	S	»	»
Flatvarp	12. Mar. 1924	55	55. 64	S	»	»
Visby	May 1923	41				
	June »	36				
	Oct. »	36				
	Oct. 1924	53				
		166	55. 63	S	»	»
Emtö	8. Apr. 1924	55	55. 42	S	»	»
Kappelshamn	Feb. 1920	42				
	Feb. 1923	90				
	May 1923	24				
	July 1923	44				
		200	55. 55	S	»	»
Nynäshamn	Sept. 1921	52				
		57				
	Apr. 1923	43				
	Aug. 1923	45				
		197	55. 57	S	»	»
Sandhamn	2. Aug. 1923	36	55. 66	S	»	»
Utvalnäs	9. Oct. 1924	60	55. 50	S	»	»
Kråköen	8. Aug. 1923	74				
	1. Nov. 1924	60				
		134	55. 46	S	»	»

Locality	Date	Nos	Vert.	V or S	Publication	Investigator
Trysunda	31. Aug. 1923	80	55.56	S	Public. de circonstance 1925	Chr. Hessle
Bjurö Klubb	26. Aug. 1923	49	55.45	S	»	»
Brändöskär	17. Aug. 1923 20. Aug. 1923	84	55.48	S	»	»
W. coast of Gotland (Kappelshamn-Visby)	Febr. 1920 May-Oct. 1923 Oct. 1924	366	55.59	S	»	»

A LIST OF THE ABBREVIATIONS USED

(REFERENCES TO THE LITERATURE)

Abh. D. S. V.: Fr. Heincke: Naturgeschichte des Herings. Abhdl. des deutschen Seefischerei Vereins **II**. 1898.

Ann. S. B.-s.-M.: M. Cligny: Contribution à l'étude biolog. du hareng. Annales de la Stat. de Boulogne-sur-Mer. **I**. 1905.

Bergens Mus. Aarb.: Hjalmar Broch: Norwegische Heringsuntersuchungen. Bergens Museums Aarbog 1908.

D. Fisk. Tid. 15 og 16: Dansk Fiskeri Tidende 1915 og 1916.

D. W. K. N. F. III/2: W. Schnakenbeck: Rassenuntersuchungen am Hering. Berichte der deutsch. Wiss. Komm. für Meeresforschung. N. F. Bd. **III**, H. 2, 1927.

D. W. K. N. F. IV/2: K. Altnöder: Untersuchungen an den Heringen der westlichen Ostsee. Berichte der deutsch. Wiss. Kom. für Meeresforschung. N. F. Bd. **IV**, H. 3, 1928.

J. M. B. A. 1928: E. Ford: Herring Investigations at Plymouth. **II**. Journal of the Marine Biological Association of the U. K. Vol. **XV**, 1928. Plymouth.

K. Medd. V: A. C. Johansen: On the large spring spawning Sea Herring (*Clupea harengus* L.) in the North West European waters. Meddelelser fra Kommissionen for Havundersøgelser. Serie: Fiskeri, Bd. **V**, Nr. 8, 1919.

K. Medd. VI: A. C. Johansen: On the Summer-spawning Herring (*Clupea harengus* L.) of Iceland. The Atlanto-Scandian Spring Herring spawning at the Faroes. Ibid. Bd. **VI**, Nr. 3—4, 1921.

K. Medd. VII: A. C. Johansen: On the Summer- and Autumn-Spawning Herring of the North Sea. Ibid. Bd. **VII**, Nr. 5, 1924.

Public. de Circonstance 1925: Chr. Hessle: The Herring, along the Baltic coast of Sweden. Publication de Circonstance No. 89. Conseil internat. 1925.

Rap. Pr. V. 39: A. C. Johansen: Investigations on Icelandic Herrings in 1924 and 1925. Rapports et Procés-Verbaux. Conseil internat. Vol **XXXIX** 1926.

R. en V. R. V.: H. C. *Delsmann*: Über das Wachstum von Nordseehering und Zuiderzeehering etc.
Rapp. en Verhandl. uit door het Rijksinstit. v. Visscherijonderz. Deel 1. Afh. 2. 1914.

R. en V. R. V.: H. C. Redeke: Bijdrage tot de Kennis van de Nordzee-Heringstammen ibid. Deel 1. Afh. 4. 1918.

W. M. D. K. XV: S. Awerinzew: Herring of the White-Sea, I.
Wissensch. Meeresuntersuch. Abt. Helgoland. Bd. **XV**, 1926.

XII. Appendix.

Since the finishing of the paper some samples from various waters have come to hand. The results not shown on the charts or in the lists are given in the following.

Denmark:

Little Belt:

Off Røjle Klint, abt. { 55° 33.3′ N. lat. / 9° 48′ E. long.
depth 13—45 m. 19th March 1930.

Vertebrae: 54:*3*; 53:*59*; 52:*112*; 51:*27*. *a* 201 = **52.19**.

D_2: 23:*1*; 22:*3*; 21:*7*; 20:*26*; 19:*67*; 18:*53*; 17:*34*; 16:*9*; 15:*1*. *a* 201 = **18.51**.

Between Strib and Stavnshoved, abt. { 55° 33′ N. lat. / 9° 48.4′ E. long.
depth 20—30 m. 20th—27th March 1930.

Vertebrae: 54:*3*; 53:*25*; 52:*73*; 51:*21*; 50:*1*; *a* 123 = **52.07**.

D_2: 22:*1*; 21:*7*; 20:*31*; 19:*32*; 18:*38*; 17:*12*; 16:*5*. *a* 126 = **18.77**.

Æbelø:

Southwest of Æbelø, abt. { 55° 37.8′ N. lat. / 10° 10′ E. long.
depth 5 m. abt. 1st April 1930.

Vertebrae: 54:*4*; 53:*61*; 52:*111*; 51:*27*. *a* 203 = **52.21**.

D_2: 23:*1*; 22:*1*; 21:*20*; 20:*36*; 19:*63*; 18:*53*; 17:*23*; 16:*6*; *a* 203 = **18.83**.

The same
7th April 1930.

Vertebrae: 53:*21*; 52:*65*; 51:*28*; 50:*1*. *a* 115 = **51.92**.

D_2: 22:*1*; 21:*8*; 20:*28*; 19:*27*; 18:*28*; 17:*18*; 16:*5*. *a* 115 = **18.72**.

The Sound:

The west edge of the deep channel east of »Disken«. { 56° 00.8′ N. lat. / 12° 40′ E. long.
depth abt. 20 m. 21st March 1930.

Vertebrae: 54:*1*; 53:*30*; 52:*54*; 51:*16*. *a* 101 = **52.16**.

D_2: 21.*8*; 20:*11*; 19:*28*; 18:*25*; 17:*20*; 16:*8*; 15:*3*. *a* 103 = **18.28**.

About 1 naut. mile NW. of the Hveen lighthouse. { 55° 55.5′ N. lat. / 12° 39′ E. long.
depth abt. 24—27 m. 21st March 1930.

Vertebrae: 54:3; 53:29; 52:59; 51:7; 50:1. a 99 = **52.26.**

D_2: 23:1; 22:0; 21:5; 20:17; 19:30; 18:26; 17:14; 16:6; 15:1. a 100 = **18.55.**

These results are quite in accord with those previously reported from the Danish waters, and give no occasion for further remarks.

Belgium:

A sample consisting of 37 cod, derived from the Belgian coast, was received on the 26th May 1930 from Professor G. Gilson, Ostende.

Vertebrae: 54:3; 53:14; 52:16; 51:3; a 36 = **52.47.**

D_2: 23:1; 22:1; 21:2; 20:6; 19:16; 18:9; 17:1; 16:1. a 37 = **19.08**

The average values of this sample are a little higher than might have been expected from the chart Pl. V; but the sample is too small to give occasion for further remarks.

Ireland:

A sample consisting of 5 cod, caught by a Belgian trawler off the south coast of Ireland, was received on the 26th May from Professor G. Gilson, Ostende.

Vertebrae: 52:2; 51:3. a 5 = **51.4.**

D_2: 20:1; 19:2; 18:0; 17:2. a 5 = **18.4.**

The values are quite in accord with what might be expected in this area; but the sample is, of course, far too small to admit of final decisions.

The English Channel.

A sample from Plymouth Sound, taken in the autumn and winter of 1929—30, has been received from The Marine Biological Association through Mr. R. A. Todd.

Vertebrae: 53:2; 52:5; 51:5. a 12 = **51.75.**

D_2: 21:1; 20:0; 19:6; 18:5. a 12 = **18.75.**

The values of this sample likewise agree very well with the few samples available from this, the southernmost part of the cod's distribution area in European waters. As will be seen, it is, however, on account of the very small samples from this area, desirable that further information should be collected from this quarter.

XIII. Remarks as to the charts, Pl. I—X.

The position of the stations is shown on chart Pl. 1. The serial-numbers refer to the lists, pages 34—48, where detailed information is given; all the stations are not marked but their position will be found from the lists, pages 34 et seq. Likewise the samples mentioned in section XII, page 69, are not noted on the chart, as they did not come to hand until after the completion of the chart and have not therefore been numbered.

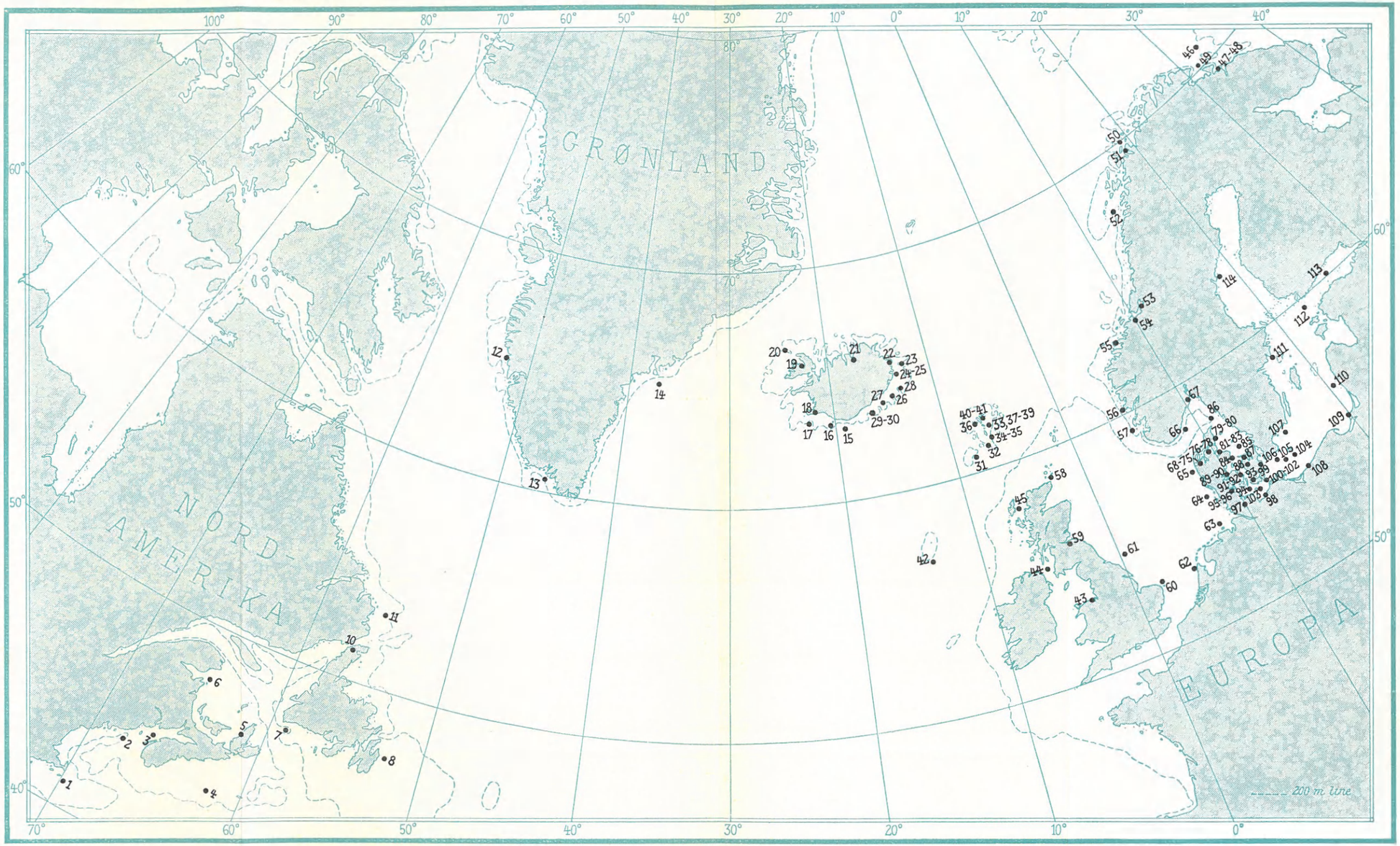
The north Atlantic is divided into several areas for which special charts will be found, drawn to a larger scale.

On most of the charts that show the values found for Vertebrae and the second dorsal fin (D_2), red has been used to indicate the vertebrae, and black the D_2 figures.

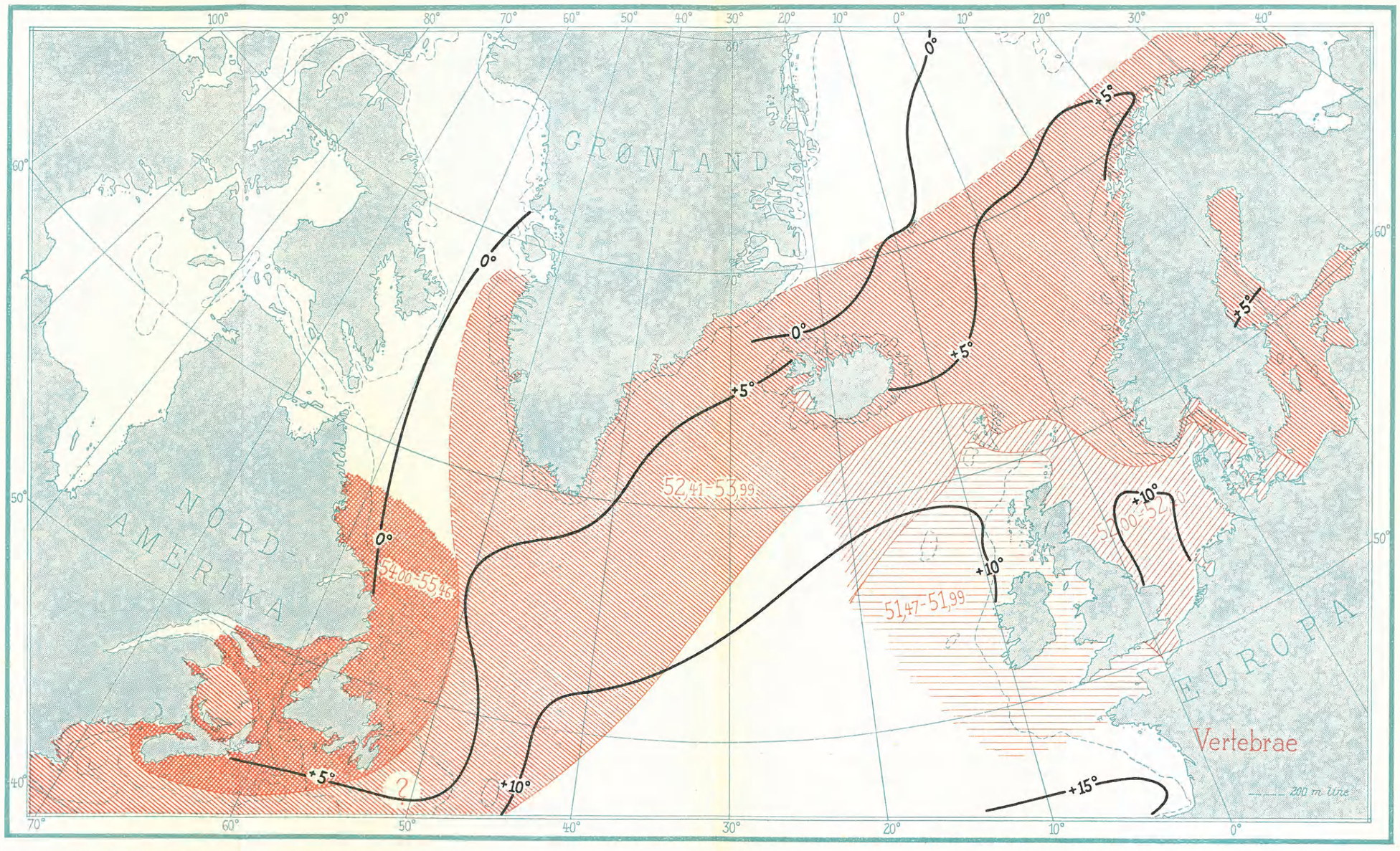
On the charts Pl. II—III curves for the yearly average surface temperatures are given (according to G. Schott: Geographie des Atlantischen Ozeans. 1912).

The vertebrae figures for the herring (*Clupea harengus* L.) are shown on the charts Pl. IX and X; details will be found in the tables, section XI, pages 61—68).

CONTENTS

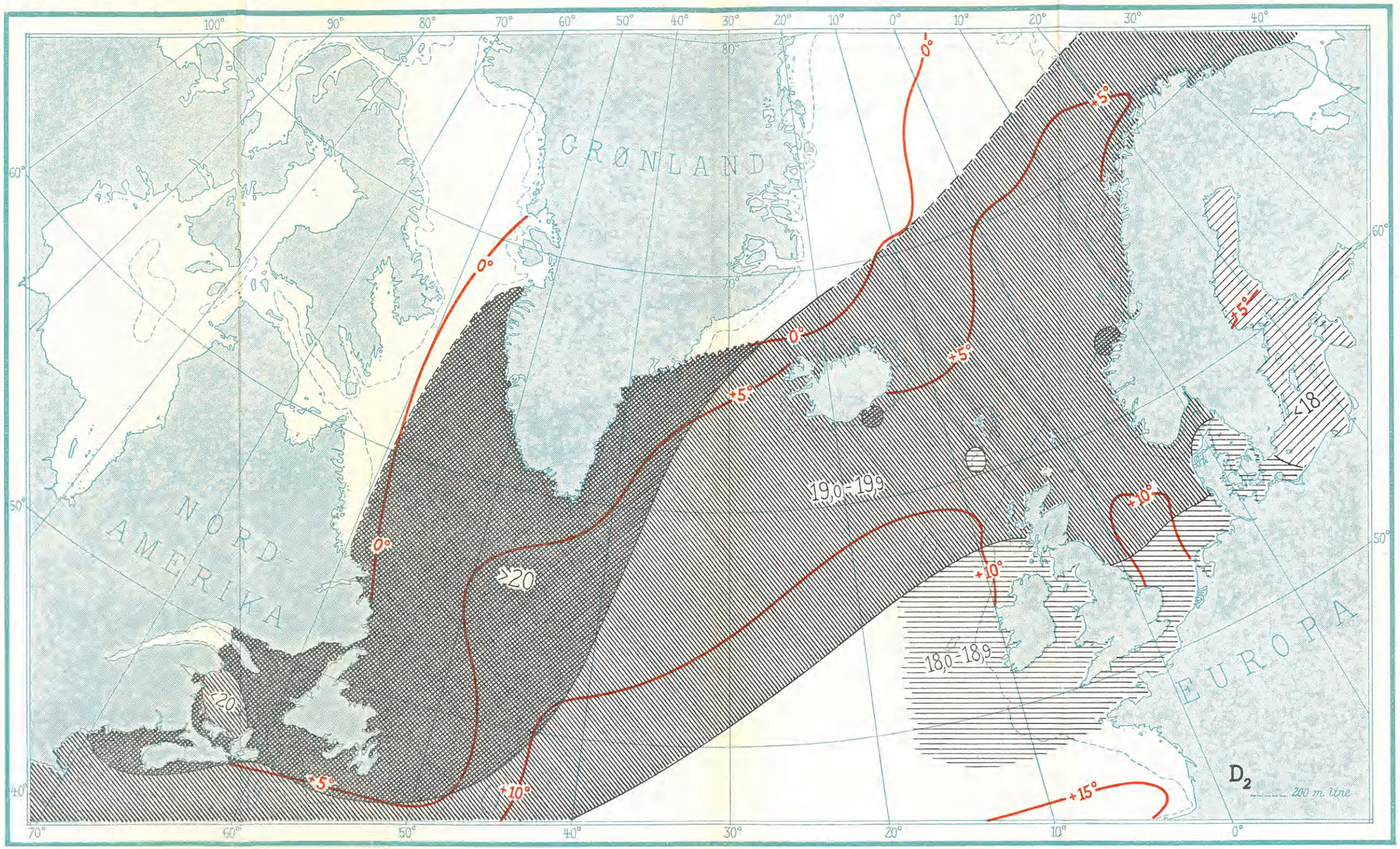


The Atlantic Cod (*Gadus callarias* L.). The populations investigated.



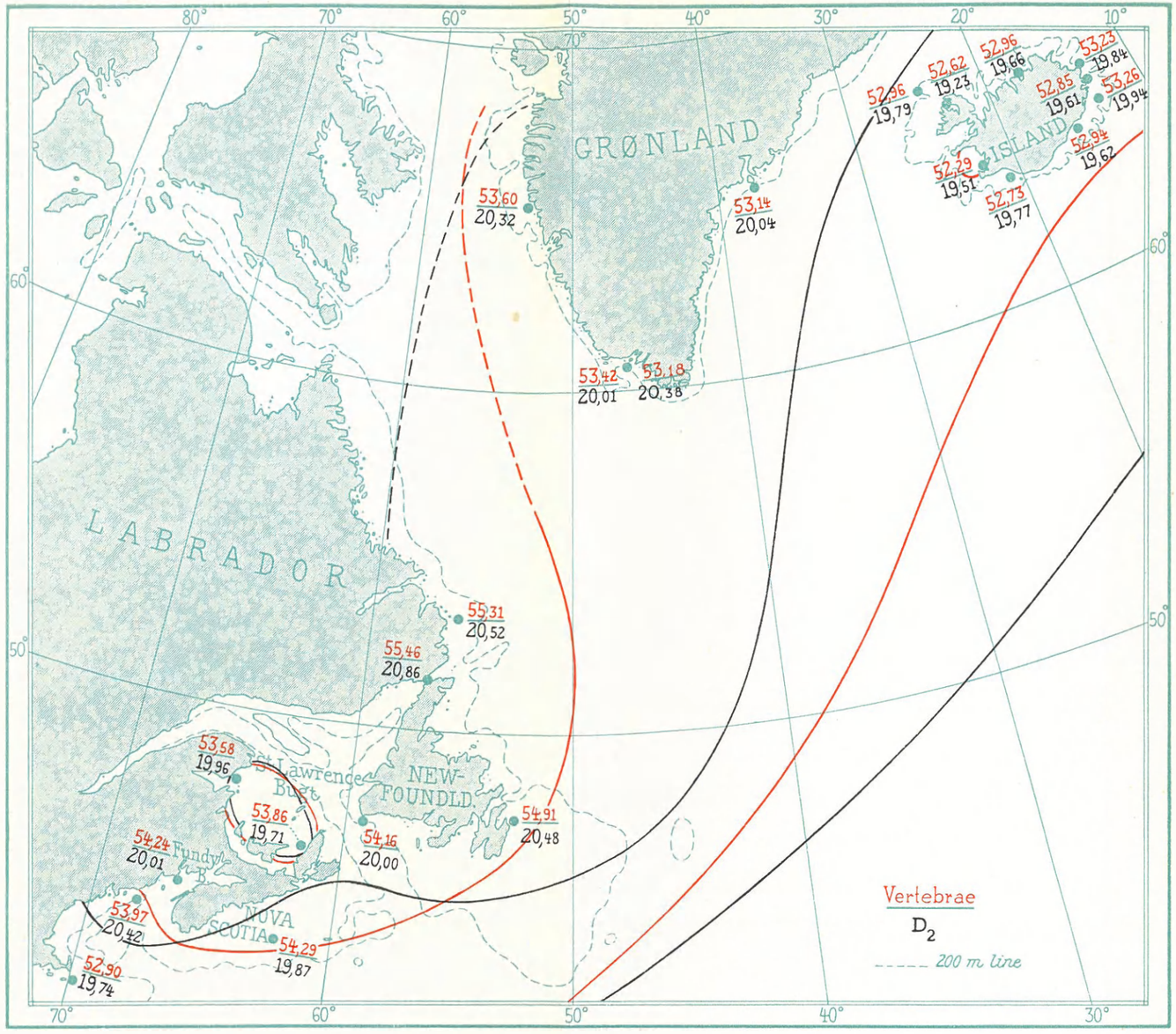
Cod (*Gadus callarias* L.). Distribution of racial characters: Average number of Vertebrae. Schematic.

Surface-Isotherms indicated.



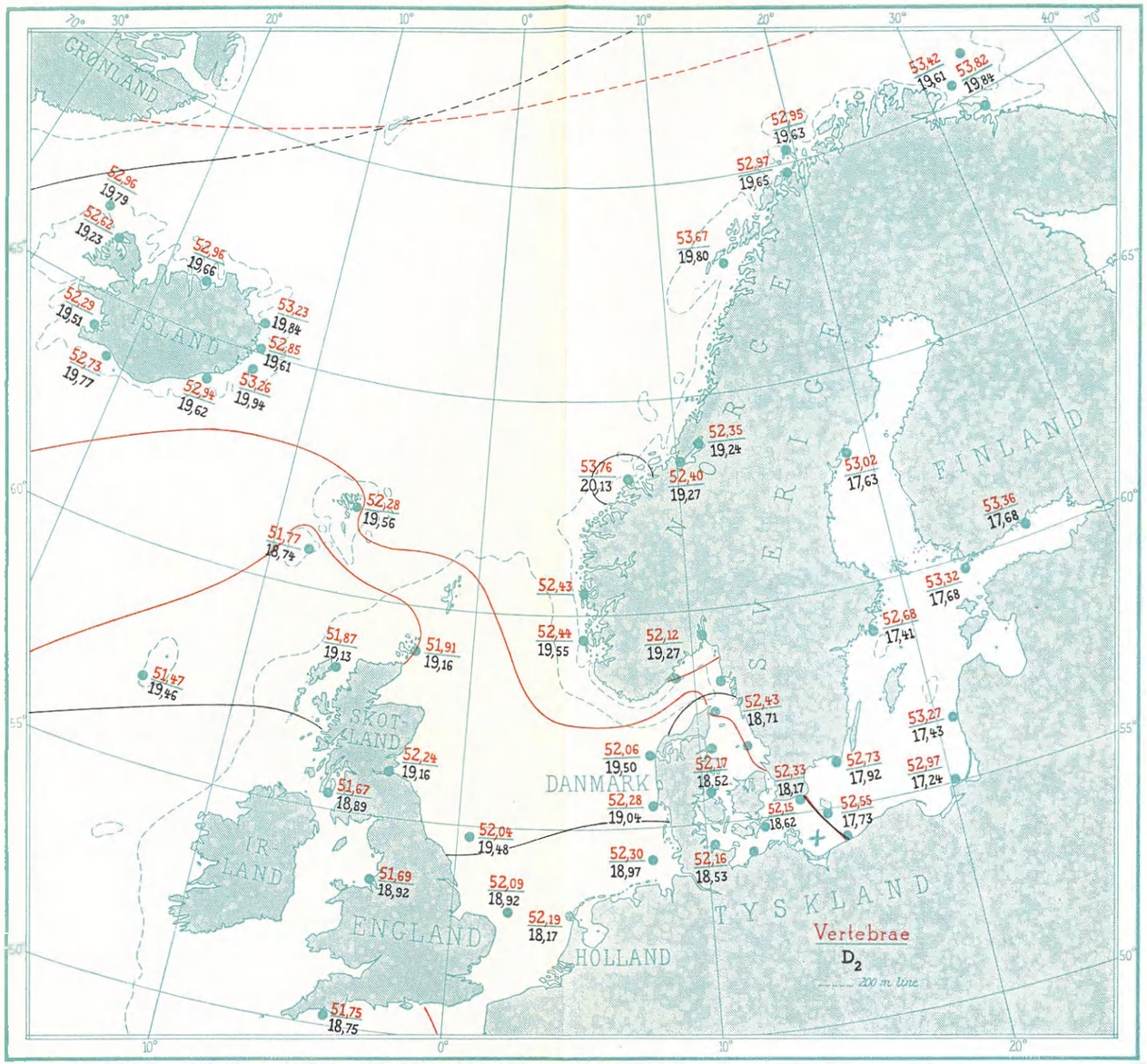
Cod (*Gadus callarias* L.). Distribution of racial characters: Average number of rays in second dorsal fin (D_2). Schematic.

Surface-isotherms indicated.



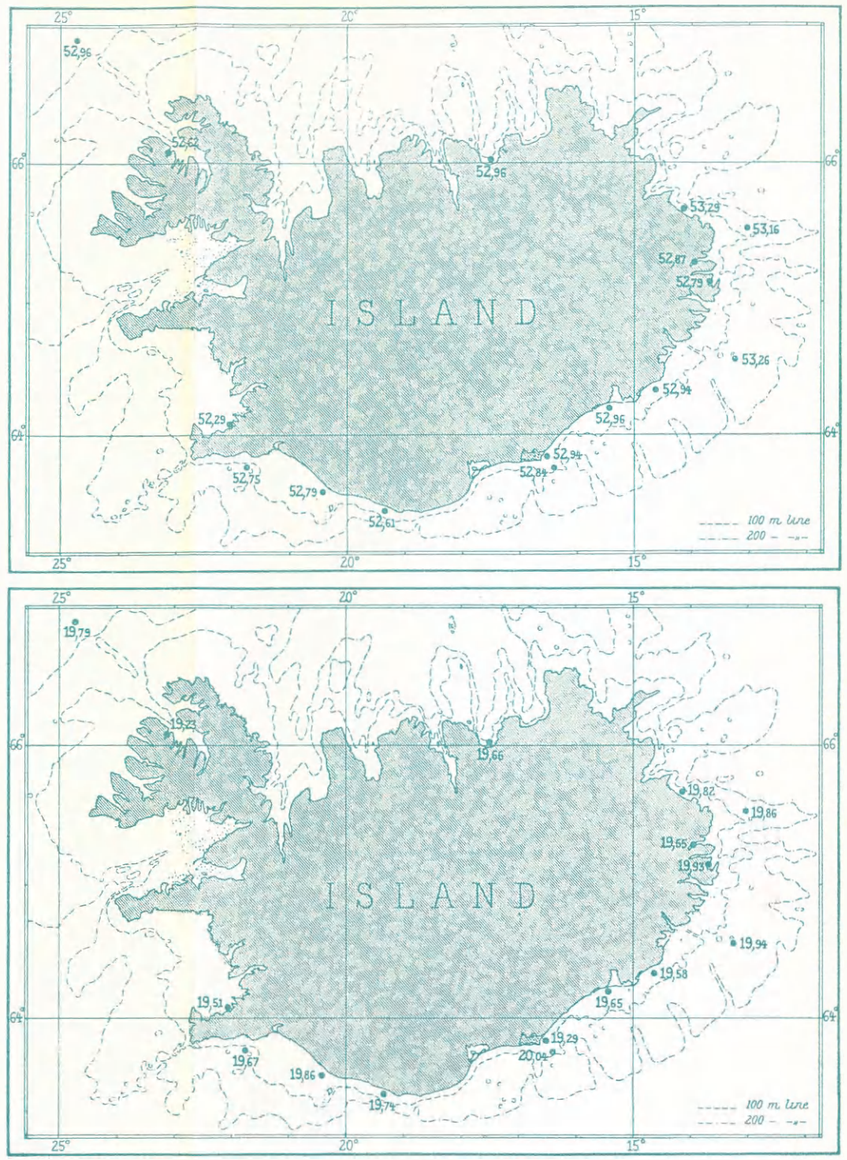
Cod (*Gadus callarias* L.). Western section of the Area. Distribution of racial characters: Vertebrae and D_2 (averages).

Red and black curves showing distribution of averages of Vertebrae and D_2 as in Pl. II and III.

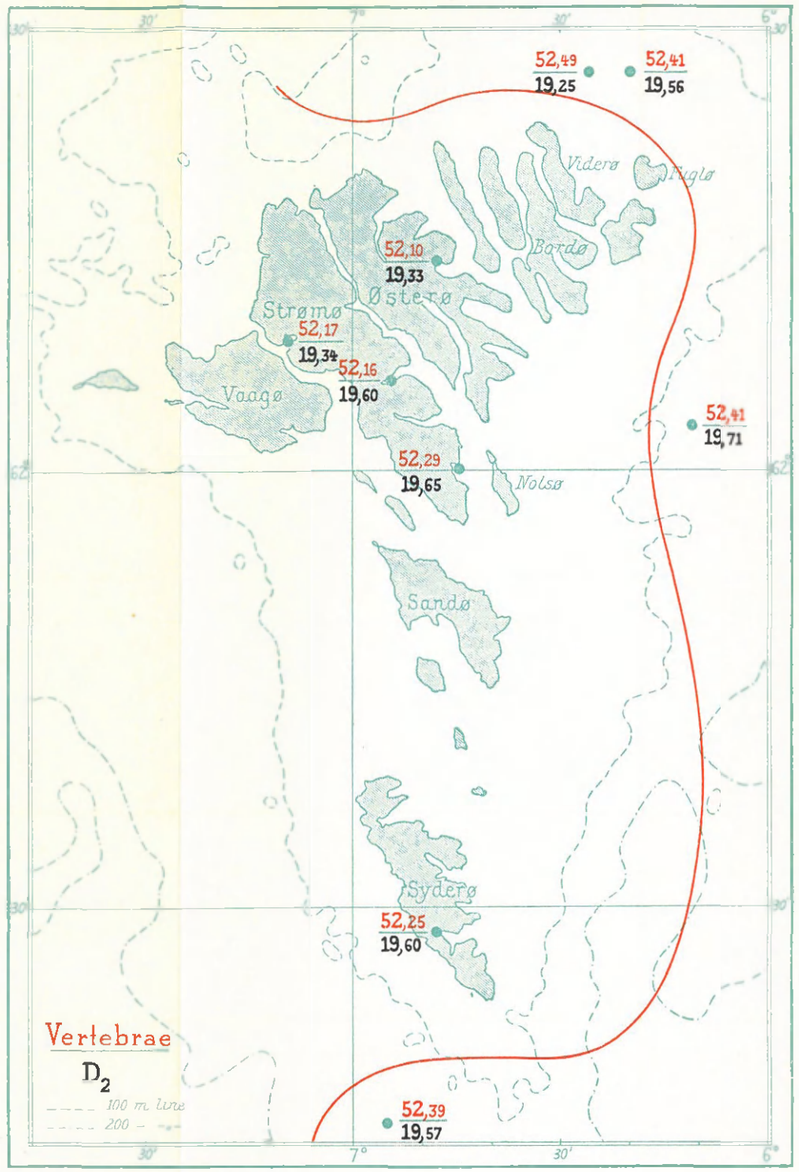


Cod (*Gadus callarias* L.). Eastern section of the Area. Distribution of racial characters: Vertebrae and D_2 (averages).

Red and black curves showing distribution of averages of Vertebrae and D_2 as in Pl. II and III.



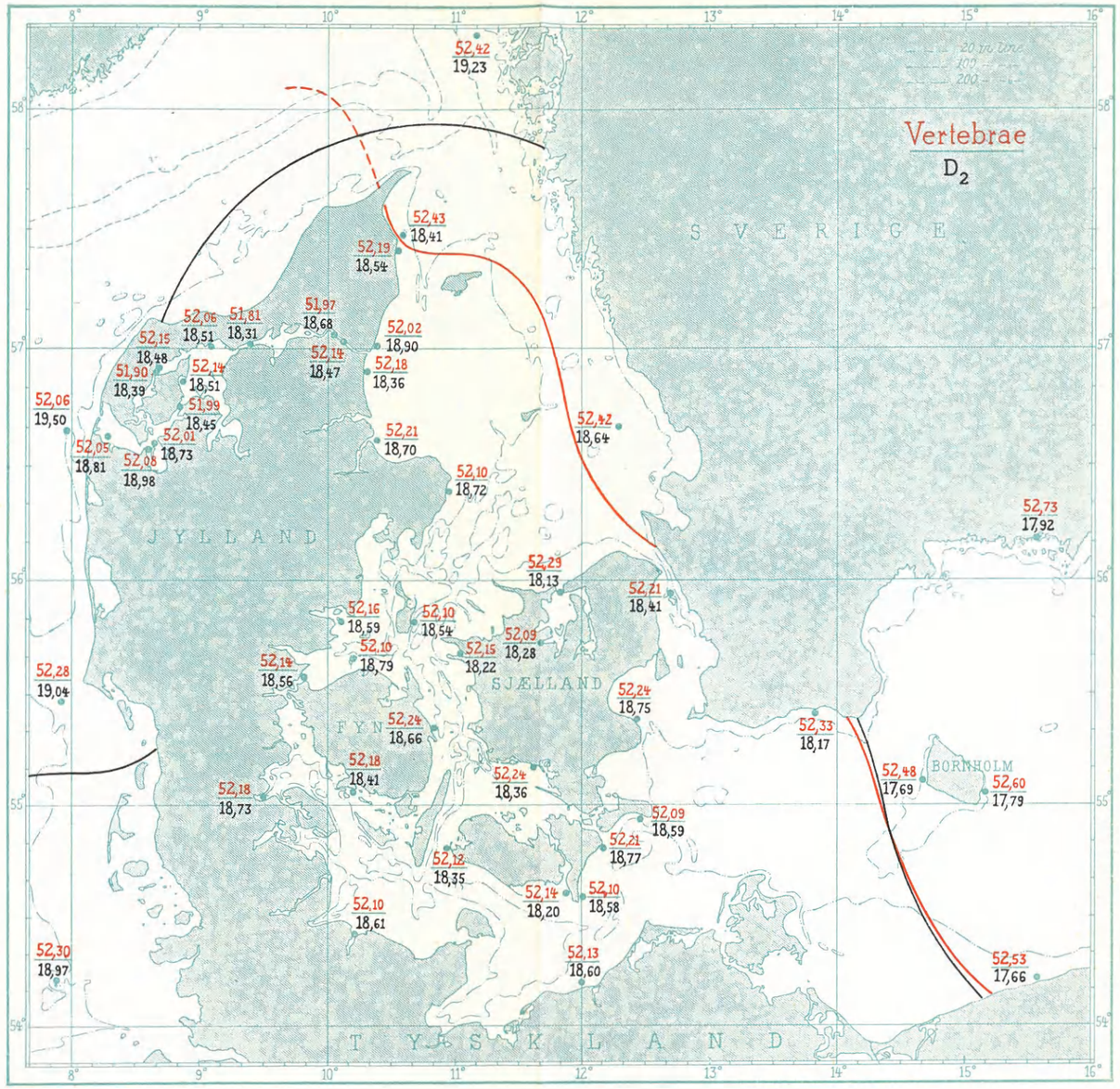
Cod (*Gadus callarias* L.). Iceland.
Top figure: Vertebrae (averages).
Lower figure: D_3 (averages).



Cod (*Gadus callarias* L.). Faroe Islands.

Vertebrae and D_2 (averages).

In the inshore populations west of red curve the averages for vertebrae are less than $52._{30}$.



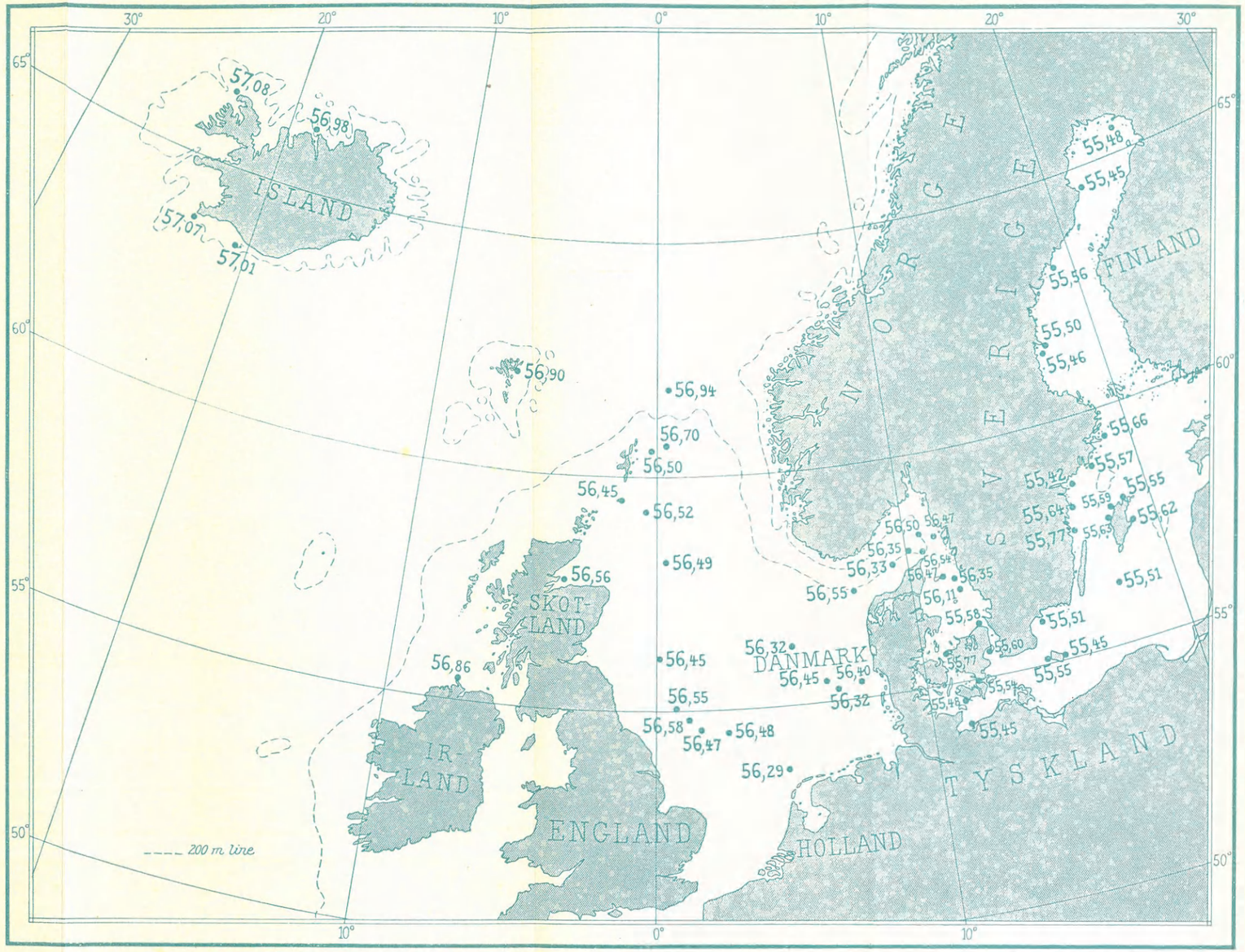
Cod (*Gadus callarias* L.). Danish waters.

Vertebrae and D_2 (averages).

Red and black curves showing distribution of averages of Vertebrae and D_2 as in Pl. II and III.

Herring (*Clupea harengus* L.).

Winter-spawning populations. Vertebrae (averages).



Herring (*Clupea harengus* L.).

Summer-spawning populations. Vertebrae (averages).

JOHS. SCHMIDT:

INVESTIGATIONS ON HOPS

(HUMULUS LUPULUS, L.)

Of this series the following papers have been issued:

I. JOHS. SCHMIDT: The growth in length of hop stems and its diurnal periodicity, Comptes-rendus des travaux du Laboratoire Carlsberg, vol. 10, page 233—251 (1913).

II. JOHS. SCHMIDT: The rotational movement of hop stems and its diurnal periodicity. Ibidem, vol. 10, page 267—283 (1913).

III. Ö. WINGE: The pollination and fertilization processes in *Humulus lupulus, L.* and *H. Japonicus* Sieb. et Zucc. Ibidem, vol. 11, page 1—44 (1914).

IV. Ö. WINGE and J. P. H. JENSEN: A method for quantitative determination of resins in hops. Ibidem, vol. 11, page 116—147 (1914).

V. JOHS. SCHMIDT: On the aroma of hops. Ibidem, vol. 11, page 149—163 (1915).

VI. JOHS. SCHMIDT: On the amount of lupulin in plants raised by crossing. Ibidem, vol. 11, page 165—183 (1915).

VII. SVEND HÖEG LARSEN: The employment of artificial light in titration of the resins in hops. Ibidem, vol. 11, page 184—187 (1915).

VIII. JOHS. SCHMIDT: On the flowering time of plants raised by crossing. Ibidem, vol. 11, page 188—198 (1915).

IX. JOHS. SCHMIDT: The occurrence of the wild hop in Denmark. Ibidem, vol. 11, page 314—329 (1916).

X. JOHS. SCHMIDT: On the aroma in plants raised by crossing. Ibidem, vol. 11, page 330—332 (1917).

XI. JOHS. SCHMIDT: Can different clones be characterised by the number of marginal teeth in the leaves? Ibidem, vol. 14, no. 2, page 1—24 (1918).

JOHS. SCHMIDT:

RACIAL INVESTIGATIONS

Of this series the following papers have been issued:

I. JOHS. SCHMIDT: *Zoarces viviparus* L. and local races of the same. Comptes-rendus des travaux du Laboratoire Carlsberg, vol. 13, page 277—397 (1917).

II. JOHS. SCHMIDT: Constancy investigations continued. Ibidem, vol. 14 no. 1, page 1—19 (1917).

III. JOHS. SCHMIDT: Experiments with *Lebistes reticulatus* (Peters) Regan. Ibidem, vol. 14 no. 5, page 1—8 (1919).

IV. JOHS. SCHMIDT: The genetic behaviour of a secondary sexual character. Ibidem, vol. 14, no 8, page 1—12 (1920).

V. JOHS. SCHMIDT: Experiments with *Zoarces viviparus* L. Ibidem, vol. 14, no. 9, page 1—14 (1920).

VI. KIRSTINE SMITH: Statistical investigations on inheritance in *Zoarces viviparus* L. Ibidem, vol. 14, no. 11, page 1—64 (1921).

VII. JOHS. SCHMIDT: Annual fluctuations of racial characters in *Zoarces viviparus* L. Ibidem, vol. 14, no. 15, page 1—24 (1921).

VIII. JOHS. SCHMIDT: The numerical signification of fused vertebrae. Ibidem, vol. 14, no. 16, page 1—5 (1921).

IX. KIRSTINE SMITH: Continued statistical investigations with *Zoarces viviparus* L. Ibidem, vol. 14, no. 19, page 1—42 (1922).

X. JOHS. SCHMIDT: The Atlantic cod (*Gadus callarias* L.) and local races of the same. Ibidem, vol. 18, no. 6, page 1—88 (1930).