REPORT ON NORWEGIAN FISHERY AND MARINE INVESTIGATIONS VOL. III NO. 6

PUBLISHED BY THE DIRECTOR OF FISHERIES

On the Growth of the Cod

and

the Formation of annual Zones in the Scales

BY

ALF DANNEVIG

BERGEN 1925
A.S. JOHN GRIEGS BOKTRYKKERI

Preface.

The material discussed here is not great enough to form a base for a general discussion of the growth of the cod or the formation of annual zones in the scales. When, in spite of this fact, I will venture to give an account of the experiments carried on here, I am doing so believing that some of the facts stated may be of interest to persons dealing with age determination of the cod on the basis of the scale method.

In consequence I will not discuss the problem, nor the literature on the subject, but only deal with the experiments made and the results obtained. The general discussion must be postponed, inasmuch as the experiments will be continued on a more exact basis.

When in 1919 I was planning the investigations bearing upon the scale problem I had much good advice from konsulent Einar Lea, but on account of adverse circumstances however the work, was not carried on in accordance with the original plan. Konsulent Paul Bjerkan has also rendered me valuable service. My thanks are due to both of them.

Flødevig Sea-Fish Hatchery December 1923.

Alf Dannevig.

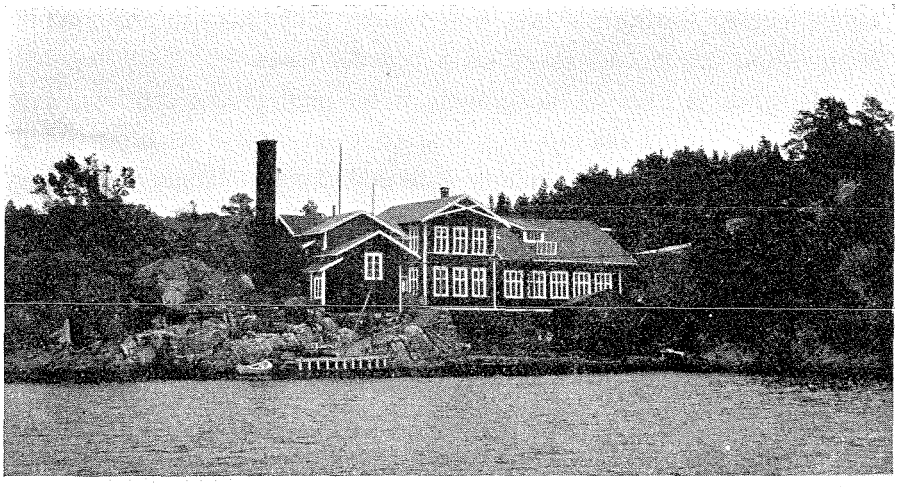


Fig. 1. The Flødevig Sea-fish Hatchery.

General remarks.

From the winter 1914 I have been collecting samples of the scales of the cod from the Norwegian Skagerrack coast in order to study the size and numerical strength of the different age groups. In dealing with the material, however, I found it necessary to make some preliminary studies as to the method of counting the age of the cod by the zones of the scales. I fancied there was some uncertainty about it, especially as the scales of the cod caught in October might have fully formed "Winterzones" near the edge of the scale, and some time afterwards — in the middle of the winter there might be formed a great zone of broad sclerites indicating quick growth. Other individuals had scales in conformity with the common theory of the scale method: A zone of small sclerites near the edge of the scale during the winter.

In order to study the problem I found it most convenient to keep a lot of codling in confinement in the rearing pond of the hatchery, and when taking those from the nature — instead of rearing them from the larval fry in the hatchery — I had the opportunity of following the same yearclass in nature: the start of the two parties, tha in the pond and that in nature was the same. The problem of the

cod in nature, however, I have found most convenient to postpone till this question can be discussed on a broader basis.

To give an idea of the growth of the quite young cod I will give an account of some rearing experiments of larval cod as produced in the hatchery. These experiments were undertakén to study the biology of the cod in the pelagic stage, and several other questions.

The rearing pond, or large pond, of the hatchery has been built between rocks behind the hatchery. The dimensions are 34 × 22

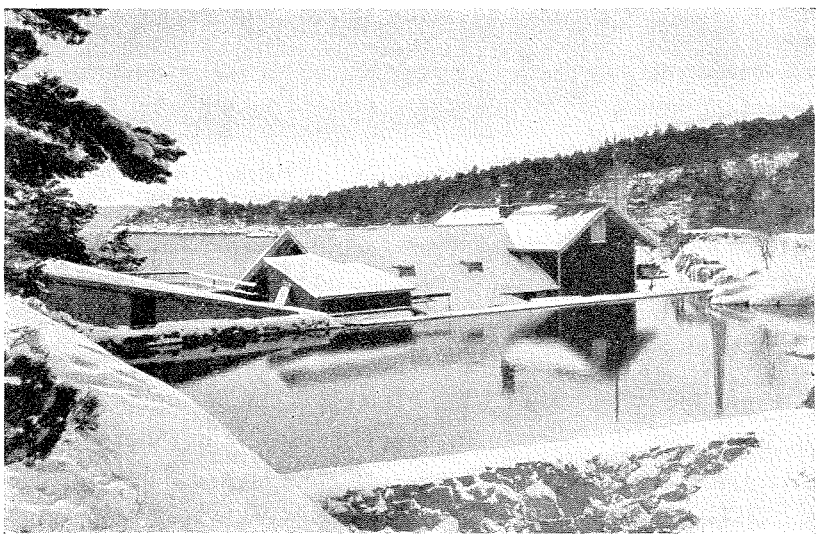


Fig. 2. The rearing pond.

m. with a maximum depth of 5 m. The bottom consists of sand and rocks, and has in the deapest part a wooden floor for the purpose of keeping the fish away from the drain pipe. When the hatching operations are going on during the months of February to May the pond is used as a reservoir, and about 30 tons of sea water will pass through it in the course of an hour. During July and August — the time of lobster rearing — the water circulation in the years referred to was about 1000 tons a week. Between the rearing seasons, when the weather is warm, about one fourth of the water in the pond is renewed each week while in winter the renewal of the water is carried out at a weekly rate of one tenth of the water capacity of the pond.

Rearing of larval cod.

In the annual report of the hatchery for 1886 Capt. G. M. Dannevig gives some dates as to the problem in question. The following table is taken from the report: "Aarsberetning for 1886 for Selskapet for de norske fiskeriers fremme".

Tab. 1. **Rearing experiments 1886.**

	Date	Age	Average length in m.m.
Hatched.....	April 26.	0 days	about 3 mm.
Liberated in the pond	May 3.	6 „	5 „
	16.	19 „	7 „
	18.	21 „	8 „
	21.	24 „	9 „
	31.	1 month 5 „	10 „
	June 3.	1 „ 8 „ (50 individuals)	12 „ (9—16 mm.)
	6.	1 month 11 days	about 15 mm.
	July 12.	2 „ 15 „	55 „
	Aug. 12.	3 „ 15 „	70 „
	Sept. 12.	4 „ 15 „	85 „
	Oct. 12.	5 „ 15 „	115 „ (max 157 mm.)

In the winter 1889, when two and a half years old, the cod had reached a length from 9 to 18 inches, a result which is in concordance with later experiments.

As a student I had during the spring 1909 the opportunity of undertaking some experiments as to the hardiness of the cod eggs and fry in water of different salinity and temperature, and also to rear a lot of the larvae hatched at the station in order to study the biology of the young cod.

The rearing of hatched fry of our salt water fishes is not a very easy matter especially in small reservoirs. In a pond, like that at the hatchery here, the task is easy enough — you have to shut off the water supply and water outlet, and to liberate a quantity of the hatched larvae in the pond. If the supply of food is good you might be successfull, if very poor, only a few of the larvae will survive. I have not made exact experiments on this question, but I am of opinion that the chief factor of success is the supply of suitable nourishment in the water. The finest results of several rearing experiments were attained in 1909 when the water was crowded with copepods and larvae of molluscs and decapods. The ventricles of the young cod were full of these forms.

In order to keep the young cod in small reservoirs for exact control the best way I have found is to provide for a bag of cloth or silknet fine enough to keep the young from passing through but sufficiently open to allow the escape of the water. This bag is submerged in sea water in a convenient place and kept afloat at the upper edge by the aid of a frame of planks. In this little basin the young cod are liberated from the apparatus when the yolk-soc is nearly absorbed, they will swim about in the water and feed on the small animals there. In order to renew the water and also to augment the supply of nourishment a slow running current of seawater is led into the bag.

An easy outlet of the water is of importance, if the meshes of the net are allowed to be clogged the young cod are pressed through the remaining openings — they will either escape or succumb. If the young cod at intervals are transferred to a clean bag by the current through a communicating water pipe these difficulties are removed.

On the 25th of April — when the hatching was going on — I liberated some thousands of cod fry in the pond. For three days I could see the young cod, but later on they disappeared, probably on account of being carried away by the strong current. On the 25th of May, when the hatching apparatus were stopped, I placed something like 100 000 cod fry 1—2 days after the hatching in the pond. As the

water-circulation had now ceassed, the young cod could be observed from day to day, — keeping the first days near the surface. The sp. gravity of the water was somewhat 1.026 from surface to bottom and the temperature 9.5° C.

On the 12th of June two individuals measured 20 and 21 mm. but between the numerous codling of about the same size, swimming about in the middle layers, I observed a dozen of a larger size, approximately measuring from 30 to 40 mm. being probably survivors of such codlings placed in the pond on the first occassion.

On the 16th of June two individuals measured 27 and 28 mm. On that date I was able to count as many as 50 codlings at a time, standing on the same spot.

The feeding of the young cod had begun that day and some of them were seen fetching the fine grained *Mytilus*. Till then they had fed upon the masses of mollusc larvae, copepods and decapod larvae found in the water.

The temperature was:

0 m. ..... 20.0° C.
1 - ..... 21.4° C.
3 - ..... 21.2° C.

June 18th. The codlings kept near the bottom. Eight individuals were secured, they were from 22 to 27 mm. of length.

June 29th. The young cod could be observed close to the bottom, but scarce in number, and in the following days they disappeared alltogether. The weather had turned very hot but as the funds granted towards these experiments were insufficient to keep the steampump going renewing the water, the experiments were discontinued.

As to the growth of the cod we have the following dates:

			average length.
May 25th			4 mm.
June 12th	2 individuals	20—21 mm.	= 20.5 „
June 16th	2 —	27—28 „	= 27.5 „
June 18th	8 —	22—27 „	= 24.5 „

The measurements of June 18th give an average increment of 0.85 mm. per day.

Rearing of young cod from nature.

a. Description of the rearing experiments.

In order to have an exact material for my studies of the increment of the cod and the formation of zones in the scales 150 cod belonging to the 0 group were placed in the pond in October 1919. The cod were captured with a seine in the littoral region in the neighbourhood of the hatchery during the first week of October. On the 11th of October the fish were measured and a part of the 0 group placed in the pond. As there might be some individuals of the 1 group among the larger ones in the catches, the material taken for the experiment was selected among the smaller and medium sized individuals.

Tab. 2. **Cod 11th October 1919.**

Length cm.	7	8	9	10	11	12	13	14	15	16	Total
Total catch	2	28	48	44	40	23	25	13	5	3	231
Taken for the pond...		25	48	42	33	2					150

For the two first months the young cod were twice weekly fed with *Mytilus edulis* and *Cancer pagurus* but when the water at the surface commenced freezing in the beginning of November, and the water near the bottom was depleted of oxygen the feeding was stopped in the middle of December in order to avoid the water to putrefy. The fish was then left to seek the food among the animals growing in the pond. I found it best to do so as the cod according to my opinion needs but little food when the water is cold.

On the 27th of February the hatching was started — the water was quickly renewed and the ice melted away. In order not to spoil the water for the hatching operations the feeding of the cod was not continued till in May — when the hatching was stopped. In July the cod looked somewhat thin but in August the fish again were in a fairly good condition. In the autumn 1920 on formation of ice the feeding was stopped once more — and in the same way the following

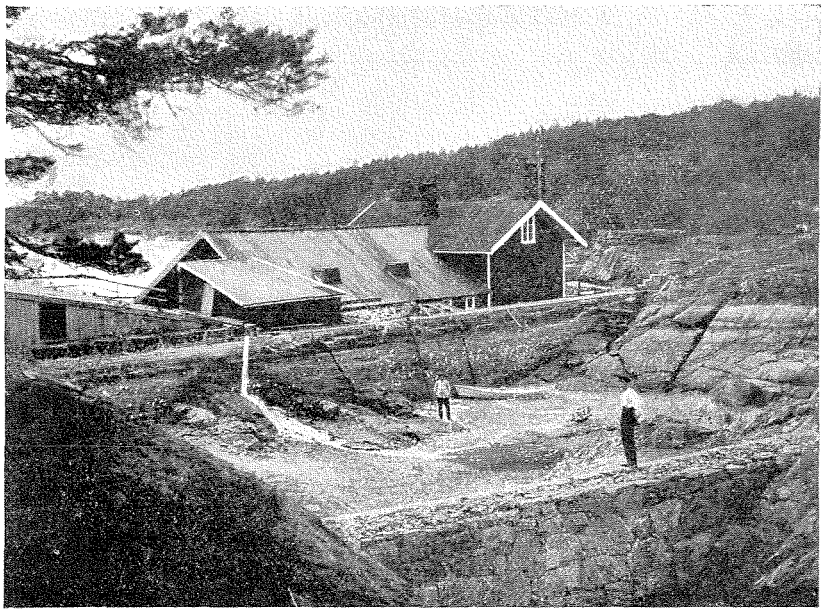


Fig. 3. The rearing pond.

year. My assistants and myself not being present at the station continually the feeding of the cod and the observation of temperature have not been carried on quite regularly. To this comes of course that the exactness of the rearing experiments suffered by the fact that the pond at the same time has also been used for hatching operations. Several of the young cod have been carried away by the current and were found dead in the water pipes etc.

b. The length increment of the cod.

On October 11th 1919 the cod measured between 8 and 12 cm. and during $2^1/_2$ years unto May 1922 the largest attained a length of 47 cm. i. e. an increase of from 35 to 39 cm. according to the length of the individual, when placed in the pond.

The number of cod examined and the length of the individuals might be seen in tab. 3.

Tab. 3. **Length of the cod.**

Length cm.	When set out.	When recaptured								
		1920						1921		1923
	11/10 1919	3/3	21/3	28/5	9-10/6	5/12	28/3	2/4	3-5/10	23/5
8	25	—	—	—	—	—	—	—	—	—
9	48	—	—	—	—	—	—	—	—	—
10	42	—	—	—	—	—	—	—	—	—
11	33	—	1	—	—	—	—	—	—	—
12	2	—	—	—	2	—	—	—	—	—
13	—	—	—	4	1	—	—	—	—	—
14	—	1	—	4	2	—	—	—	—	—
15	—	—	—	4	4	—	—	—	—	—
16	—	—	—	4	4	—	—	—	—	—
17	—	—	—	2	2	—	—	—	—	—
18	—	—	1	4	1	—	—	—	—	—
19	—	—	—	3	—	—	—	—	—	—
20	—	—	—	1	1	—	—	—	—	—
21	—	—	—	1	—	1	—	—	—	—
22	—	—	—	1	3	—	—	—	—	—
25	—	—	—	—	—	—	—	—	1	—
27	—	—	—	—	—	—	2	—	—	—
29	—	—	—	—	—	—	—	1	—	—
31	—	—	—	—	—	—	—	—	1	—
36	—	—	—	—	—	—	—	—	—	1
40	—	—	—	—	—	—	—	—	1	—
46	—	—	—	—	—	—	—	—	—	1
47	—	—	—	—	—	—	—	—	—	1
Total:	150	1	2	28	20	1	2	1	3	3
Average length	9.7 cm.	14 cm.	14.5 cm.	16 cm.	16.4 cm.	21 cm.	27 cm.	29 cm.	32 cm.	43 cm.

Table 4 gives a summary of the dates. 61 cod have been recaptured and the growth appear to have been rather regular during the

Tab. 4. **Cod recaptured.**

	Number examined	Approximate Age in months	Length cm.			Approximate number of months in the pond	Increase cm.		
			Aver.	Min.	Max		Aver.	Min.	Max.
1919.									
October 11. . . .	150	6.5	9.7	8	12	0	0	0	0
1920.									
March 3—21. . .	3	11.5	14.3	11	18	5.0	4.6	0	10
May 28.	28	14.0	16.0	13	22	7.5	6.3	1	14
June 9—10. . . .	20	14.5	16.4	12	22	8.0	6.7	0	14
December 5. . .	1	20.5	21.0	—	—	14.0	11.3	9	13
1921.									
March 28.	2	24.0	27.0	27	27	17.5	17.3	15	19
April 2.	1	24.5	29.0	—	—	18.0	19.3	17	21
October 3—5. .	3	30.5	32.0	25	40	24.0	22.3	13	32
1922.									
May 23.	3	38.0	43.0	36	47	31.5	33.3	24	39

whole year. The scanty material, however, will not permit a close examination of that question, the individual variations, are too great.

According to measurement we may be sure that the cod put into the pond in October all belong to the 0 group — and if we suppose that the hatching of the cod has been at its maximum about the first of April, we find that the cod in the pond during the first year has reached the length of about 15 cm., two years old 27—29 cm. Three years old we find three specimens between 36 and 47 cm.

c. The scale increment.

In order to examine the cod scales they are imbedded in glycerin and investigated by the aid of Edingers projection apparatus — first with a low power lens, afterwards with a strong one, and the breadth

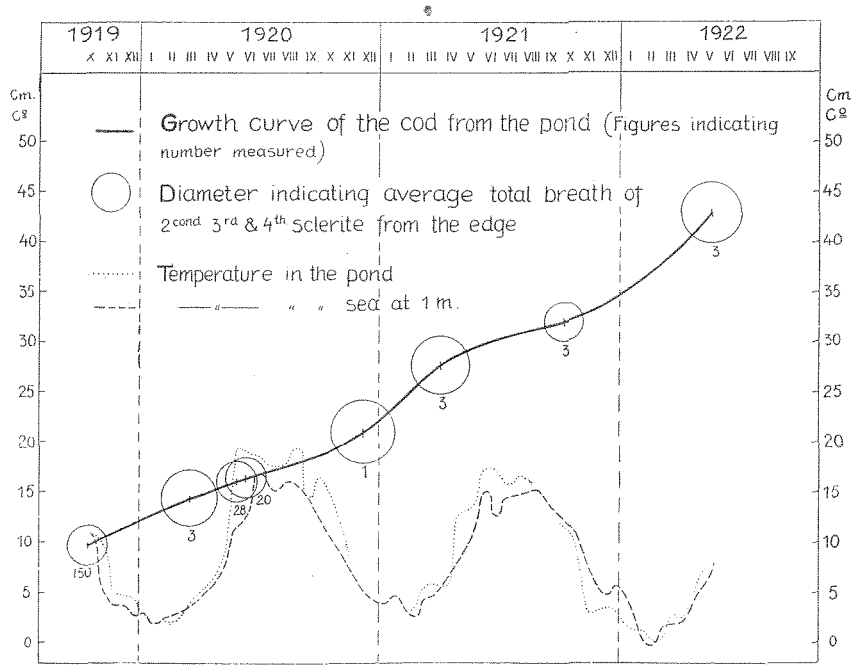


Fig. 4. Graph showing the length of the cod measured, the size of sclerites at the margin of the scale, the temperature in the pond and in the sea at a deapth of 1 m. below the surface.

of each sclerite is counted*). The measurement of the sclerites is done by placing a slip of millimeterpaper on the projection board and each sclerite being marked off on the paper slip. (Vide Lea: Report on Age and Growth of the Herring in Canadian Waters — Canadian Fisheries Expedition 1914 - 1915).

In this way we may obtain a section of the scale showing the variation in the size of the sclerites and the length of the scale. The enlargement is invariably kept on 160 : 1. In order to make these sections more usefull for later examination they are all by the aid of Lea's method, loc. cit. brougth into the same relation to the length of the fish from which they are taken. In the accompanying graphs these corrected measures have been put down on the abscisse = 1/4 of the length of the fish, the original measures as ordinates as read on the millimeterpaper counted in millimeters. The ordinate to the left presents

*) Measuring of sclerites have been undertaken previously by O. Sund: Rapports et Proces-Verbaux, Volume XX 1914. And Ø. Winge: Meddelelser fra kommisionen for havundersøkelser. Serie Fiskeri, Bind 4 No. 8.

the radial width of the central plate of the scale, ordinate no. 2 that of the first sclerite a. s. o.

According to Winge the increment of the scale of the cod is practically proportional to the growth of the fish, in this way we may

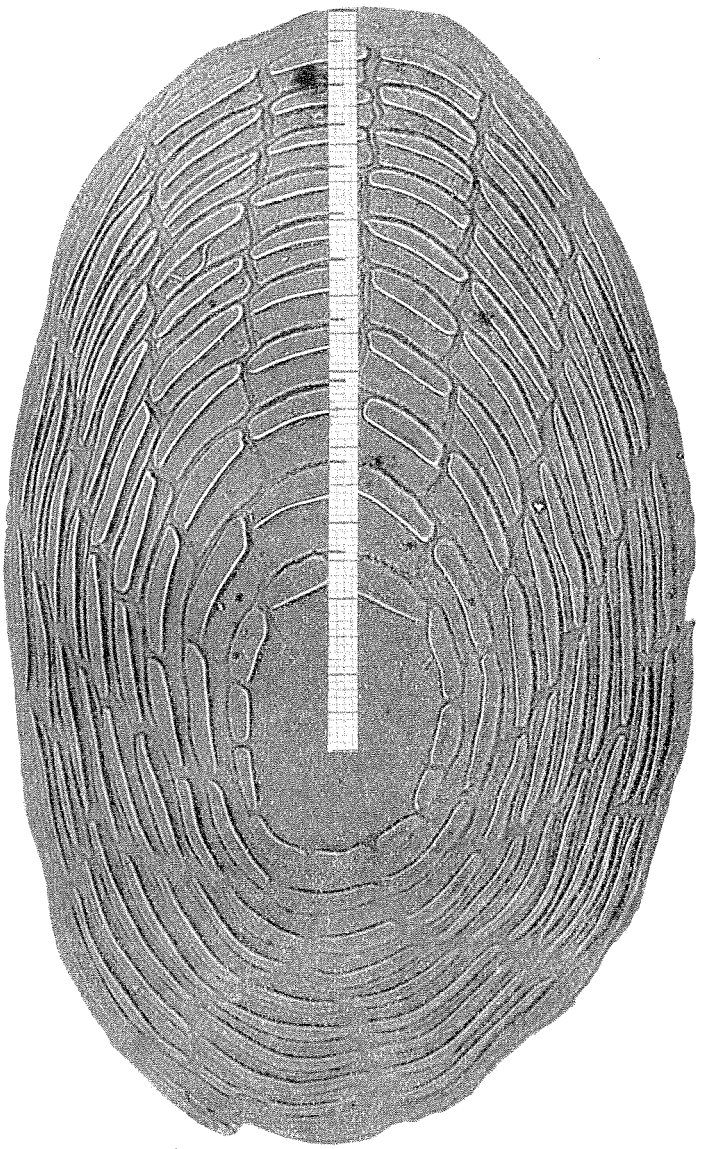


Fig. 5. [Photos no. 1.] Scale of cod 9.8 cm. October 11th 1919. (J. no. 75. Graph no. 5.) Enlargement 220 : 1. Illustrates the measurements of the sclerites.

be able to examine what was the breadth of the sclerites corresponding to each length of the fish. It would have been of interest to examine if the proportionality of the length of the fish and that of the scale holds good on this material, this question however will be subjected to a carefull examination later on.

I. The graphs no. 1 to no. 16, photos 4-7 are representing the scales from 16 cod of the same material as put into the pond. The fish are of nearly the same size and from the same date Oct. 11th 1919.

There are some variation in the breadth of the sclerites, but by taking a general view of the graphs it is evident that the sclerites are declining from the centre of the scale towards the edge, in some scales, however, with a tendency to increase in size near the edge.

The photos of the scales from these fish — photos 4-7 — illustrates this feature. In general a photo is more fit for studying a scale than a mere section of it, but when dealing with a sample the sections (graphs) — are more convenient and permit numerical calculations which are of great importance. The photos and graphs are not always from the same scale.

For comparison the photos of the scales from the smallest and largest individuals of the O group are given: Photos no. 3 and 8—9.

II. 1920 March 3rd. 1 cod recaptured. Length 14 cm. Graph no. 17, photo no. 10. As the length now was 14 cm. the individual must have grown between 2 and 6 cm. compared with the length when placed in the pond:

14 cm. $\div$ (8 to 12 cm.) = 6 to 2 cm.

The scale has broad sclerites near the edge.

III. 1920 March 21st. 2 cod recaptured.

Length: 10,5 cm. graph no. 18, photo no. 11
— 18,0 „ „ „ 19, — „ 12

The individual of 10,5 cm. has grown very little if anything, the scale is somewhat deformed or has been taken too near the dorsal fin, the scales on the flank being rubbed off in the water pipe where the fish was found. It lacks large sclerites near the edge.

The individual of 18 cm. must have grown

18 cm. ÷ (8 to 12 cm.) = 10 to 6 cm.

in less than 6 months. The scale has a lot of large sclerites near the edge.

These three specimens, march 1920, are apt to show:

1. Young cod — O group — might grow quickly during the winter.
2. Rapid growth give large sclerites, slow growth small ones.

IV. 1920 May 28th. 28 cod recaptured. Length 13—22 cm.

Graphs no. 20—47. Photos no. 13—15.

The length of the cod falls between 13 and 22 cm. the length increments accordingly within the following limits.

13 cm.—12 cm. = 1 cm.

22 cm.— 8 cm. = 14 cm.

The average growth in 7.5 month may be somewhat 6.3 cm.

When studying the graphs no. 20—47 it is obvious that the size of the sclerites in the outer part of the scale is increasing as we proceed from the smaller to the larger fish. We may get the impression that the smaller fish have been stagnating during the winter, the length increment has been slow and the appearance of the scale is in concordance herewith, displaying a number of small sclerites near the edge.

The larger fish of the sample have been growing rapidly, the graphs show a great number of large sclerites in the scale — but near the edge the sclerites are again declining.

The relation between the size of the sclerites and the length of the fish is shown in table 5.

The sclerites near the centre of the scale are omitted in order to avoid the influence of the central plate, and the last figures may be somewhat incorrect owing to the difficulty of determining the exact limits of the sclerite just formed.

Taking it for granted that the relation between the growth of the fish and that of the scale is nearly proportional we find that the formation of small sclerites falls when the cod has attained a lenght of between 7 and 9 cm. and as that size was reached before and at the time of transplanting the cod from the sea to the pond it takes place in the autumn, September to October.

Tab. 5.

Showing the average breadth of the sclerites*) for each length of the cod from the sample of May 28th, the material plotted according to the size of the fish.

Graph No:	Length of cod in centimeters.																					
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
20—23	12	12	9.5	10	9	8.5	9	9	9.5	6	—	—	—	—	—	—	—	—	—	—	—	—
24—28	14.3	12.2	10	9.8	9.4	8.4	10	8.8	10.6	11.8	7.6	—	—	—	—	—	—	—	—	—	—	—
29—33	16	12.5	9.6	9.6	9	10.4	10	11	10.4	11.6	13.2	10.2	7	4	—	—	—	—	—	—	—	—
34—38	16.3	12.6	10.4	10	10.4	9	8.8	11.8	12.6	13	14.8	13.6	9	9.3	9	—	—	—	—	—	—	—
39—43	14.6	11.2	9.8	9.6	10.2	10.4	9.8	13.2	14.6	15.4	17	16.4	13	10.6	8.8	8	—	—	—	—	—	—
44—47	14	11.5	9.3	8.8	9.3	9.5	9	11.8	14.3	13.5	14.8	15.8	16.5	14.3	12.3	11.3	11	12	12	—	—	—

*) The unite = 0.0031 mm.

It may be presumed that the diminuation of the sclerites might have continued if the cod had been left in the sea, and the formation of minimum sclerites might then perhaps have taken place in the middle of the winter, in other words: That the conditions of life in the winter have been more suitable in the pond than in the sea.

The temperatures in the pond and in the sea at a depth of 1 m. might be compared in fig. 4, the differences are insignificant.

As to the food we remember that the feeding of the cod was discontinued from the middle of December to May — the fish were then left to feed upon the quantities of food in the pond.

I cannot imagine any factors which are apt to increase the growth of the cod — but of course, the disadvantage by rearing experiments is that the results cannot be considered as quite natural. At least they must be verified by parallel investigations in the sea.

The results, however, obtained on the base of the three first individuals recaptured are confirmed.

As to maximum sclerites, they are insignificant for the smaller individuals but very conspicuous for the larger fish, but they are rapidly declining towards the edge of the scale.

The photos no. 13 - 15 give the scale of the smallest, — largest and a medium sized cod of the sample. Fig. 13 is of interest, the scale filled up with small sclerites is by some large ones divided in three zones.

V. 1920 June 9th & 10th. 20 cod recaptured. Length 12 - 22 cm.
Graphs no. 48 - 67. Photos no. 16 - 18.

The graphs are in accordance with the results arrived at on dealing with the sample of May 28th. The decline of the sclerites in the scales of the larger individuals is very marked (graphs 63 - 67). The photos no. 16 - 18 are chosen in the same way as the former ones.

VI. 1920, December 5th. 1 cod. Length 20.7 cm.
Graph no. 68. Photo no. 19.

The sclerites near the edge are very large. I want to draw attention to this fact as the photo at a glance may be taken as

not convincing. Both the basal and upper contours of the sclerites have become more distinct than usual and may be misleading. The scale show two minima, the first when the fish was 7 - 9 cm. and the second when 12 - 14 cm. of length.

VII. 1921, March 28, two individuals. Length 27 cm.

Graph no. 69 and 70. Photos no. 20 - 21.

Of interest are the two minima — the first when the fish were 8 - 10 cm. the second when about 14 - 16 cm. of length. Notice large space of broad sclerites near the edge.

VIII. 1921, April 2nd. One inividual. Length 29 cm.

Graph no. 71. Photo no. 22.

There are two minima — but not very pronounced, the last one at a considerable distance from the edge.

It is characteristic of these 4 specimens from the winter 1920 - 1921 that the scales show 2 minima at a considerable distance from the margin although the fish has not reached the age of two years till the spring 1921.

IX. 1921 October 3—5. 3 individuals. Length 25—40—31 cm.

Graph no. 72—73—74. Photos no. 23—25.

These three specimens are 2½ years of age but the scales show 3 minima. The last one near the edge, has obviously been formed in the space of time just preceding the date of capture i. e. in the month of September.

X. 1922 May 23th. 3 individuals. Length 36—46—47.

Graphs no. 75—76—77. Photos no. 26—28.

The sclerite measurements are not very convincing — except for the larger one (Graph no. 77) but all of the scales give 3 minima. Photo no. 26 has a „secondary" minimum, but it is not conspicuous enough to cause confusion. The distance between the first and second minimum is very narrow for all specimens, indicating a slow growth at that time. Later on, however, the growth has been very good and the third minimum is situated at a good distance from the margin of the scale.

d. Summary of scale studies.

The scales from the codlings from 11th october 1919 show that the sclerites are declining towards the edge of the scale. The three specimens from March—April 1920 show large sclerites except for the smaller one.

On the 28 of May 1920 we find the smaller individuals with small sclerites — the great individuals with a number of larges ones, but with a tendency of declining towards the edge. The material from 9th to 10th of June confirms these facts.

Three specimens from the winter 1920—1921 show large sclerites near the edge and two minima although the age of two years is not reached till the spring of the same year.

1921 October 3—5 three specimens show three minima although the fish are but 2 1/2 years of age — and small sclerites at the margin.

1922 May 23th the three specimens show three minima in the scales, the last one at a considerable distance from the margin.

On the basis of the facts mentioned we may get the impression that the formation of small sclerites normally takes place in the autumn or late in the summer. For the individuals with slow growth the formation of small sclerites might be prolonged during the winter — slow growth give small sclerites.

The formation of maximum sclerites takes place during the winter, and as the measures show great length increment of the cod during that time, the theory of correspondence between rapid growth and large sclerites, and vice versa may be taken for verified. Figure 4 illustrates this feature — the largest sclerites occur when the curve is rizing.

The term of "winterzones" for the zones formed by the small sclerites must be abandoned. We may speak of zones with minimum sclerites, or resting zones.

In the case of the rearing experiments the resting zones are normally formed during late summer and the same is the case as regards the material taken from the sea during October 1919.

The number of resting zones in the majority of individuals examined gives the age of the cod, or more explicit, it tells us how many autumns the fish has lived. The greatest difficulties appear when dealing with the slow growing individuals, the lack of large sclerites makes the resting zones to intermerge, being often only separated by a few medium sized sclerites.

On the other hand such medium sclerites might appear in the middle of a resting zone, in such cases we may erroneously be inclined to count two zones. This is the case especially when dealing with the medium sized material from May and June 1920.

As mentioned in the preface I will not on the basis of the rearing experiments discuss the problem of annual zones in the cod scales from nature, I will only draw the attention of the scientists dealing with age determination to the facts mentioned.

I hope later on to be able to give the results of more detailed experiments on the problem, and also of my investigations on the age and growth of the cod in nature.

Fig. 6. [Photos no. 2.] Scale of cod 15 cm. May 28th 1920.
J. no. 430. Graph no. 31. Enlargement 130 : 1.
Illustrates the occurrence of large sclerites in a resting zone.

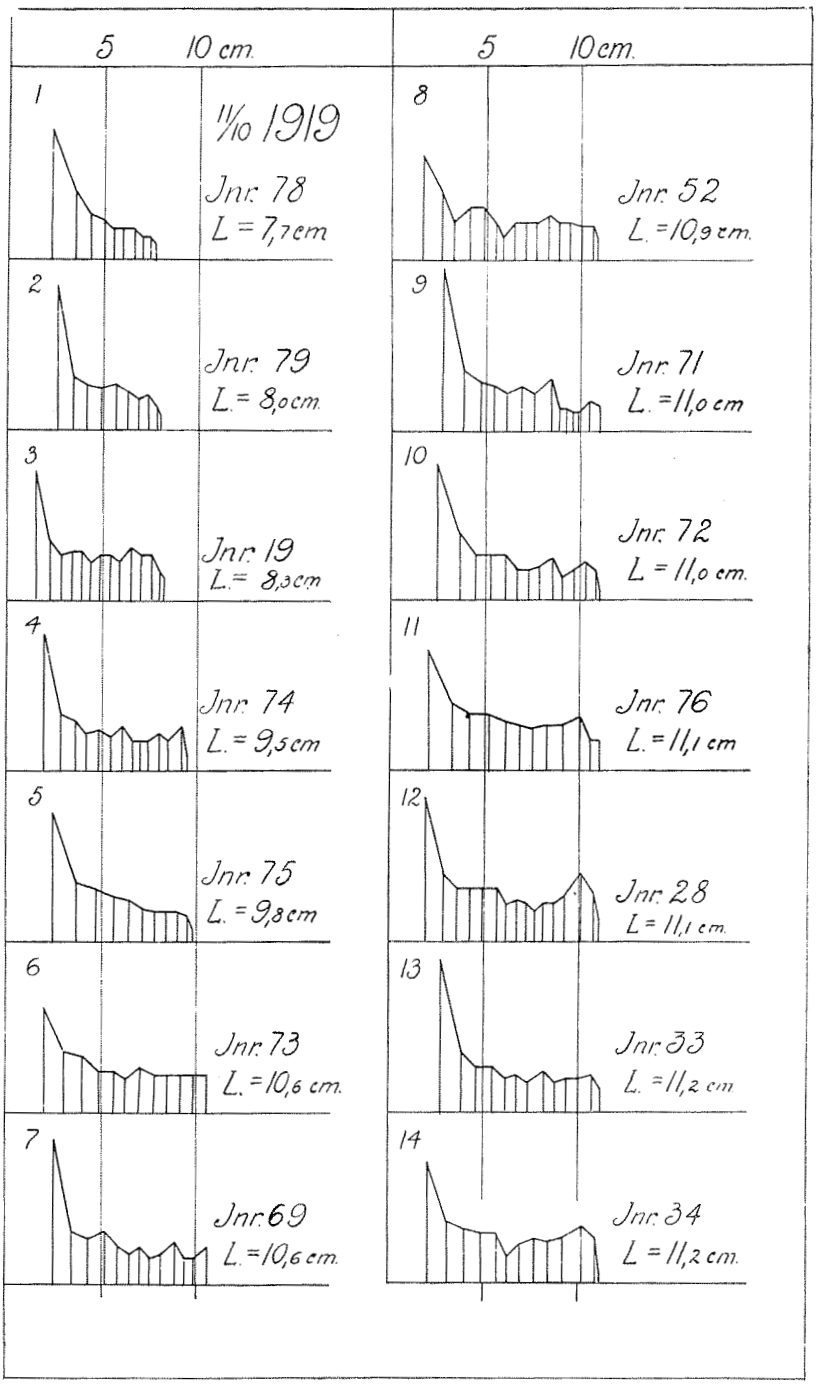
Plates.

Pl. I—VII graphs of sclerites put down according to date, and according to the length of the fish within the same sample.

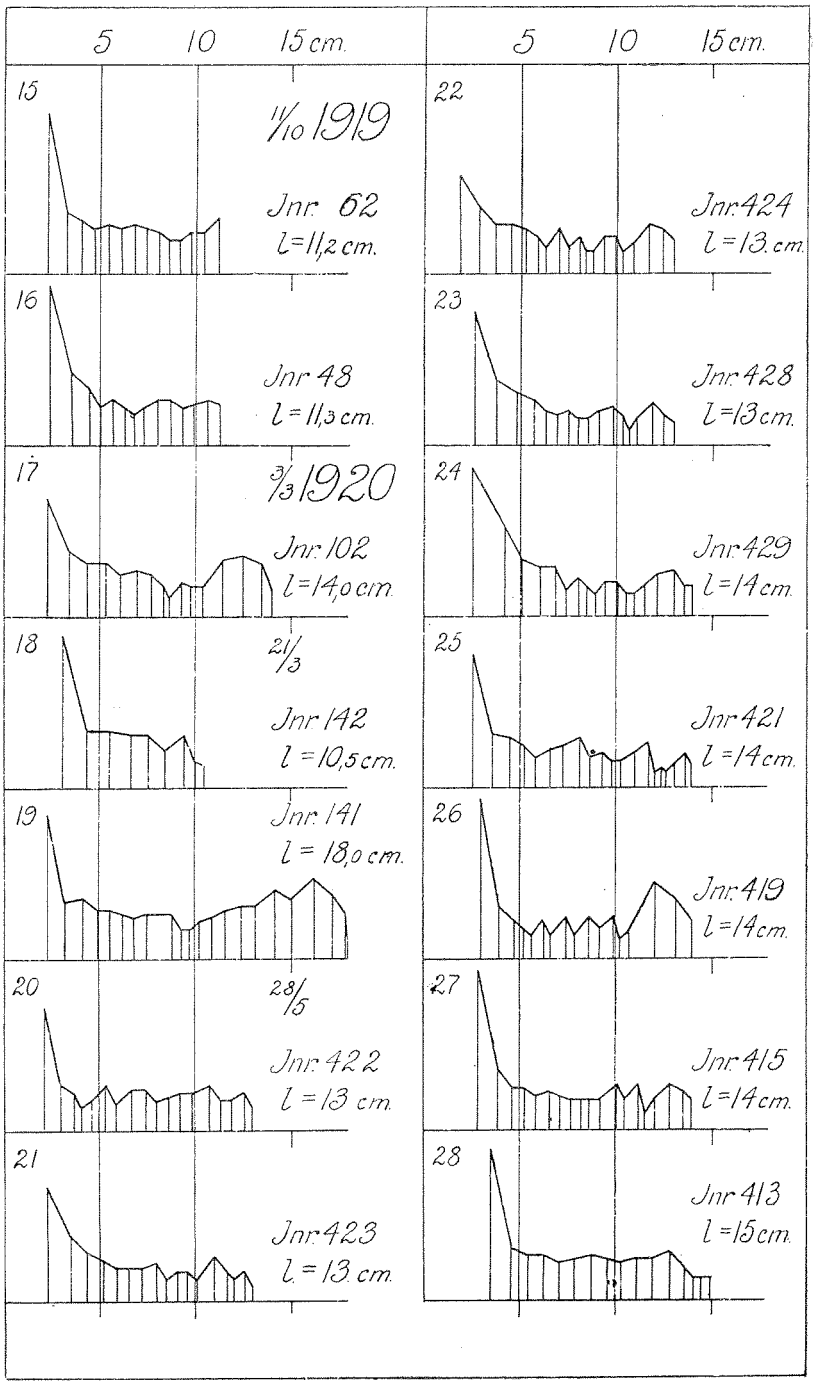
Pl. VIII—XIII photos of cod scale (× 40.):

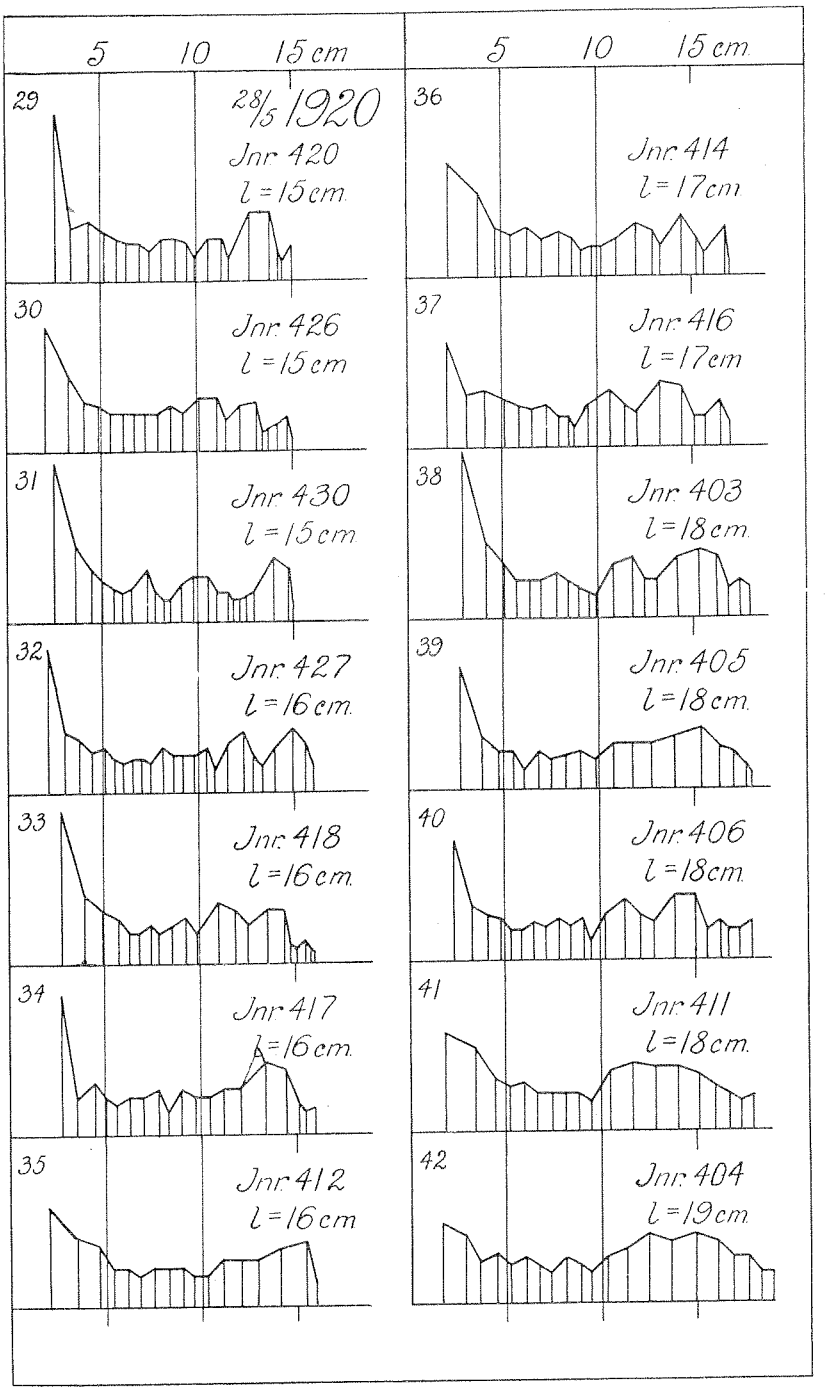
The graph No. is put in ( ) beside the number of the figure.
Photos and graphs not always from the same scale.

Pl. VIII.	Photo no. 3.		$^{11}/_{10}$. 1919.	J. no. 81.	L. = 7.0	cm.
	„ „ 4.	(1)	$^{11}/_{10}$. 1919.	J. no. 78.	L. = 7.7	„
	„ „ 5.	(3)	$^{11}/_{10}$. 1919.	J. no. 19.	L. = 8.3	„
	„ „ 6.	(5)	$^{11}/_{10}$. 1919.	J. no. 75.	L. = 9.8	„
	„ „ 7.	(16)	$^{11}/_{10}$. 1919.	J. no. 48.	L. = 11.3	„
	„ „ 8.		$^{11}/_{10}$. 1919.	J. no. 70.	L. = 12.0	„
	„ „ 9.		$^{11}/_{10}$. 1919.	J. no. 16.	L. = 16.1	„
	„ „ 10.	(17)	$^{3}/_{3}$. 1920.	J. no. 102.	L. = 14.0	„
	„ „ 11.	(18)	$^{21}/_{3}$. 1920.	J. no. 142.	L. = 10.5	„
Pl. IX.	„ „ 12.	(19)	$^{21}/_{3}$. 1920.	J. no. 141.	L. = 18.0	„
	„ „ 13.	(20)	$^{28}/_{5}$. 1920.	J. no. 422.	L. = 13.0	„
	„ „ 14.	(35)	$^{28}/_{5}$. 1920.	J. no. 412.	L. = 16.0	„
	„ „ 15.	(47)	$^{28}/_{5}$. 1920.	J. no. 408.	L. = 22.0	„
	„ „ 16.	(48)	$^{9}/_{6}$. 1920.	J. no. 432.	L. = 12.0	„
	„ „ 17.	(57)	$^{10}/_{6}$. 1920.	J. no. 439.	L. = 16.0	„
	„ „ 18.	(67)	$^{9}/_{6}$. 1920.	J. no. 431.	L. = 22.0	„
Pl. X.	„ „ 19.	(68)	$^{5}/_{12}$. 1920.	J. no. 534.	L. = 20.7	„
	„ „ 20.	(69)	$^{28}/_{3}$. 1921.	J. no. 167.	L. = 27.0	„
	„ „ 21.	(70)	$^{28}/_{3}$. 1921.	J. no. 181.	L. = 27.0	„
	„ „ 22.	(71)	$^{2}/_{4}$. 1921.	J. no. 182.	L. = 29.0	„
Pl. XI.	„ „ 23.	(72)	$^{3}/_{10}$. 1921.	J. no. 556.	L. = 25.0	„
	„ „ 24.	(73)	$^{3}/_{10}$. 1921.	J. no. 555.	L. = 40.0	„
	„ „ 25.	(74)	$^{5}/_{10}$. 1921.	J. no. 557.	L. = 31.0	„
Pl. XII.	„ „ 26.	(75)	$^{23}/_{5}$. 1922.	J. no. 213.	L. = 36.0	„
	„ „ 27.	(76)	$^{23}/_{5}$. 1922.	J. no. 212.	L. = 46.0	„
Pl. XIII.	„ „ 28.	(77)	$^{23}/_{5}$. 1922.	J, no. 211.	L. = 47.0	„

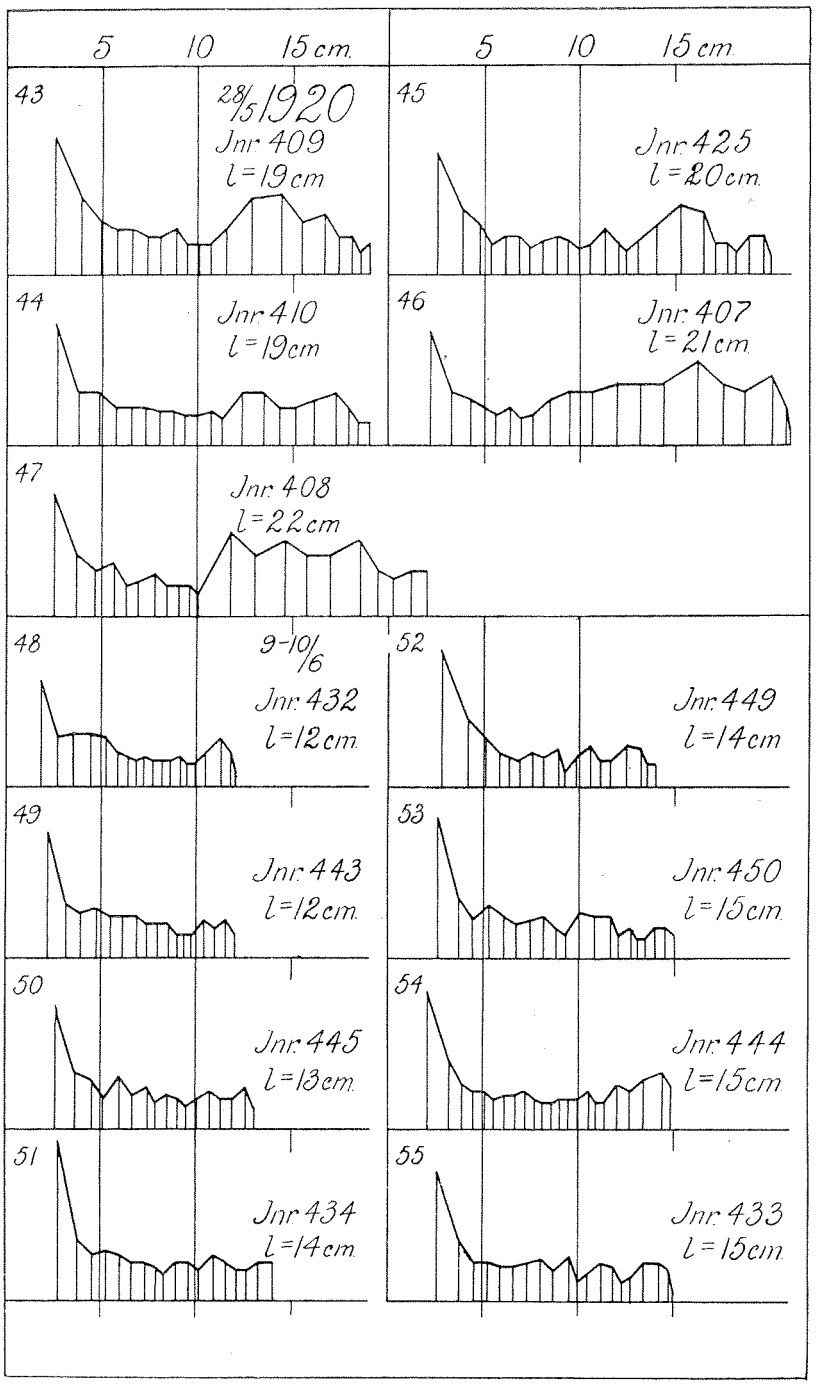

5 10 cm.
1
11/10 1919
Jnr. 78
L = 7,7 cm
2
Jnr. 79
L. = 8,0 cm.
3
Jnr. 19
L. = 8,3 cm
4
Jnr. 74
L. = 9,5 cm
5
Jnr. 75
L. = 9,8 cm
6
Jnr. 73
L. = 10,6 cm.
7
Jnr. 69
L. = 10,6 cm.
5 10 cm.
8
Jnr. 52
L. = 10,9 cm.
9
Jnr. 71
L. = 11,0 cm
10
Jnr. 72
L. = 11,0 cm.
11
Jnr. 76
L. = 11,1 cm
12
Jnr. 28
L. = 11,1 cm.
13
Jnr. 33
L. = 11,2 cm
14
Jnr. 34
L. = 11,2 cm.

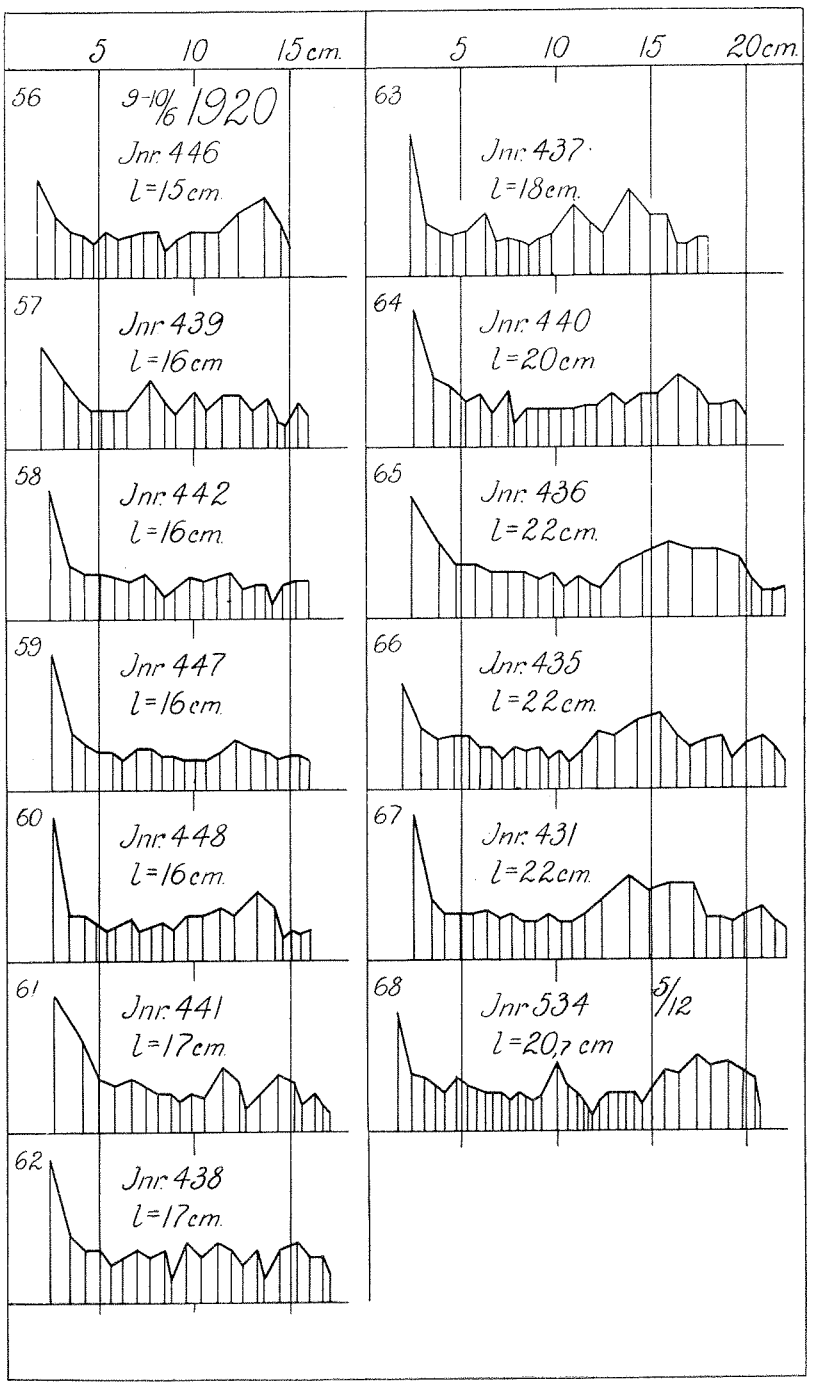
Pl. II.


5
10
15 cm.
15
1/10 1919
Jnr. 62
l = 11,2 cm.
16
Jnr 48
l = 11,3 cm.
17
3/3 1920
Jnr. 102
l = 14,0 cm.
18
21/3
Jnr 142
l = 10,5 cm.
19
Jnr. 141
l = 18,0 cm.
20
28/5
Jnr. 422
l = 13 cm.
21
Jnr. 423
l = 13 cm.
22
Jnr. 424
l = 13 cm.
23
Jnr. 428
l = 13 cm.
24
Jnr. 429
l = 14 cm.
25
Jnr. 421
l = 14 cm.
26
Jnr. 419
l = 14 cm.
27
Jnr. 415
l = 14 cm.
28
Jnr. 413
l = 15 cm.

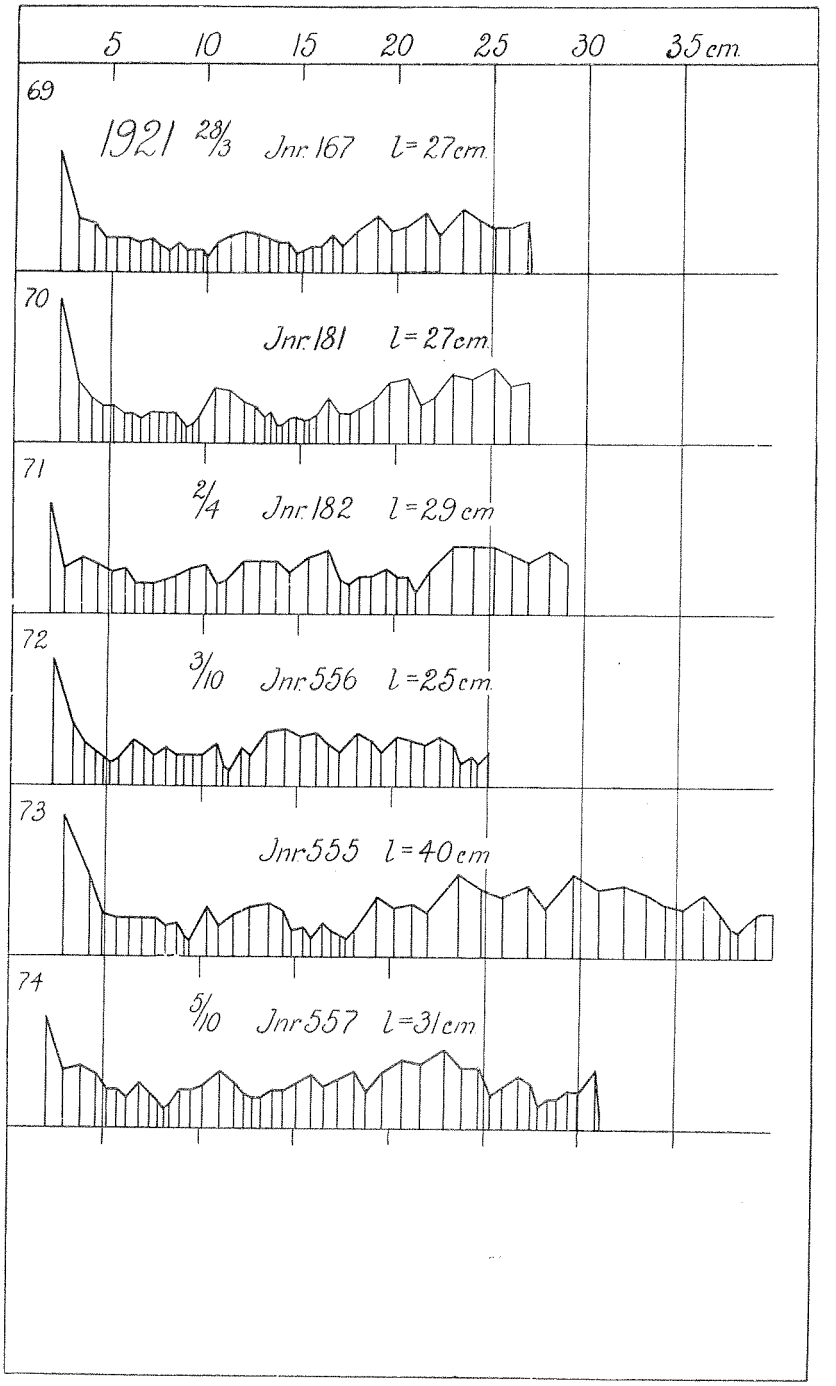

5
10
15 cm
29
28/5 1920
Jnr. 420
l = 15 cm.
30
Jnr. 426
l = 15 cm
31
Jnr. 430
l = 15 cm.
32
Jnr. 427
l = 16 cm.
33
Jnr. 418
l = 16 cm.
34
Jnr. 417
l = 16 cm.
35
Jnr. 412
l = 16 cm
5
10
15 cm.
36
Jnr. 414
l = 17 cm.
37
Jnr. 416
l = 17 cm.
38
Jnr. 403
l = 18 cm.
39
Jnr. 405
l = 18 cm.
40
Jnr. 406
l = 18 cm.
41
Jnr. 411
l = 18 cm.
42
Jnr. 404
l = 19 cm.

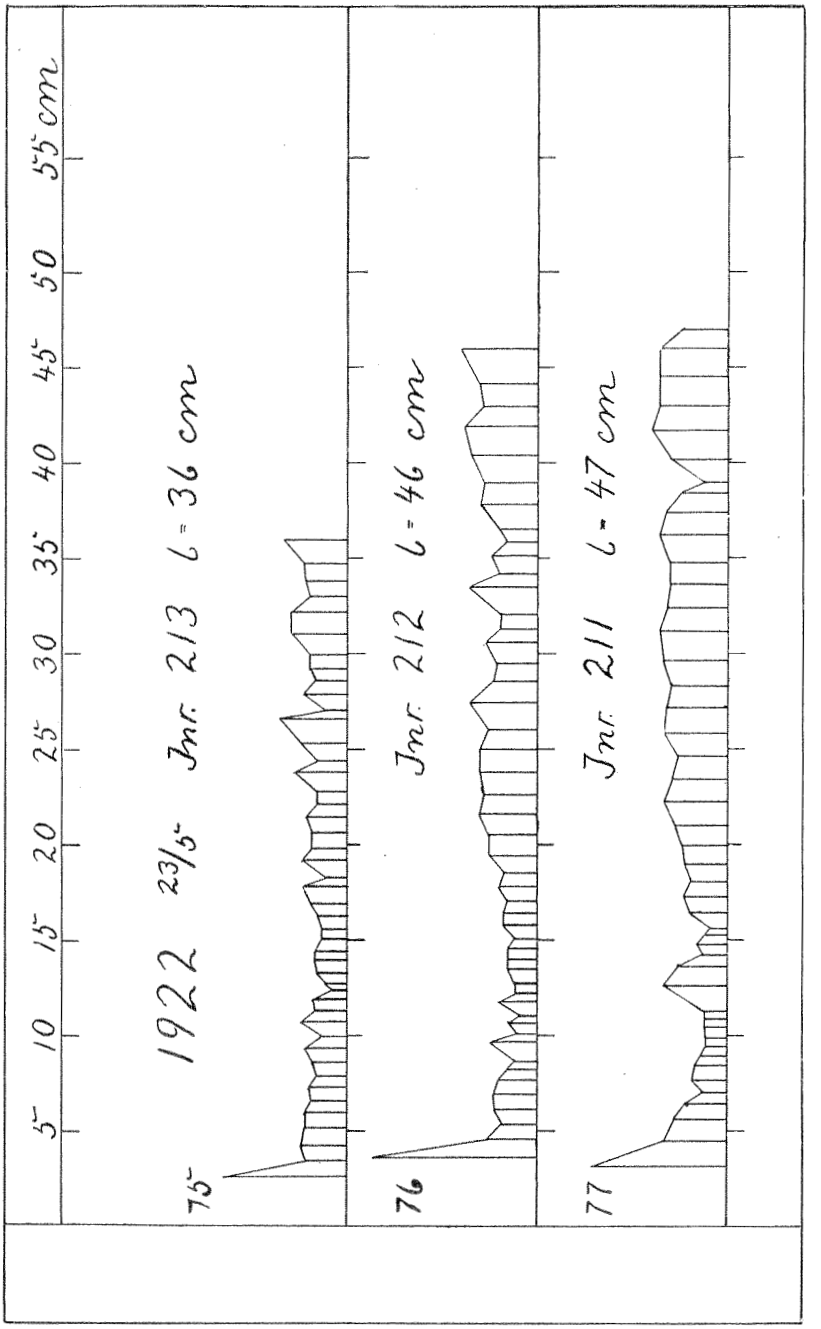
Pl. IV.


5
10
15 cm.
43
28/5 1920
Jnr. 409
l = 19 cm
44
Jnr. 410
l = 19 cm
45
Jnr. 425
l = 20 cm.
46
Jnr. 407
l = 21 cm
47
Jnr. 408
l = 22 cm
48
9-10/6
Jnr. 432
l = 12 cm.
49
Jnr. 443
l = 12 cm.
50
Jnr. 445
l = 13 cm.
51
Jnr. 434
l = 14 cm.
52
Jnr. 449
l = 14 cm
53
Jnr. 450
l = 15 cm.
54
Jnr. 444
l = 15 cm.
55
Jnr. 433
l = 15 cm.


5
10
15 cm.
56
9-10/6 1920
Jnr. 446
l=15 cm.
57
Jnr. 439
l=16 cm
58
Jnr. 442
l=16 cm.
59
Jnr. 447
l=16 cm.
60
Jnr. 448
l=16 cm.
61
Jnr. 441
l=17 cm.
62
Jnr. 438
l=17 cm.
5
10
15
20 cm.
63
Jnr. 437
l=18 cm.
64
Jnr. 440
l=20 cm
65
Jnr. 436
l=22 cm.
66
Jnr. 435
l=22 cm.
67
Jnr. 431
l=22 cm.
68
Jnr. 534
5/12
l=20,7 cm

Pl. VI.


5
10
15
20
25
30
35 cm.
69
1921 28/3 Jnr. 167 l = 27 cm.
70
Jnr. 181 l = 27 cm.
71
2/4 Jnr. 182 l = 29 cm.
72
3/10 Jnr. 556 l = 25 cm.
73
Jnr. 555 l = 40 cm.
74
5/10 Jnr. 557 l = 31 cm.


5 10 15 20 25 30 35 40 45 50 55 cm
75 1922 23/5 Jnr. 213 l = 36 cm
76 Jnr. 212 l = 46 cm
77 Jnr. 211 l = 47 cm

Pl. VIII.
[Photos 3—11]

3

4

5

6

7

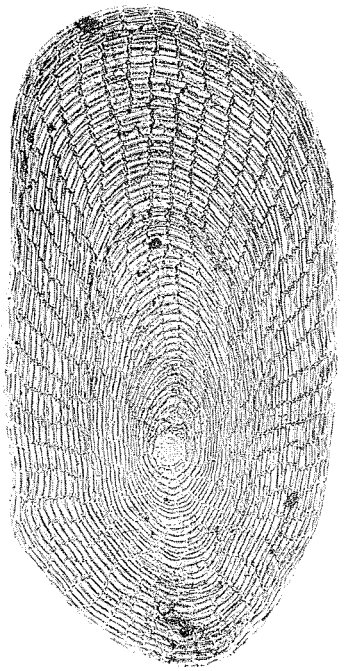
8

9

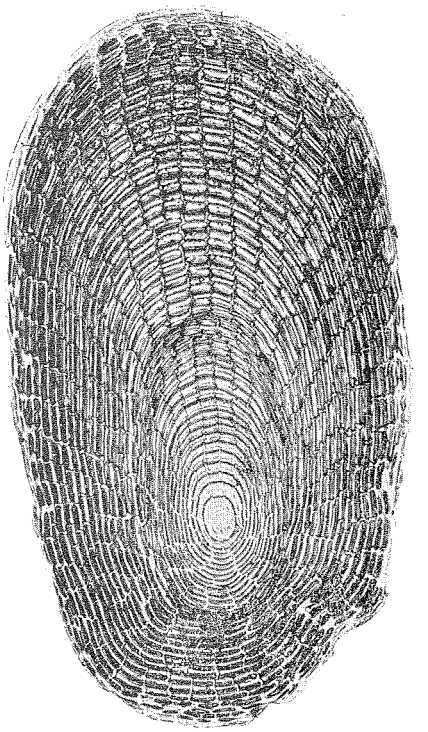
10

11

Pl. XI.
[Photos 23—25]



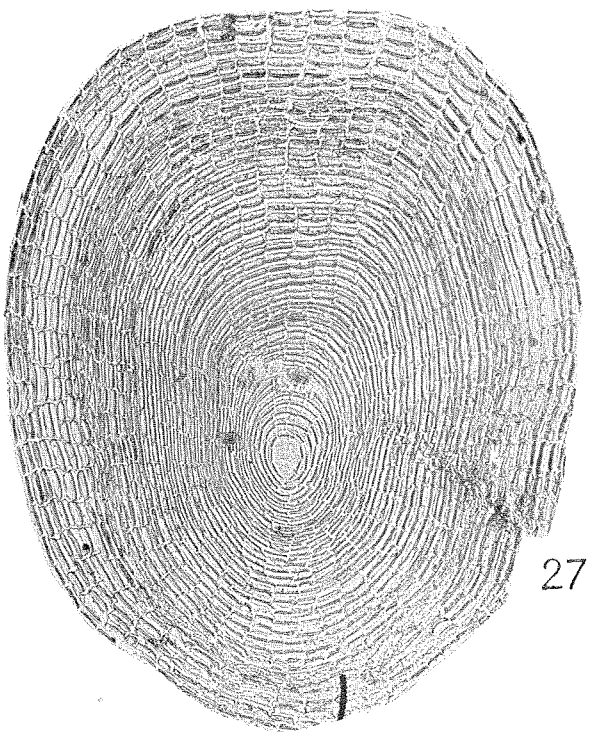
23



24

25

26



27

Pl. XIII.
[Photos 28]

28