

The Littoral Cod of the Norwegian Skagerrak Coast

by
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In the coastal waters of southern Norway the fishermen distinguish between three different types of cod.

The "dyptorsk" living in deep water in the fjords and in the skjærgård, and especially outside the coastal banks.

The "tareorsk" is living in the shallow waters of the skjærgård.

The "fjordorsk" lives in the shallow waters of the fjords and in narrow sounds.

The characters used by the fishermen to separate the different types are colour and body proportions. These characters are, however, influenced by the environments and rate of growth. The different types may be phenotypes. But we must also take into consideration that genotypical factors may come into the problem. The possibility exists that the young of the deep-sea cod will seek the deep layers, and grow up to a deep-sea cod. And the young of the littoral cod will prefer the littoral region. That question cannot, however, be discussed on the basis of the material at hand.

The investigations referred to here will show that the population of cod in the skjærgård differ in several ways from the cod in the fjords. And the population in one fjord differs from that in another. As to the deep-sea cod the material is too scanty.

The Oslofjord material will be dealt with separately by cand. real. Finn Otterbech.

The Colour.

In 1932 Dr. Erling Sivertsen, then assistant at this laboratory, examined the colour and food of 421 cod of the 0-group. The fish was caught in the littoral region of the fjords and inner skjærgård between Kragerø and Mandal 20/9 - 1/10 1932.

The cod was divided into 5 groups according to the abundance of red chromatophores. Those with little red pigment had a greenish shade owing to the predominance of the yellow pigment.

The result (not published) was the following:

Colour of fish	I	II	III	IV	V
	(Red)	(Intermediate)			(Green)
Crustacean only	7 (29%)	36 (48%)	132 (59%)	15 (25%)	11 (28%)
Fish only	5 (21%)	17 (23%)	64 (29%)	35 (58%)	19 (49%)
Crustaceans and fish	12 (50%)	22 (29%)	27 (12%)	10 (17%)	9 (23%)
Total	24	75	223	60	39

It is evident that crustaceans are the most prominent food in the redcoloured types, and fish in the greenish types.

Sivertsen states that the different types often occurred in the same area. It was apparent that the young cod selected a special type of food. Whether this selection resulted in special colour types - or if the special types selected different food - is an open question.

Owing to the cod in some degree being able to adopt the colour of the surroundings the problem is difficult. By examining the character of the chromatophores, however, it is evident that great variations do occur. The colours existing are black, red and yellow. In deep-sea cod the red chromatophores seem to be totally lacking. In the littoral cod of the skjærgård the red chromatophores are dominating. In extreme cases even the flesh may attain a pink colour. In cod from the fjords yellow pigment is often abundant.

The ability of the cod "to change colour" is a limited one. A deep-sea cod cannot turn red. When different types of cod are kept together in a pond they all adopt a dark colour. The black colours dominate.

The problem of the colour of the cod is, however, till now not studied in details.

Another character mentioned by the fishermen is the body proportions of the fish. The cod living near the coast is more slender than that of the fjords. As the proportions are affected by the rate of growth and size of maturity, this character will be dealt with in connection with those problems.

The Growth of the Cod.

In a paper: "The Variation in Growth of Young Codfishes from the Norwegian Skager Rack Coast" (3) I have demonstrated that the length of the 0-group may vary between neighbouring places in the same fjord. In this case it must be assumed that the young fish must be of the same age and of the same offspring, the difference in growth must be ascribed to differences in the milieu. The growth appears to be relatively slow in the most stagnant parts.

In the same paper it is demonstrated that the length of the 0-group in the autumn varies from fjord to fjord. The pollack varies in the same way - to a higher degree. The whiting, however, diverges in the western fjords. The resulting length of the 0-group in different fjords may be influenced by the time of spawning. The spawning and hatching of eggs may occur earlier in some fjords than in others. In neighbouring fjords, however, this is hardly of importance. The largest mean size is found near the coast. But a length of more than average is also found in one insulated fjord (Hellefjord).

As to the older yearclasses we have sufficient material from the skjærgård (Flødevigen), from the Søndeledfjord to the east - near Risør and from the outer part of the Topdalsfjord near Kristiansand. We have also the measurements and age determinations of the spawners from the hatchery. The cod is bought in the market and is mostly fished in the skjærgård. As we are selecting large fish only, the mean length of the youngest yearclass (III) is not representative.

For the experimental fishing in the fjords and at Flødevigen the values for yearclass I only represent the largest individuals.

The tables I and II give the measurements quarterly for yeargroup I and II, and halfyearly for the elder. The table I gives the material for 1922 - 29, and table II for 1930 - 1953.

The measurements of the cod from the Topdalsfjord, Flødevigen and the hatchery show no differences between the early and late period. This is, however, the case as far as concerns the insulated Søndeledfjord. It is apparent from fig. 2a that the mean length of the yearclasses III - V is decidedly higher, about 5cm., in the years 1930 - 1942. In the same period the catches per gear has decreased considerably. We may here have an example that the rapidity of growth of the cod is influenced by the number of fish.

The fig. 2b illustrates the difference in the length of fish in the different waters. The rapidity of growth is smallest in the Søndeledfjord. Then comes Topdalsfjord, Flødevigen and the spawners from the skjærgård.

At the normal age of spawning, 4 years, we have the mean length at:

Søndeledfjord, approximately	50cm.
Topdalsfjord, " "	55 "
Flødevigen, " "	62 "
Spawners, " "	64 "

The growth intensity of the cod on the Norwegian Skagerrak Coast augments from the insulated fjord to the open coast.

Age and Size of Maturity.

K. Dahl (1) has examined the age and size of the spawning cod in the Søndeledfjord. From his table E 4 we have the following results as to 138 cod caught 25/11 - 1905. It should be observed that the individuals determined as ripe will not spawn till in spring, and will then belong to the next higher yearclass. This correction is made in this extract.

Yearclass	III	IV	V	VI	VII
No. examined	66	46	20	3	3
No. ripe	36	36	19	3	3

At an age of 3 years 54% will spawn. At an age of 5 years 95%.

Sivertsen (526) has studied the development of testis and ovaries of the cod caught mostly in the skjærgård near Flødevigen.

As most of the cods have been collected for hatching purposes the younger year-classes are not represented. Only the large specimens have come into the material.

The results were the following:

Yearclasses:	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
1932											
<u>Males</u>											
No. examined	8	16	3	86	36	10	28	2	4		
No. ripe	0	0	0	80	34	10	29	2	4		
<u>Females</u>											
No. examined	20	18	9	168	57	11	38	13	6	3	1
No. ripe	0	0	1	147	51	10	37	13	6	3	1
1934/35											
<u>Males⁺⁾</u>											
No. examined			1	89	102	87	38	5	4		
No. ripe			1	77	92	82	35	4	4		
<u>Females</u>											
No. examined			8	158	168	120	56	12	1	1	
No. ripe			8	141	152	111	54	12	1	1	

⁺⁾ And one ripe 13 years of age.

It is of interest to note that we here have unripe fish till an age of 7 years. But we also find spawners at an age of 3 years. But only large specimens.

The average length of the spawners from Søndeledfjord 1905 and Flödevigen 1934/35 (♂ + ♀) is the following:

Yearclass:	III	IV	V	VI	VII	VIII	IX	X	XI
Søndeledfjord cm.	30.3	33.3	57.6	48.3	54.0				
No. measured	36	36	19	3	3				
Flödevigen 1934/35 cm.	63.2	71.2	75.6	77.8	78.5	78.2	79.0	93.0	80.0
No. measured	9	257	274	220	95	17	6	1	1

For the elder yearclasses in Søndeledfjord and the yearclass III from Flödevigen, the material is small. It is evident, however, that the length when reaching maturity is far greater at Flödevigen than in the insulated Søndeledfjord. No wonder that the fishermen have observed a difference in body proportions. The cod from the fjords is corpulent, the cod from the skjærgård is slender.

Number of Vertebrae.

The results of countings of vertebrae are reported upon by Alf Dannevig (2). As the biology of the cod of the rich 1938 yearclass was quite abnormal, the values for that yearclass was given separately. The totals for the coast between Kragerø and Kristiansand are the following:

	1928/39 1938 excluded		1938		1925/35
	O-Gr.	I-Gr.	O-Gr.	I-Gr.	Spawners
No. of Vertebrae	52.07	51.92	52.05	52.11	51.92
No. of Cod	2.565	696	2.143	154	3.242

The O- and I-group are caught in the littoral region. And the spawners are littoral cod.

It is very interesting that the no. of vertebrae of the O-group of the 1928/39 material is higher than that of the I-group and that of the spawners. The last two correspond. We must assume that the high value of the O-group is the result of some intermingling of codlings not belonging to the littoral region. Those will apparently at an age of approximately one year leave the littoral region. We have the same phenomenon in northern Norway, where the young of the skrei seek deeper water, whereas the young of the littoral cod stay in the littoral region.

The no. of vertebrae of the O-group 1938 corresponds to that of the 1928/39 yearclasses. The material for the I-group is insufficient, but gives still higher values.

The biology of the exceedingly rich yearclass 1938 was quite abnormal, the young being pelagic till late in summer. Normally the young cod will seek to the bottom in early June. The biology indicates that the 1938 yearclass to a considerable degree was a foreign element.

The detail ed. tables indicated that the no. of vertebrae augmented from the eastern to the western part of the coast.

In the following table the averages are given for the means of the different fjords:

	1928/39 1938 excluded		1938
	O-Gr.	I-Gr.	O-Gr.
Kragerø-Arendal	51.89	51.76	52.02
Arendal-Grimstad	52.12	52.03	52.04
Grimstad-Kristiansand	52.15	52.12	52.09

The difference is high for the 1928/39 material, less so for the 1938 year-class. This may be explained in the way that we in 1938 had an influx of codlings from the inner Skagerak. The No. of vertebrae of this foreign fish suppressed the normal variation of the native cod.

The no. of vertebrae varies somewhat from year to year, both in the O-group countings, and in those of the elder fish. It is reasonable to assume that this is the result of a varying degree of intermingling of different populations, or an effect of external factors on the development of the embryo.

Migrations.

In 1904 and 1905 K. Dahl (1) tagged about 700 cod, mostly between 25 and 40cm. in the Søndeledfjord and skjærgård outside Risør. 97 were recaptured. The distance between place of liberation and recapture was on an average 0,31 naut.mile. One specimen, liberated in deep water in the fjord was recaptured outside the fjord, at a distance of 1,25 naut.mile.

R. Løversen (4) tagged 473 medium sized cod in the skjærgård and the Søndeledfjord. During the first year 239 were recaptured, 33 in the second and 6 in the third year. The total was 59% recaptured.

The distance between place of liberation and recapture was the following:

0 - 1 km	137 = 49%
1 - 2 "	65 = 23%
2 - 5 "	53 = 21%
> 5 "	18 = 7%

The recapture according to the length of fish when tagged was:

Length in cm. when tagged	Number		%
	Tagged	Recaptured	
10 - 20	20	10	50
21 - 30	198	110	55
31 - 40	225	137	61
41 - 50	25	17	68
over 50	5	4	80
	473	278	59%

The percentage of recapture is very high - especially for the larger fish.

The migrations are very restricted. Of the fish tagged in the Søndeledfjord some were recaptured in the skjærgård just outside the fjord. And vice versa. The validity of such exceptional migrations are questionable. The migration may be an effect of tagging. Especially if the fish is liberated over deep water.

The Variations in the Strength of Yearclasses.

Fig. 3 illustrates the variation in the occurrence of the 0-group of some gadidae in the littoral region of the fjords and inner skjærgård. The fish is caught in a fine-meshed seine between Kragerø and Mandal. The hauls are made in the same locality in September every year. During the war no fishing took place.

The fishermen are aware of the fact that the occurrence of the pollack is varying very much. In the beginning of this century the pollack was a rare fish in these waters. During the first world-war it was abundant both in the fjords and in the skjærgård. It spawns in the fjords and in the skjærgård. The biology of the young pollack is very like that of the cod. The 0-group of the whiting is more pelagic.

The variations of the cod and the pollack are nearly parallel. The number pr. haul is decreasing. The whiting, however, is keeping status.

The turning point for the cod and pollack occurs in 1930. It has been discussed if the deterioration of the *Zostera* may be a factor of importance - making the shallow waters less attractive to the young. It is difficult to come to any valid conclusion on that point. It is worth mentioning, however, that it was not till 1933 that the *Zostera* disappeared from this coast, and later it has gradually regenerated. And besides - we have some very strong yearclasses also in 1938 and 1945.

There has been no apparent intensifying of the fishery, although during the war the fishing in the inner waters was very intense.

Fig. 4 gives the results of the experimental fishing with traps in Søndeledfjord, Flødevigen and Topdalsfjord. Most of the fish is 1 to 3 years of age (Fig. 5).

The fishing in the fjords was stopped in 1942 - it was not possible to get material for the gear used. The curves for the two fjords run parallel, the catch per gear decreases. In 1939, however, we have fine catches in the Søndeledfjord. It was the strong yearclass 1938 which then appeared in the gears at an age of 1 to 2 years. It is interesting to note that this yearclass was not outstanding in the Topdalsfjord. The catches at Flødevigen have not decreased. Flødevigen is situated near the open coast.

The results in the fjords are in full agreement with the results of the fishing for the 0-group in the littoral region of the fjords and inner skjærgård.

We must assume that the propagation of the cod in the fjords is too small to maintain the stock of 0-group and young. The spawning near the coast is evidently still high enough to maintain the fishery for young fish. But as is evident from Fig. 5 the young fish is harvested to a degree that must reduce the stock of elder fish.

The experimental fishing at Flødevigen started in 1921. The author is, however, well acquainted with the occurrence of fish at Flødevigen from ca. 1900. Without doubt the occurrence of young cod - and elder - was much higher in the beginning of the century. I should think that the decrease started simultaneously with the introduction of motor-power in the fishingboats. The rising difficulty in obtaining spawners for the hatchery points also towards a heavy reduced stock.

Fig. 6 gives the total number of each yearclass collected by the experimental fishing, given as average pr. gear.

In the Søndeledfjord the 1924 yearclass was very rich. The 1938 yearclass was less so, but outstanding in relation to the neighbouring yearclasses. These are very poor.

At Flödevigen the 1924 yearclass was scarce, the 1925 yearclass, however, rich. The yearclasses 1938, 1941 and 1947 were relatively abundant.

In the Topdalsfjord the yearclasses 1922 - 25 furnished good catches. Later yearclasses resulted in small catches - also the 1938 yearclass.

The difference between the Søndeledfjord and Flödevigen as to the 1924 and 1925 yearclasses indicates that rich yearclasses may be the effect of more or less local factors.

The missing of the rich yearclass 1938 in the Topdalsfjord is also very interesting. This yearclass was especially rich on the eastern and middle part of the Norwegian Skagerak Coast.

The fig. 7 gives the yearclasses of the spawners from the hatchery. Although we are selecting the largest cod for spawners the fish is relatively young, 4 - 6 years. As those yearclasses normally are dominating it is difficult to follow up the rich yearclasses. Even strong yearclasses will not manifest themselves for more than 2 or 3 years. Owing to the interruption of the hatching operations during the war, in icewinters etc., the material is not representative for the yearclasses from about 1935 to 1944. As indicated on the figure the material is also incomplete for some other yearclasses.

Outstanding yearclasses are 1915, 1925, 1928, 1941, 1945 and 1947.

The yearclass 1941 manifests itself with high percentage at an age of 7, 8 and 9 years (spawners from 1948 - 1950). And the 1947 yearclass is relatively abundant at an age of 6 years in 1953.

The rich yearclasses among the spawners corresponds reasonably well with those of the experimental fishing at Flödevigen.

SUMMARY.

Popular Names. Colour.

Along the Norwegian Skagerak Coast the fishermen distinguish between three different types of cod.

1. The "dyptorsk", living in deep water in the skjærgård and outside the coast.
2. The "taretorsk", living in shallow water in the skjærgård.
3. The "fjordtorsk", living in the fjords and narrow sounds.

The types are characterized by colour and proportions.

The deep sea cod is not dealt with in this paper. This type, however, lacks red chromatophores - in contrast to the other types mentioned.

The taretorsk is red to brown. The fjordtorsk is mostly grey to green. This colour is accomplished by a strong development of yellow pigment.

When different types are kept in the same pond they all adopt a dark colour.

The problem of colour has not been studied in detail.

By examining the O-group cod it ^{is/} shown that the main food of the red cod is crustaceans, and for the green cod, fish. Whether the young cod turns red as a result of eating crustaceans, or red coloured cod prefer crustaceans we do not know.

The fishermen mention that the cod living in the skjærgård is more slender than those living in the fjords. This is a result of different intensity of growth, and age at maturity.

The Growth.

By measuring a great number of the O-group it is apparent that the intensity of growth varies from one locality to another in the same fjord. Here it must be assumed that the young must be of the same age - and of the same offspring. The difference in growth must be ascribed to local differences in the environments. Localities with relatively stagnant watermasses give slow growth.

The length of the O-group in the autumn varies from one fjord to another.

By examining the length of the young and elder yearclasses it is shown that the length of cod of the same age is lowest in the insulated fjords and augments towards the coast. At the age of 4 years the difference between the means is approximately 16cm. In one insulated fjord, the Søndeledfjord, the length of the cod at an age of 3 to 4 years is nearly 5cm. longer in the years 1930 - 42 than in the period 1922 - 29. As the cod population is lower in the last period, it is assumed that the rapidity of growth may be correlated to the density of fish.

Age and Size at Maturity.

In the insulated Søndeledfjord a great number of the cod were ripe at an age of three years - but few in the skjærgård. At an age of four years nearly all were ripe in both localities, the average length of the material examined in the fjord being 33,3cm., in the skjærgård 71,2cm. Later measurements show that the four year old cod in the Søndeledfjord now is about 50cm.

Number of Vertebrae.

The number of vertebrae of the O-group and I-group augments from the east to the west along the coast. The number of vertebrae of the I-group in the littoral region is generally less than for the O-group in the same locality. It is assumed that cod-fry with a high number of vertebrae is carried into the shallow waters. They may be the offspring of cod living in deeper waters, or outside the skjærgård. They may then leave the littoral region at an age of about one year.

The number of vertebrae of the grown-up cod is conform with that of the I-group.

Migrations.

By tagging 2 to 4 years old fish it is shown that the cod is very stationary. No regular migrations are manifested. Single specimens may migrate from the skjærgård to a fjord near by. Or vice versa. This may be the effect of the tagging itself, especially if the tagged fish is liberated in relatively deep water.

The percentage of recapture is very high - especially for the large fish.

Variations in the Strength of Yearclasses.

The number of the O-group cod in the littoral region of the fjords and inner skjærgård has been heavily reduced since approximately 1930. Later we have only two rich yearclasses, viz. 1938 and 1945. During the war the investigations were discontinued.

The experimental fishing for the grown-up yearclasses gives the same results for the fjords. The catches have declined heavily.

This is, however, not the case at Flödevigen (near the coast). Here the catches now are equal to those 30 years ago.

It is likely that the spawning is insufficient to maintain the population of cod in the fjords. The intense fishing for the younger yearclasses prevents a sufficient number of cod to reach maturity.

Near the coast the spawning intensity is still evidently sufficient. The skjærgård may have some influx of cod larvae from the coastal waters. The intensity of fishing in the skjærgård is very high and reduces the local stock of grown-up cod in the same way as in the fjords.

The occurrence of rich yearclasses may be restricted to special localities. The 1924 yearclass was rich in the Søndeledfjord, but quite ordinary at Flødevigen and in the Topdalsfjord. The 1925 yearclass was rich at Flødevigen and in the Topdalsfjord but ordinary in the Søndeledfjord.

The 1938 yearclass was extraordinarily rich in the eastern part - but did not manifest itself in the Topdalsfjord.

By analysis of the age of the spawners used at the hatchery it is apparent that the following yearclasses are relatively rich: 1915, 1925, 1928, 1941, 1945 and 1947.

The material for the yearclasses from approximately 1935 to 1944 is incomplete.

The variation in yearclasses among the spawners and the mostly younger fishes caught at Flødevigen corresponds fairly well.

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TABLE I.

1922 - 29 incl. Mean Length of Cod.No. in (-)

Agegroup	Søndeledfjord	Topdalsfjord	Flödevigen	Spawners
I				
Jan.-March	24.0 (54)	24.2 (11)	23.5 (38)	
April-June	26.0 (173)	25.9 (77)	25.2 (71)	
July-Sept.	26.6 (202)	28.4 (236)	25.2 (72)	
Oct.-Dec.	28.8 (283)	33.0 (224)	29.0 (170)	
II/Jan.-March	31.2 (529)	33.2 (80)	31.1 (207)	
April-June	32.9 (673)	36.3 (176)	35.5 (145)	
July-Sept	35.5 (316)	39.7 (191)	39.4 (51)	
Oct.-Dec.	38.5 (107)	43.5 (214)	43.8 (45)	
III				
Jan.-June	41.5 (348)	45.1 (138)	49.2 (58)	61.2 (51)
July-Dec.	44.0 (115)	50.3 (195)	54.5 (20)	
IV				
Jan.-June	47.9 (179)	55.7 (78)	56.5 (8)	69.0 (403)
July-Dec.	50.2 (44)	60.2 (63)	60.2 (5)	
V				
Jan.-June	53.0 (69)	62.8 (18)		72.5 (620)
July-Dec.	52.1 (11)	72.0 (6)	70.0 (1)	
VI				
Jan.-June	56.2 (18)	68.3 (7)		76.6 (316)
July-Dec.	64.8 (5)	88.9 (7)	71.0 (2)	
VII				
Jan.-June	66.0 (7)	68.2 (5)		78.4 (141)
July-Dec.	(0)	77.8 (6)		
VIII				
Jan.-June	87.0 (3)			80.2 (60)
July-Dec.	83.0 (2)			
IX				
X - XII				80.9 (31)
				83.6 (14)

TABLE II.

Mean Length of Cod. No. in (-).

Agegroup	1930-42 Søndeledfjord	1930-41 Topdalsfjord	1930-52 Flödevigen	1930-53 Spawners
I				
Jan.-March	24.4 (214)	26.8 (34)	23.1 (70)	
April-June	25.0 (415)	28.8 (73)	24.4 (407)	
July-Sept.	25.6 (491)	28.8 (106)	25.5 (543)	
Oct.-Dec.	27.2 (386)	32.3 (72)	28.8 (453)	
II				
Jan.-March	34.4 (469)	34.6 (120)	31.6 (505)	54.0 (4)
April-June	34.8 (636)	36.8 (267)	35.1 (673)	
July-Sept.	36.7 (423)	40.2 (222)	37.5 (352)	
Oct.-Dec.	38.8 (238)	43.0 (85)	42.1 (183)	
III				
Jan.-June	44.0 (504)	46.5 (172)	47.2 (179)	61.5 (590)
July-Dec.	48.4 (211)	50.6 (79)	51.9 (97)	
IV				
Jan.-June	53.2 (205)	57.7 (66)	59.6 (15)	68.5 (1379)
July-Dec.	53.4 (68)	57.0 (26)	63.4 (17)	
V				
Jan.-June	58.7 (103)	64.0 (30)	66.1 (8)	73.6 (1414)
July-Dec.	58.8 (23)	60.0 (9)	68.3 (6)	
VI				
Jan.-June	61.5 (47)	65.4 (6)	57.8 (3)	77.0 (1081)
July-Dec.	58.6 (8)	71.1 (5)	87.0 (1)	
VII				
Jan.-June	65.4 (17)	70.0 (1)		79.5 (435)
July-Dec.	72.5 (3)	97.0 (1)	95.0 (1)	
VIII				
Jan.-June	84.5 (3)	76.5 (2)		83.1 (261)
July-Dec.	75.0 (1)	81.0 (2)		
IX				
Jan.-June				87.5 (68)
July-Dec.	67.0 (1)			
X - XIII				
				90.2 (19)

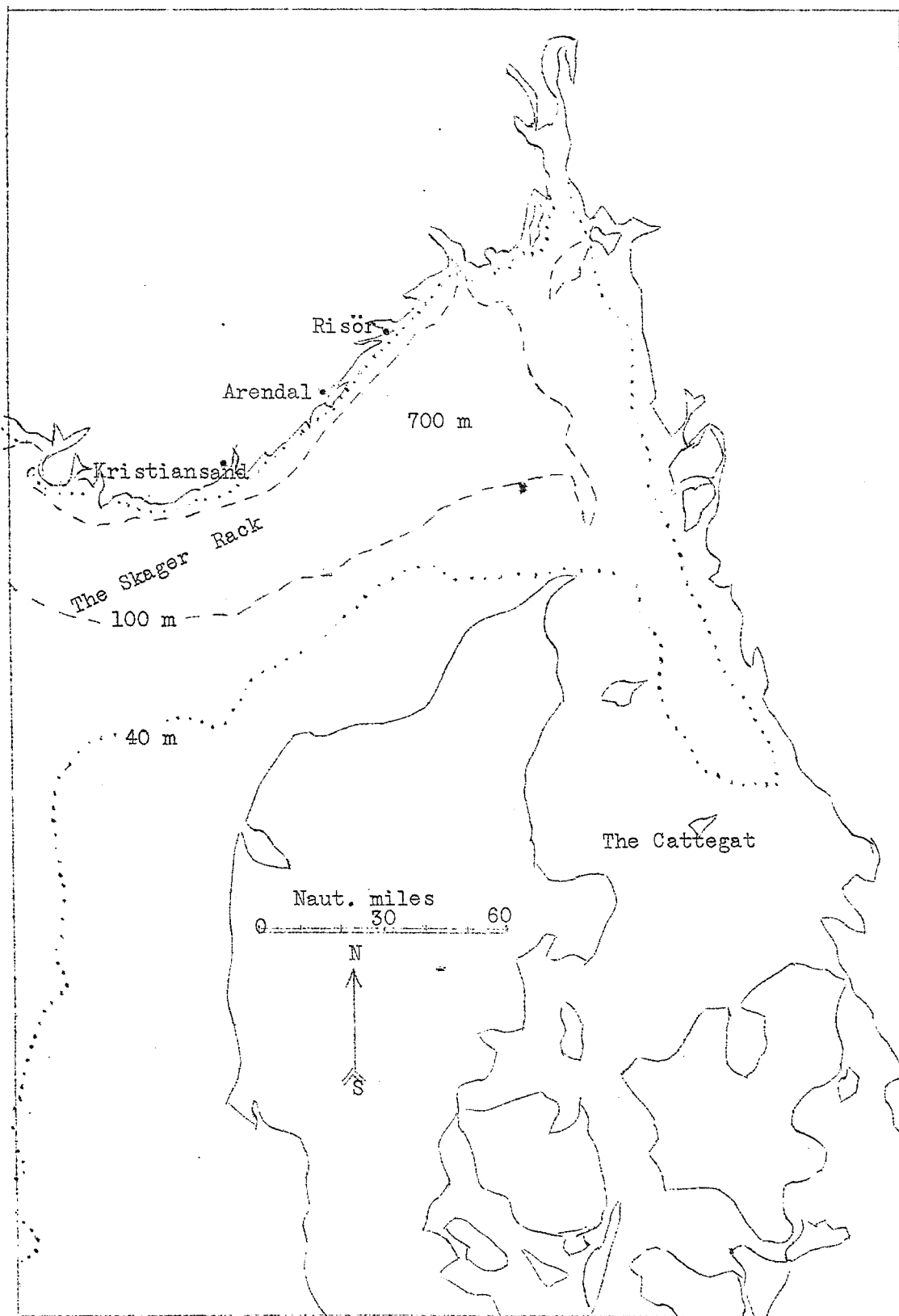
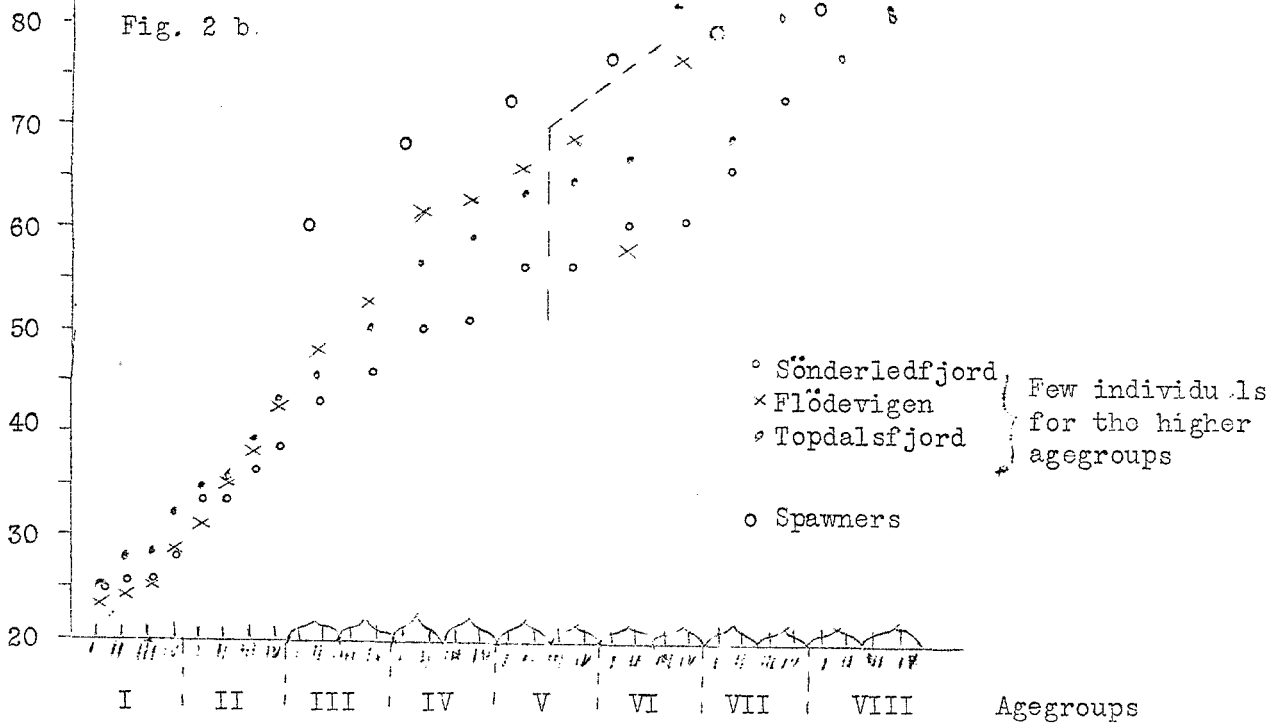
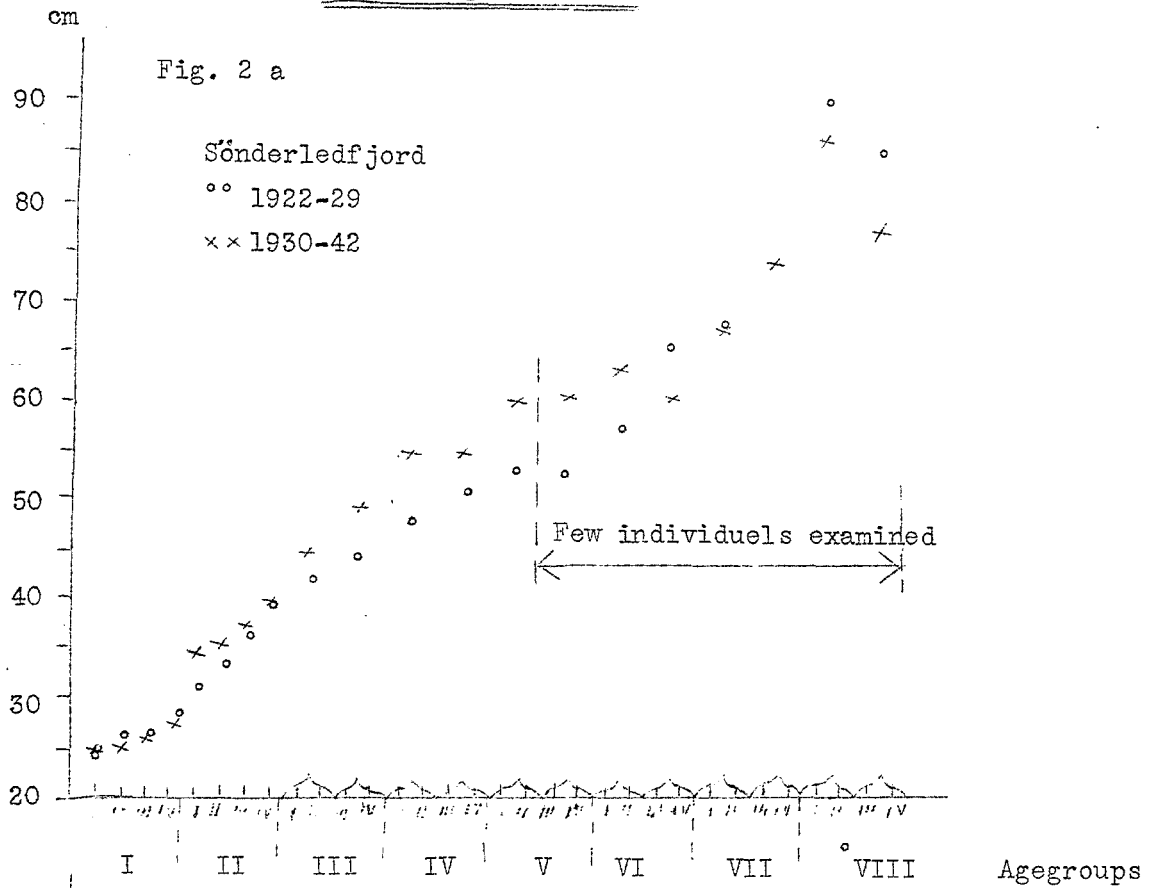


Fig. 1.

Mean Length of Cod.



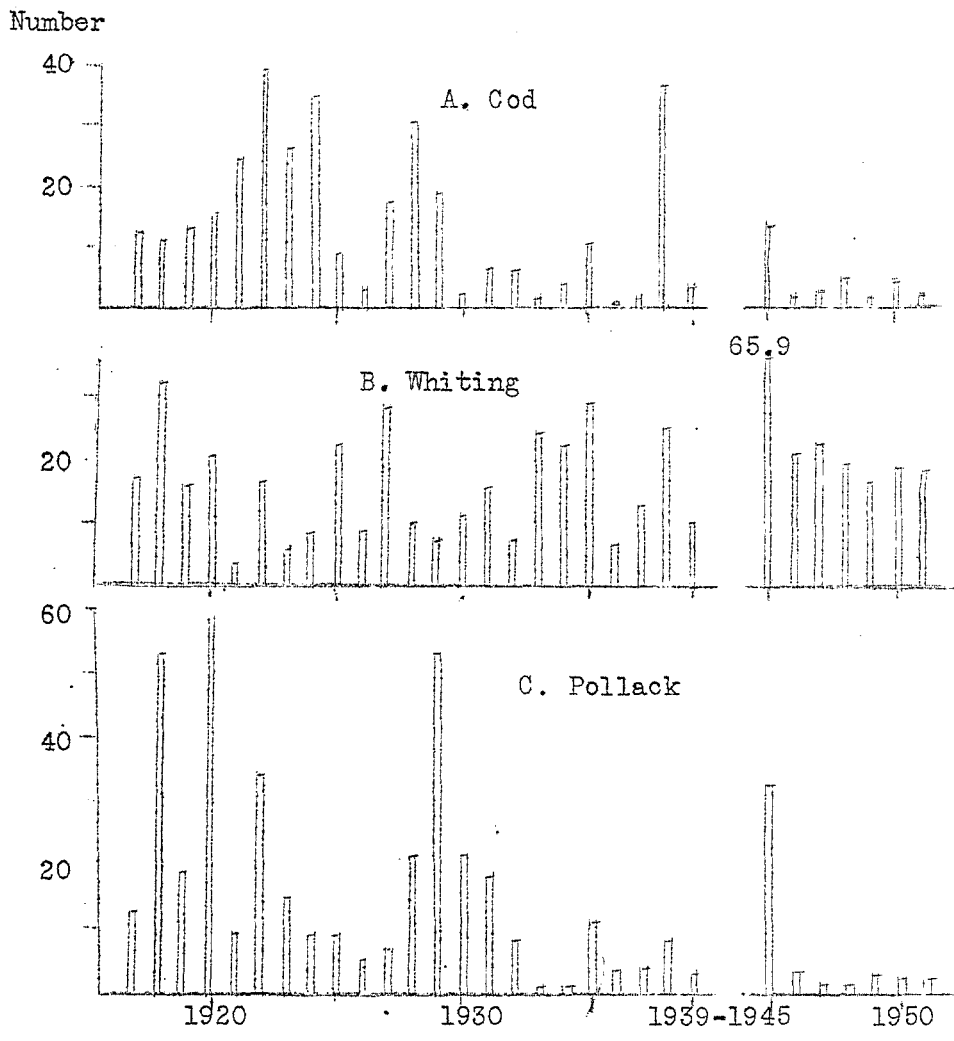


Fig. 3
 The Fjords and Inner
 Skjærgård
Number of the 0-group per Haul
Mean of ca. 75 Hauls per Year

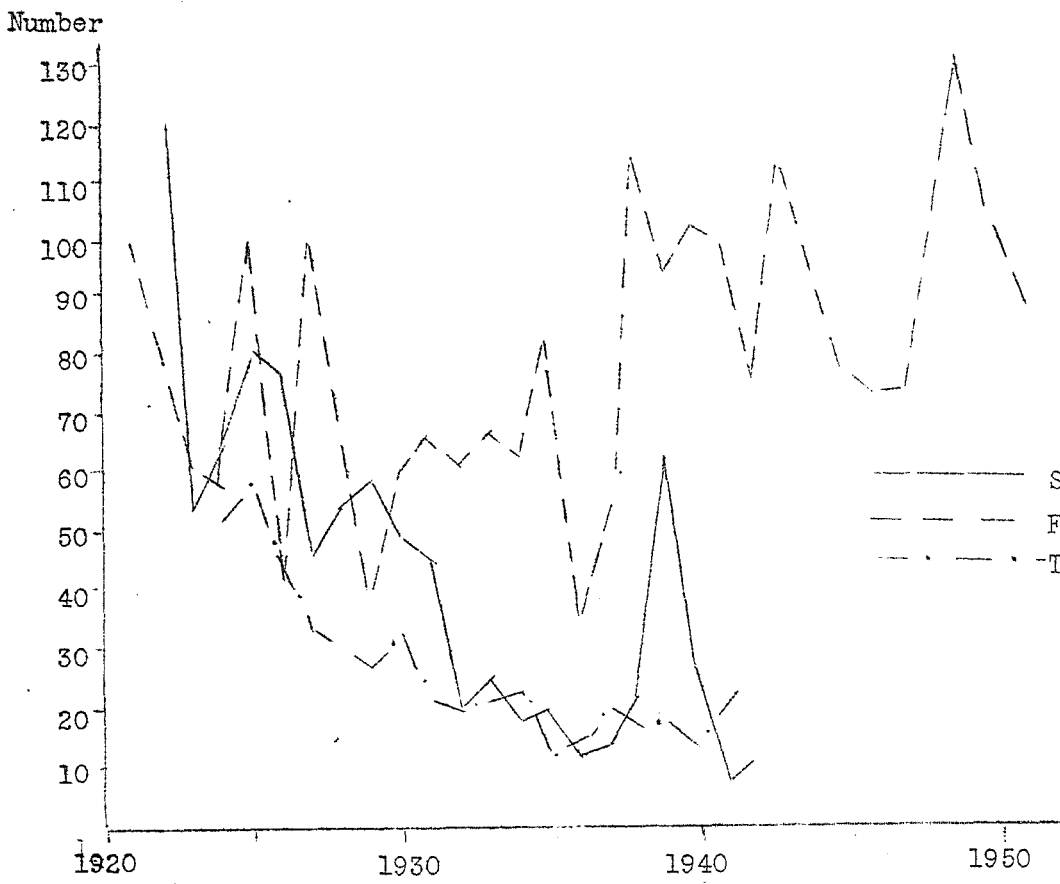


Fig. 4.
Number of Cod Caught
per Trap per Year

— Sönderledfjord
 - - - Flödevigen
 ····· Topdalsfjord

Fig. 6 Number of Cod per Gear

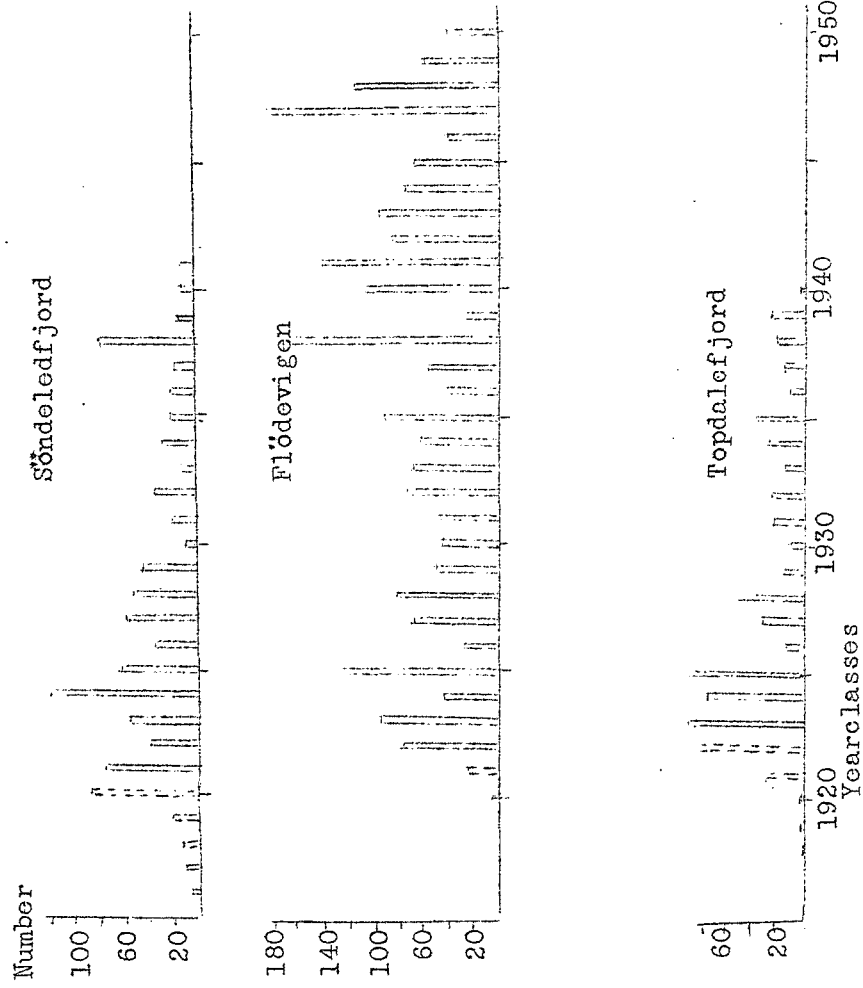
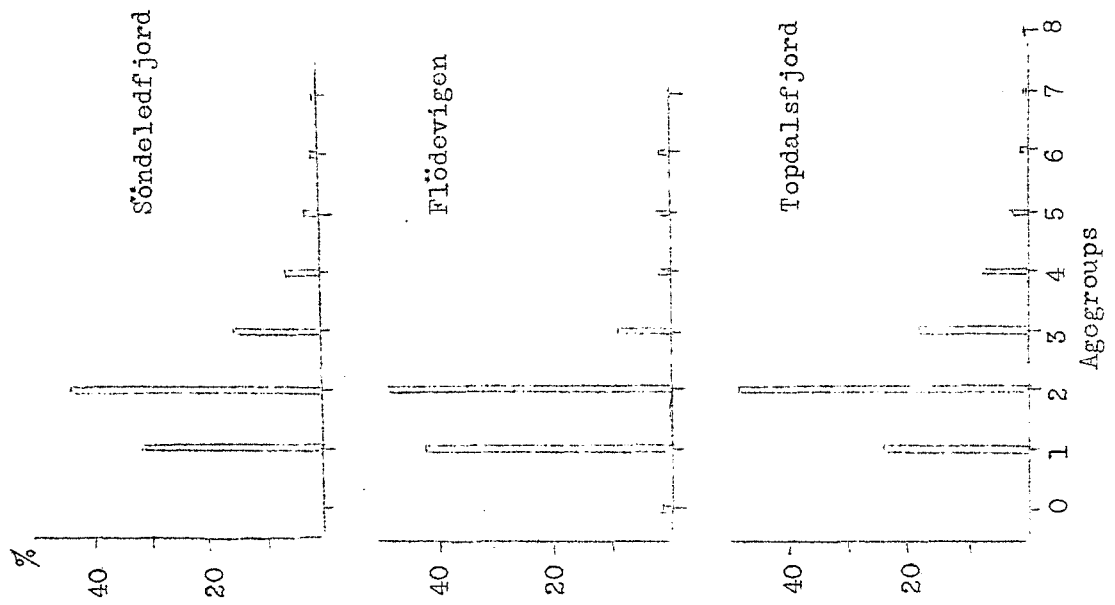


Fig. 5 The Age of the Cod



Environ Biol Fish
1950, 1: 1-10

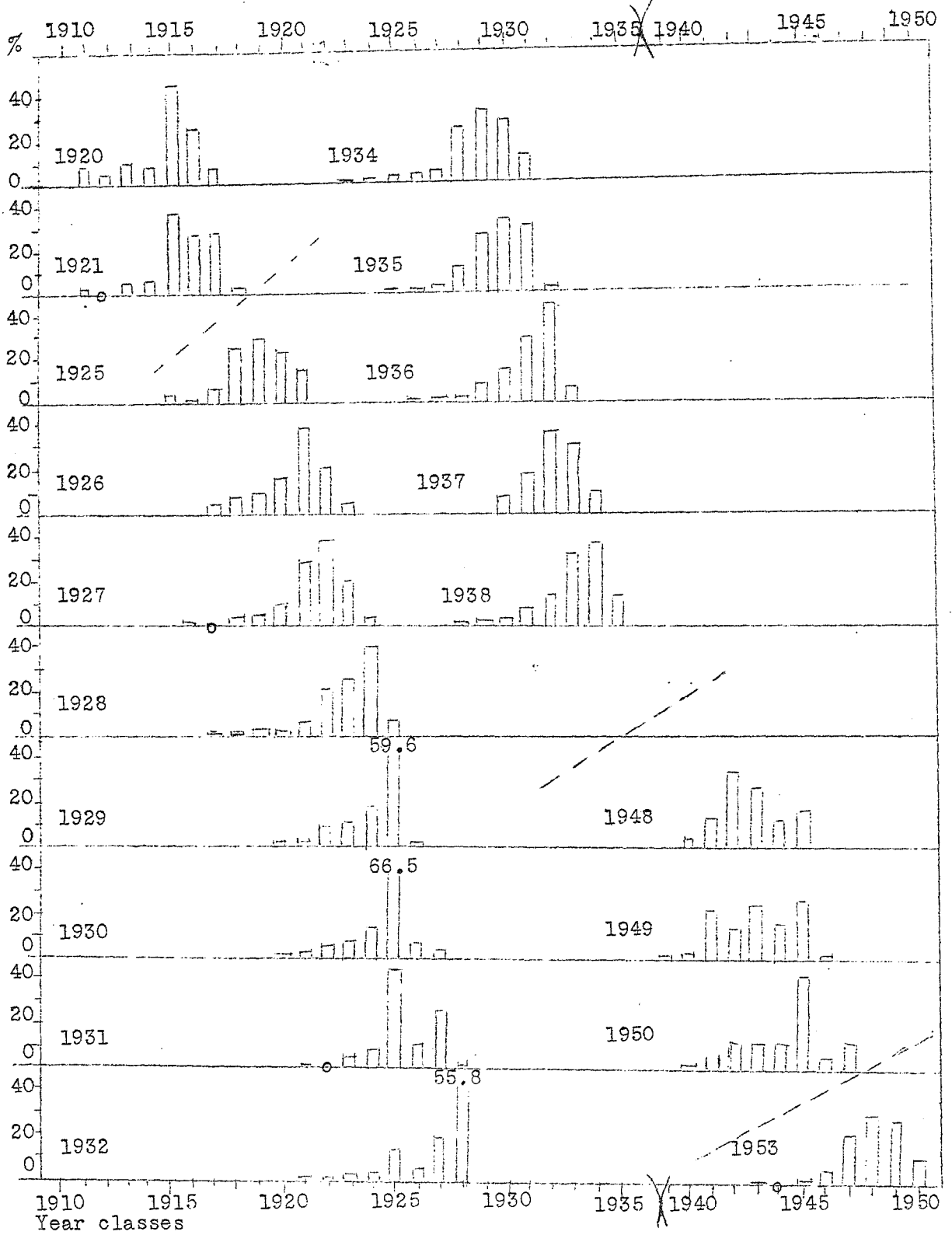


Fig. 7. Spawners from the Hatchery. Occurrence of Yearclasses.