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The North Atlantic Halibut and Net Fishing

By
FINN DEVOLD
(Preliminary Report)

APPENDIX:

THE BOTTOM TEMPERATURES

By
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1 9 3 8

A.s John Griegs Boktrykkeri, Bergen

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INTRODUCTION

The most common form of fishing halibut is by means of longlines. This is a very old method, and the halibut plays an important part in the fisheries of Norway. Research on the biology of the halibut has been but slight, for various reasons. The halibut is such a valuable fish that merely the procuring of material is a costly affair. As halibut fishing is carried on scatteringly on the ocean banks and along our coast, research work will be expensive also. On account of this, special work on the biology of the halibut has not been on the programme of Norwegian fishery research.

At the end of September 1936 the Norwegian halibut fishery was revolutionised. A fisherman from Vesteraalen, OVE JOHANSEN, Bø got a contribution from the Government towards his experiments with a special halibut net in deep water. His experiments proved that the nets were effective to such a degree that this new way of taking halibut in a couple of months brought a catch without parallel i Norway. As early as at Christmas no less than 2.500 fishermen were making use of it. In the middle of November the Director of Fisheries considered it necessary to obtain first hand information on this halibut fishing with nets. As the halibut were caught in greater numbers in restricted areas an opportunity arose of cheaply procuring the material essential to ascertain age and growth. The writer was commissioned to the task, and proceeded to the north of Norway in order to make investigations.

In December, 1936, 5.000 kr. and additional 3.000 kr. in May 1937 were granted towards the marking of halibut in two fjords in the north of Norway and also on the Røst Bank and west of the Faroe Islands.

Otoliths of the halibut were collected and data on length and weight were recorded at a number of the most important places in the North of Norway.

I have received valuable assistance from Messrs. PAUL BJERKAN and OSCAR SUND, fishery consultants, and also from Mr. GUNNAR ROLLEFSEN to all of whom I wish to express my sincerest thanks. Further I wish to thank Dr. JOHANNES LUNDBECK of Wesermünde, Mr. THOR IVERSEN, fishery consultant, and Mr. JENS EGGVIN, oceanographer, for valuable information. In particular I wish to acknowledge my indebtedness to the late Director of Fisheries, Mr. ASSERSON and also to Mr. BJERKAN, for my being entrusted with this important task which I very greatly appreciate. The figures are drawn by Mr. TH. RASMUSSEN, the draughtsman of the Fisheries Directorate. The translation has been revised by Mr. OSCAR SUND.

STATISTICS

In the Norwegian fishery statistics »Norges Fiskerier«, are recorded the quantities of halibut landed in every parish.

The distribution of the catch on the parishes has not been printed for the years 1930—1934, but they are found in manuscript at the office of the Fisheries Directorate. In this report however it is the statements by counties (fylke) and the total quantity for the whole land that are of special interest. In the table below the output of halibut is given for the whole country and for the counties: Finnmark, Troms, Nordland and Møre, the entire Skagerrack Coast, the three west Coast and the two Trøndelag counties not being considered as being of subordinate importance.

Table 1.

Year.	Total	Finnmark	Troms	Nordland	Møre
	tons	tons	tons	tons	tons
1910.....	2.445	331	81	556	1.080
11.....	2.180	170	145	721	659
12.....	2 063	159	202	739	595
13.....	1.781	194	211	575	543
14.....	1.686	417	235	530	346
15.....	1.070	175	250	266	231
16.....	1.001	270	96	338	168
17.....	1.058	110	234	433	113
18.....	1.860	232	254	907	315
19.....	1.930	266	224	666	599
20.....	2.097	200	243	574	858
21.....	2.752	173	317	612	1.383
22.....	2.764	365	252	967	976
23.....	2.733	481	331	836	908
24.....	3.034	568	360	823	1.102
25.....	2.868	431	339	847	1.016
26.....	3.280	946	513	807	736
27.....	4.304	995	1.053	1.095	906
28.....	4.804	1.078	1.621	1.190	682
29.....	4.895	1.026	1.895	1.146	504
30.....	4.833	1.046	1.590	1.106	811
31.....	5.293	1.328	1.256	1.532	917
32.....	5.688	1.306	1.473	1.519	1.142
33.....	5.265	1.040	1.249	1.320	914
34.....	3.859	955	860	873	559
35.....	3.728	766	882	1.014	581
36.....	6.268	1.145	1.845	2.384	678

Thus during the years prior to the war there was a steady decrease in the output of halibut for the whole Kingdom especially in Møre. The northern counties present varying quantities, but no tendency in any particular direction. The small catches in 1915 to 1917 may be attributed to the war. From 1918 onwards there is a steady increase in the quantity landed for the whole Kingdom, right up to 1932, after which there is a noticeable decrease, until 1936 when the net fishing was started. This new way of taking halibut increased the output for Finnmark by 150 %, for Troms by 212 % and for Nordland by 230 % compared to 1935.

The table shows that the increase up to the year 1932 was due to the fishing shifting to the north. The Northerners take halibut fishing up in earnest. As far as Møre is concerned the quantity remained fairly high only because the fishermen, to a greater and greater extent, began to fish halibut at Iceland, the Faroe Islands and on the Røst and Bear Island Banks. The proportion brought in from these banks is, unfortunately not recorded, but is known to be continually increasing.

Bear Island.

Fishing here was started in earnest in 1928. Table 2 shows the quantity landed in Norway from this area.

Table 2. Catch of Halibut in the Bear Island Area.

Year	Tons	% of the 1928 catch
1928	1.242	100
29	479	39
30	230	19
31	171	14
32	299	24
33	299	24
34	151	12
35	71	6
36	112	9
37	91	7

As however accurate records of the fishing effort are lacking no definite rate of decrease in the stock can be derived from the Norwegian statistics for this area.

Table 3 shows the quantity of halibut taken by British and German trawlers in the same area. Here it is also known how many fishing trips have been made, so that it is possible to ascertain the average catch per voyage for each year.

Table 3. British and German Trawlers' Catch of Halibut in the Bear Island Area.

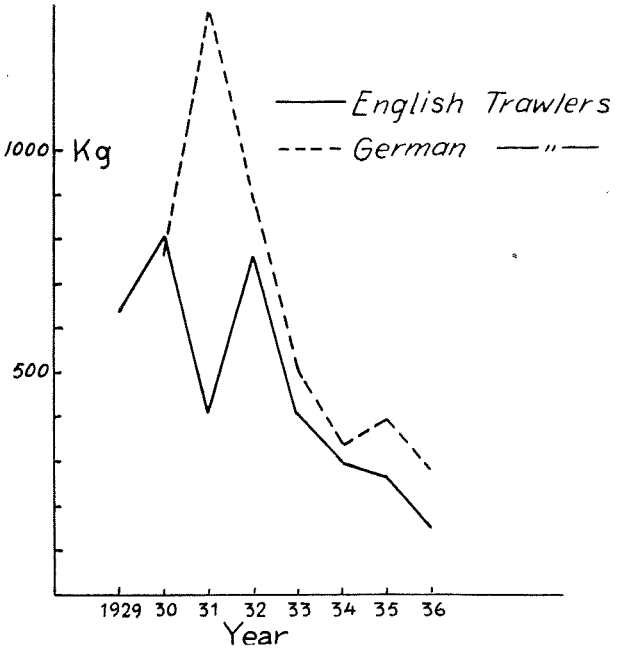
Year	British Trawlers		German Trawlers	
	Tons	Kg. per Voyage	Tons	Kg. per Voyage
1929	418	633	—	—
30	153	810	53	760
31	213	406	93	1.310
32	349	765	199	880
33	142	402	117	494
34	134	296	66	337
35	199	266	102	394
36	123	148	90	280

The trawlers' catches present, then, the same discouraging picture of a great decline in the output of halibut on the Bear Island grounds as the Norwegian line fishing records do. The British trawlers commenced trawling operations in 1929, and had their best catch of halibut, in 1930, 810 kilos per voyage. German trawlers commenced fishing on these grounds in 1930 and had their best catch the following year amounting to 1310 kilos per voyage. In 1936 the average catch was 280 kilos. See fig. 1.

Fig. 2 shows the quantities caught by the different countries during the years 1928—36 on the Bear Island grounds. The black part of the columns represents the Norwegian catch, the broken line the British and the white part the German shares, respectively tons.

Fig. 3 shows each years output of halibut as percentages of the best year on the Bear Island grounds.

The Norwegian line fishers and British and German trawlers catch by far the greater quantity of the halibut taken on the Bear Island grounds. Ignoring the quantity taken by other countries, the figures in table 4 express the quantities caught by these three countries in the years 1928—36 and the share of each country in %.



Fig, 1. Catch of Halibut per voyage Bear Island Area.

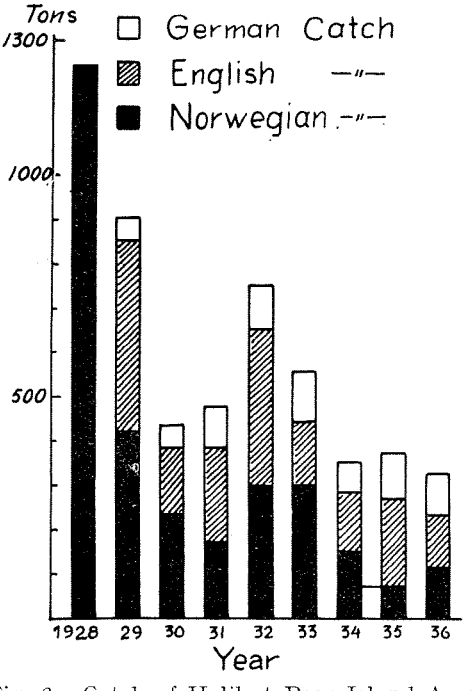


Fig. 2. Catch of Halibut Bear Island Area.

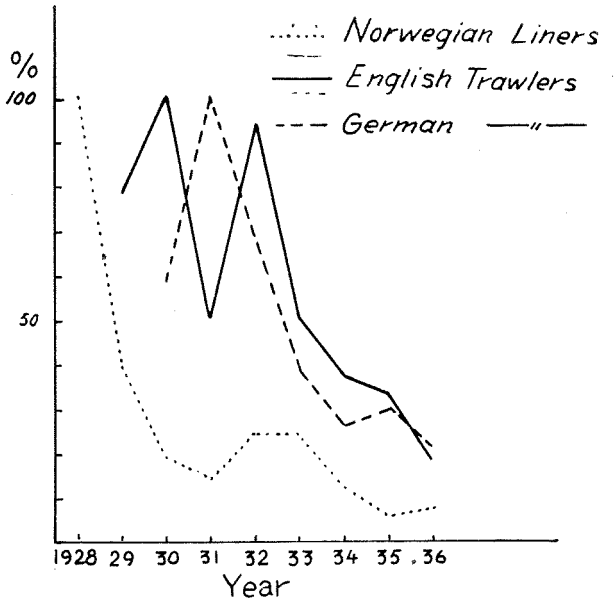


Fig. 3. Output of Halibut as percentages of the best year, Bear Island Area.

Table 4. Halibut catch at Bear Isle and % Distribution on countries.

Year	Total tons	Norway %	England %	Germany %
1928	1.242	100	—	—
29	897	53	47	—
30	436	53	35	12
31	477	36	45	19
32	847	35	41	24
33	558	54	25	21
34	351	43	38	19
35	372	19	54	27
36	325	34	38	28

The Norwegian line fishers' catch of halibut dominated during the first years, but has now been exceeded by the British trawlers' catches. The German trawlers take, year by year, a growing proportion of the halibut caught in this area.

The Barents Sea.

The Barents Sea area is looked upon as being the area of the ocean South of 73° N and East of the meridian of the North Cape to Novaya Semlya. Conditions there are somewhat better as far as the

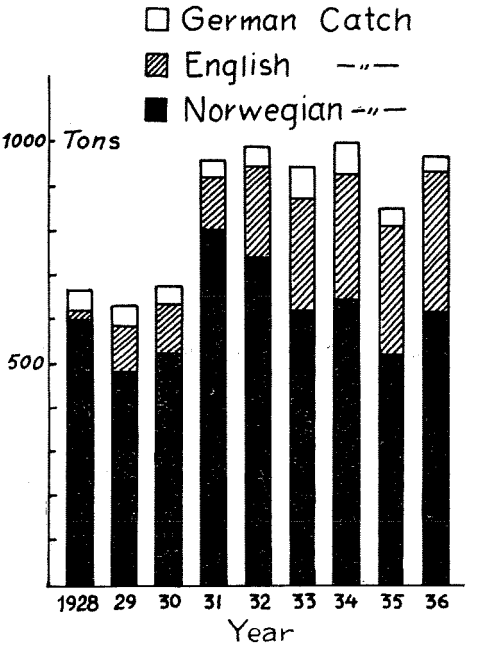


Fig. 4. Catch of Halibut in the Barents Sea.

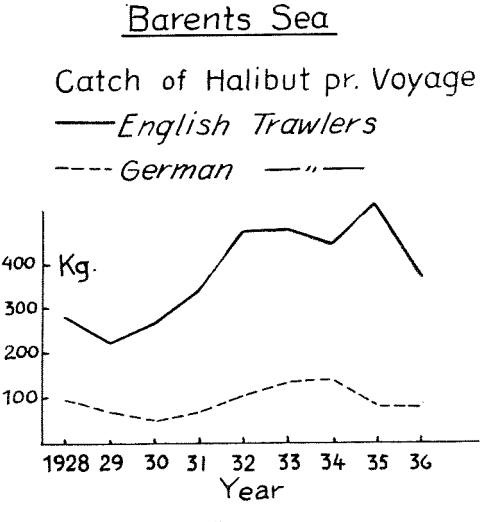


Fig. 5,

stock of halibut is concerned. The area fished over is far greater than at Bear Island.

As the Norwegian catch of halibut from the Barents Sea are taken the quantities landed east of the North Cape. As far as possible the halibut fished at Bear Island are not included.

Table 5. Halibut taken in the Barents Sea.

Year	Total tons	Norvay Tons	England		Germany	
			Tons	kg./trip	Tons	kg./trip
1928	668	600	23	282	45	93
29	630	483	102	233	45	66
30	672	524	108	265	40	48
31	955	801	117	338	47	68
32	986	737	206	472	43	104
33	940	618	251	476	71	134
34	995	642	284	440	69	139
35	847	520	288	534	39	82
36	962	615	314	378	33	80

Thus the total quantity of halibut caught in the Barents Sea has been more or less constant in the past 6 years (see fig. 4). The trawlers' catch per voyage does not point to any decline in the stock. The British trawlers made the biggest catch of halibut in 1935, and the German trawlers in 1934 (see fig. 5).

The German statistics grade the halibut into 4 size-groups. The biggest halibut — size 1 — are all fish exceeding 117,5 cm in length. Table 6 shows the percentage of this size-group in the German trawlers' halibut catch in the Barents Sea.

Table 6. Percentage »large« in German Barents Sea catch.

Year	Percentage
1929.....	36
30.....	38
31.....	28
32.....	19
33.....	14
34.....	9
35.....	9
36.....	5

The big halibut, then, are constantly becoming more rare in the trawl catches. We lack, unfortunately, similar statements from other countries. If the German trawl catches present a true picture of the stock of halibut, then the great decline of big halibut indicates that the stock is decreasing.

Table 7 shows the percentage of the total quantity of halibut caught in the Barents Sea by Norway, England and Germany.

Table 7. Distribution of Barents Sea Halibut catch.

Year	Norway	England	Germany
1928.....	90	3	7
29.....	77	16	7
30.....	78	16	6
31.....	84	12	5
32.....	75	21	4
33.....	66	27	8
34.....	65	28	7
35.....	61	34	6
36.....	64	33	3

As will be noticed the Norwegian share of the quantity is steadily decreasing while the British share increases yearly. The German participation in the halibut fishing in the Barents Sea is negligible compared with those of England and Norway.

The North West Coast of Norway.

The »Bulletin Statistique« considers the whole of the Norwegian coast from the North Cape to Statt as one zone: The Norwegian Sea. Fishing by foreign trawlers in this area, however, takes place principally off the coast of Troms and Finnmark, for which reason an erroneous idea is obtained when comparing the quantity caught by foreign trawlers and that caught by Norwegians along the whole length of this coastline. As far as the Norwegian quantity is concerned, it is difficult to ascertain what quantity of halibut has been landed from the distant banks, on this part of the coast. For Troms a considerable quantity comes from the Bear Island area. To arrive at approximately correct figures of Norwegian and foreign quotes within this zone is, therefore, impossible.

The British trawlers have for a long time favoured the Norwegian coast, and, the quantities of halibut caught there have been entered in table 8 from the British statistics. The Germans started fishing in these waters in 1934 (according to the German statistics).

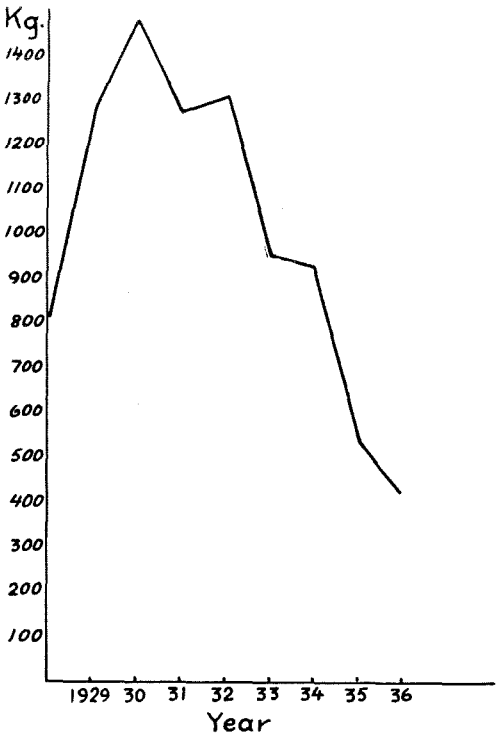


Fig. 6. NW.Coast of Norway, Catch of Halibut per Voyage of British Trawlers.

Table 8. Trawl catch of halibut on the NW coast of Noway.

Year	British Trawlers		German Trawlers	
	Tons	Kg/trip	Tons	Kg/trip
1928	19	809		
29	15	1.267		
30	16	1.482		
31	61	1.278		
32	80	1.312		
33	76	957		
34	60	932	36	373
35	73	547	112	476
36	81	422	181	232

We note here that the trawlers total catch of halibut is constantly increasing, but, on the other hand, the number of kilos taken per voyage is seen to decrease from 1930 onwards. If we put the catch of halibut per voyage for British trawlers at 100 % in 1930, it has fallen to 28 % in 1936. See further fig 6.

The North Sea.

The North Sea is without comparison the world's most important fishing basin. Of the entire output of the European salt water fisheries, more than 30 % is taken from the North Sea. Probably at no other places have the various species of fish been the object of such intense fishing and one would have expected that the great quantities taken from the North Sea would have resulted in a great decline in the output, but this, luckily, does not prove to be the case. Technical developments, with continual improvements in the fishing gear and vessels have of later years been responsible for maintaining the catch. The total quantity of all species of fish together remains at rather more than 1 million tons. With regard to the halibut, however, there is a constant and rapid decrease. One must be prepared, if nothing be done to protect it effectively, that it will become a rare fish in the North Sea in not so many years, although formerly an important article of food.

Table 9. Halibut caught in North Sea.

Year	Tons	Year	Tons	Year	Tons
1903	1.781	1914	2.800	1925	1.800
04	2.121	15	500	26	1.200
05	1.981	16	300	27	1.300
06	2.176	17	300	28	1.000
07	2.284	18	400	29	900
08	1.891	19	1 200	30	900
09	1.768	20	2.300	31	700
10	1.327	21	2.300	32	800
11	1.228	22	3.800	33	500
12	1.237	23	1.900	34	700
13	1.419	24	2.400		

Even prior to the war there was a noticeable decline in the quantity of halibut caught in the North Sea. The statistics at that time were even more deficient than now. Norway was not included in the statistics until 1905. Disregarding the war years, when the North Sea was practically free from all trawling, there has, every year up to 1929 been caught more than 1000 tons of halibut in the North Sea. The record was 3800 tons in 1922. The decline in the output will be obvious if we take note of the average of 5-year periods.

1904—08	an average of	2089	tons per annum.
1909—13	—»—	1396	—»—
1920—24	—»—	2540	—»—
1925—29	—»—	1240	—»—
1930—34	—»—	720	—»—

According to the statistics for 1905, the Norwegians caught 494 tons of halibut in the North Sea. In 1913 they caught 110 tons, or only 22 % of the 1905 quantity. In 1934 the Norwegians fished 61 tons of halibut in the North Sea, that is, despite the great increase in their fishing fleet, only 12 % of the quantity in 1905.

The statistics, notwithstanding all their errors and deficiencies, present us, however, with an ummistakable picture of the rapid decline of the stock of halibut on the fishing grounds here mentioned. Experience from all places where halibut fishing is carried on in any great measure shows that the halibut stock is easily reduced.

Pacific Halibut.

The American fishing in the Pacific Ocean for *Hippoglossus stenolepis*, near relative of the North Atlantic halibut *Hippoglossus vulgaris Flem.*, was on the point of proving profitless at the end of the twenties. A Scientific Commission which the U.S.A., and Canada appointed have collected admirable statistics on the basis of which they have been able to control the exploitation of the halibut stock. By extensive marking experiments the Commission have thrown light on the wanderings of the Pacific halibut and on many features of its biology. They have been able to ascertain what areas have their own stock of halibut; by introducing new laws they have been able to limit the fishing to quantities considered tolerable by the stock. The commission went even farther. They limited the fishing to less than what they knew the stock could stand, and in this manner it has increased again. They calculated in advance what the increase of the stock would be as a result of this, and the catches of later years have made their calculations come true. (W. F. Thompson 14, 15, 16, 17, 18).

The Pacific halibut are caught by special halibut fishermen. When the stock of halibut has been reduced to such an extent that the effort is no longer profitable, then fishing ceases. There is, then, in this »profit limit« a protecting factor preserving the stock of halibut. When the fishing no longer pays the halibut are left in peace that the stock may again recover. In European waters matters are otherwise. Halibut form but a small part of the trawlers' catches. They get other species

of fish whose numbers can stand much greater inroads. Halibut fishing therefore goes on irrespective of how small the numbers of halibut have become. It may also be said that the same applies to a certain degree to line fishing, as it is cod, ling and torsk that form the chief catch.

The Davis Strait.

In the second half of last century American fishermen carried on profitable halibut fishing in Davis Strait. In the nineties it became unprofitable and the halibut were left in peace until 1924, when the great halibut expeditions with mother ships and motor-dories commenced operations. In 1934, 30 pct. of the European consumption of halibut was taken from these waters. The results of the last years have been so poor, however, that there is reason to believe that great halibut expeditions to Davis Strait will no longer prove profitable.

The fact that the fishing becomes unprofitable is a serious matter, but it would be a far more disastrous affair if there were danger for the stock. On the Bear Island Bank, in the Barents Sea, on the Norwegian coast, in the North Sea and at Iceland one must be prepared on such a contingency. The quantity of halibut taken from the North Sea is approaching zero which will presumably be reached about 1950 if the catch is decreasing continually as statistic show the last years. There is no protection for halibut in these waters, neither does a lower limit with regard to profit exist as other species will support the fishing even after the annihilation of the halibut stock.

Net Fishing for Halibut.

In September, 1936, a fisherman, Ove Johansen, of Bø in Vesteraalen, experimented with a net especially made for catching halibut. Johansen had received a grant towards these experiments. The nets were set at a depth of some 250 fathoms in the Vestfjord near Skrova, where for many years good halibut fishing with long lines has taken place every autumn. In 1936 several boats also fished this ground with halibut long lines (»gangvad«), but the catches were poor. Johansen set 10 nets on the same patch as the lines, and the very first night caught 20 halibut. The following night the catch was even better and resulted in the whole fleet drawing in their lines in order to make halibut nets. Soon afterwards several more had started, and at Christmas time some 2500 men partook of this new way of halibut fishing.

The statistics show the great increase in the catch of halibut in the three northern counties in 1936. In Finnmark 50 % more halibut

was landed than in 1935, in Troms the quantity increased to 212 %, and at Nordland to 230 % of the previous year's catch. This was attribuable to net fishing. In Finnmark net fishing began at the end of November. In Troms this way of fishing started in the beginning of November, and in Nordland the first net fishing took place in the last days of September.

These fishing areas were very restricted deep basins in the sea bottom at depths varying between 300 and 700 metres with soft clay or mud bottom. Before Christmas the catches were chiefly made on the slopes leading down to such basins, but later on it was discovered that the halibut sought down to the deepest parts. Catches exceeding 50 halibut in about 20 nets were no uncommon thing at the best time. About Christmas when the halibut made for the deepest water, fish with running roe and milt appeared in the catches in the Vestfjord area.

The fishing off Skrova was already declining in November and the fishing fleet then made for the Tysfjord, Folla, the Skjerstadfjord, Beiarn and the Glåmfjord. At this time fishing started also farther south at Helgeland, and farther north at Andfjord and Malangen in Troms, and from December onwards huge catches were made in West Finnmark, in the deep waters of Stjernsund, Sørøysund and Alta.

At the new year the great catches began to ebb out in the best places in and near the Vestfjord, and the fishermen had to seek new grounds. At this time they were already aware that at all places where the water was deep enough and with the right sort of bottom, great numbers of halibut mature for spawning were present. By the aid of the good charts they could form an opinion as to where it was worth while fishing. East of the North Cape, however, the trials proved unprofitable, probably on account of the bottom water being too cold.

At the end of January the first attempts with nets for catching halibut were made in the Trondheimfjord, there also with excellent results. In March and in the beginning of April fishing in the deep West Coast fjords at Møre gave good catches also, for a short period.

At the end of April all net fishing stopped along the whole coast. The last catches were taken a good distance seawards in the submarine »fjords« on the banks.

The Seasonal Character of Halibut Fishing.

P. JESPERSEN (4) has discussed the Aberdeen Liners catch of halibut in Icelandic waters per 100 lines for the years 1911—12 and 1914—15, and for 1908—15 in the water round the Faroe Islands. Fig. 7 and 8, which has been taken from JESPERSEN'S paper, shows a consider-

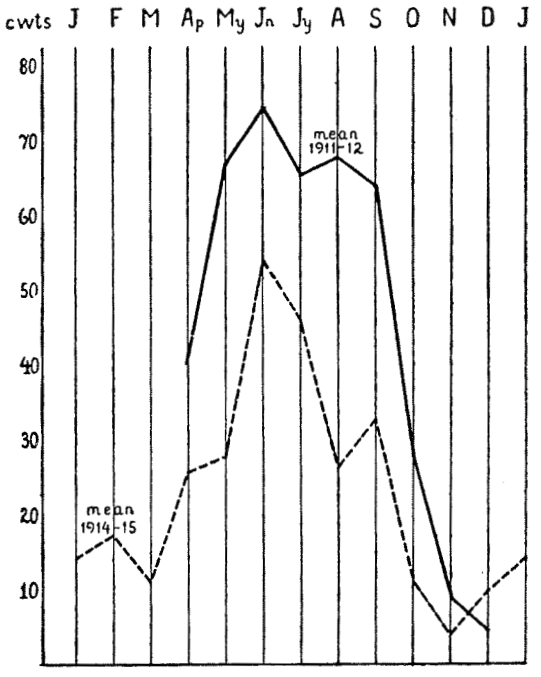


Fig. 7. Catch of Halibut per 100 lines, Iceland.

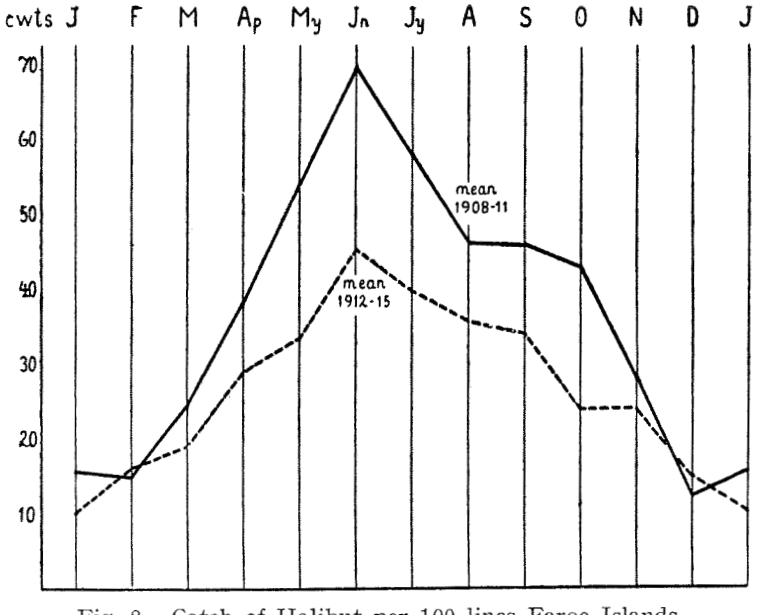


Fig. 8. Catch of Halibut per 100 lines Faroe Islands.

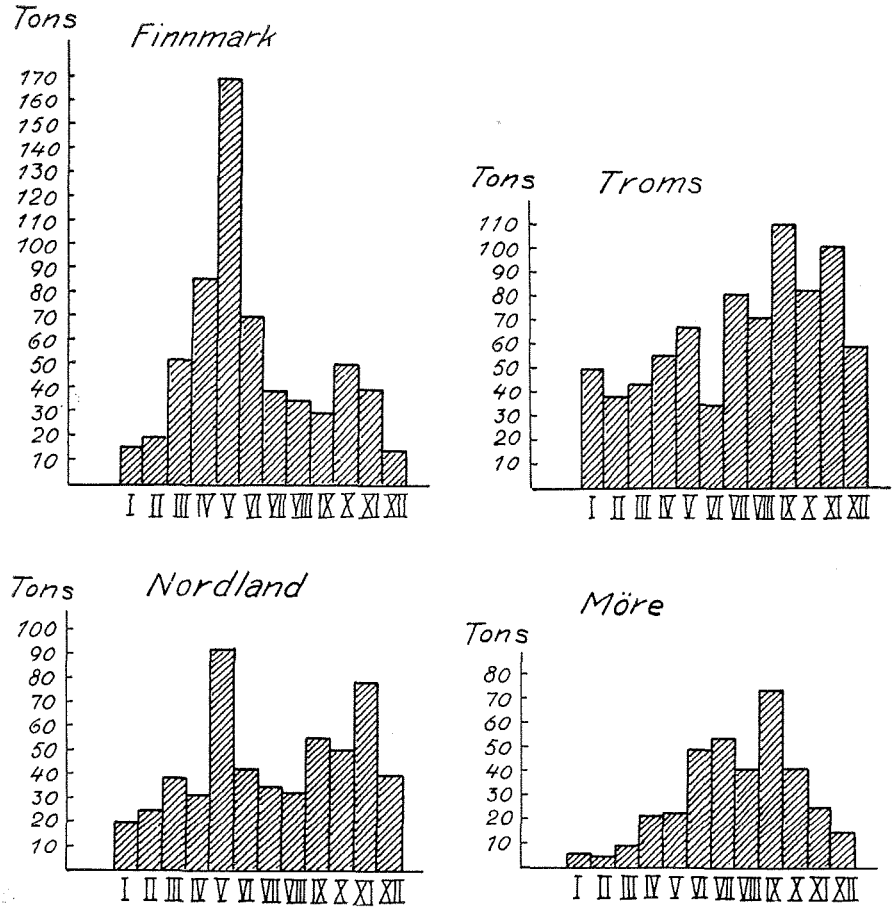


Fig. 9. Average export of Halibut to England Sept. 1933—Aug. 1936.

able increase in the catches from January and up to June, and then a decline until December. At the same time the curves show that the catches have decreased quite considerable during the two periods.

We lack, unfortunately, montly records in the Norwegian statistics, so an actual picture of the halibut fishing during the several seasons cannot be presented. We have, on the other hand, through our export to England, since quota restrictions came into force in September 1933, good records regarding it. As the greater part of our halibut is exported thereto, it should be possible to get somewhat reliable information of the quantity caught during the several months.

The graph, fig. 9 shows the average monthly quantity of halibut exported to England according to the Customs, from September 1933, to August 1936 incl. The entire quantity consists of line-fished halibut.

The three years show the same picture as the average, variations from year to year being negligible for all four counties.

F i n n m a r k : There is a great maximum in May, partly due to the many fishermen who stay in Finnmark at this time of the year on account of the spring cod fishery. We note also a maximum in October.

T r o m s : Here we have one maximum in May and another in the autumn. The high values for July, August and September may possibly be due to some halibut fished at Bear Island, and halibut caught in Finnmark are also partly exported from Tromsø. We see there is a great quantity in November.

N o r d l a n d : Two maxima are very conspicuous, one in May and one in November.

M ø r e : Here we have no maximum in spring, but a great one in September.

If we examine where the actual fishing takes place at the several seasons it is seen that in all three northern counties alike the high May quantity is made up of catches from the coastal banks and consists of fish of all sizes. On the other hand, the great autumn quantity is chiefly the result of fjord fishing in very deep water. The autumn halibut are generally big, mature fish.

The Møre catch is taken in summer far out at sea — as far as the Faroe Islands, for instance, only a very small quantity being caught on the Møre coast itself. The September maximum, on the other hand, is due to big, mature fish which are mostly taken at the entrance to the Norwegian Channel, at Aktivnesset. More halibut are also caught at Storegga and Tampen at this time.

Net fishing has shown that great numbers of halibut were present in the deep fjords in North Norway. It appeared that practically all the halibut caught in nets had empty stomachs. They eat, therefore, very little during spawning time, and this is the reason why the line fishers had not realised the presence of such great numbers before. The conspicuous minimum of winter caught halibut is therefore not due to a comparative scarcity in Norwegian waters, but rough weather hinders fishing on the banks, and the big, mature halibut are not inclined to take the bait. After spawning, the appetite increases, and the better weather also allows more bank fishing.

Sizes and Migrations.

Fig. 10 shows the size-grouping of netted halibut, which we had occasion to measure during the fishing from November to January 1936—37 in North Norway. The halibut were measured in centimetres and are here entered in 5 cm. groups, so that the 90 cm-group includes fish of 88—92 cm, and the 95 cm-group those of 93—97cm, a. s. on.

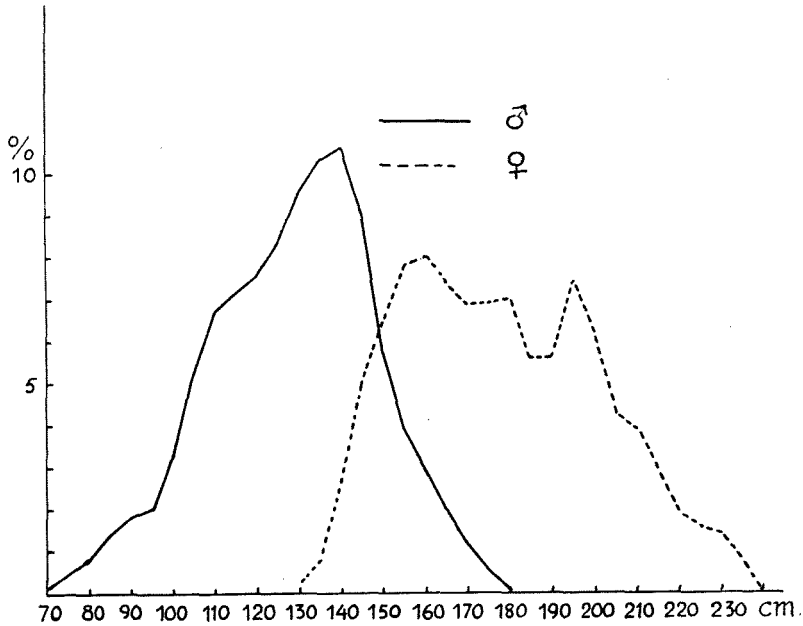


Fig. 10. Length Frequensis of netted Halibut.

The number in each 5 cm group has been smoothed in the usual manner as per formula, $b_1 = (a + 2b + c) : 4$ and the frequencies expressed as percentages. The material consists of 200 males and 129 females. No choice was made, all fish met with were measured.

All these fish were mature halibut with gonads at stage 4—7. The smallest female is 131 cm long, the smallest male 75 cm. The mesh of the nets was 7—9 inches between knots. It is therefore, reasonably assumed that the smallest mature males were not caught but have passed through the meshes. But the size of the females at first maturity is presumably brought out fairly correctly by the measurements.

The great numbers of halibut in spawn on these relatively small areas where the fishing was done point to congregation of halibut, from great areas during spawning time. In all probability the halibut prefer a special temperature and hydrographic conditions when about to spawn, such conditions being found in the deep, comparatively warm bottom water in the fjords of North Norway. Conditions, as will be seen by Mr. EGGVIN's account, are not greatly different from those obtaining where Danish explorers have found halibut eggs and larvæ on the slopes of the Atlantic deep along the ridge joining Scotland, Iceland, and Greenland. (TAANING 13).

The German statistics supply a means of ascertaining whether the mature halibut migrate from the ocean banks. As mentioned before they grade their halibut into 4 sizes. The biggest, group 1, includes all fish exceeding a length of 117,5 cm. This group contains, judging by the size grouping of the halibut caught in nets, the mature females, and a large percentage of mature males. If these fish really migrate from the ocean banks at spawning time, this ought to appear in the statistics of trawled halibut. The percentage of size (group) 1 in the catch of halibut ought to be lower during spawning time than during the rest of the year.

In order to obtain as reliable information as possible, the catches of several years form the basis of the computation. For the North Sea and the Barents Sea we make use of the quantity which, according to the German fishery statistics, has been caught in this area by German trawlers during the period 1929—36. For the Bear Island area the years 1930—36 have been employed. For the N.W. coast of Norway the years 1934—36 have been considered, as this area was specified in the statistics only from 1934. If the quantity of halibut caught by the German trawlers is summed up for the several months in these areas and the percentage of size (group) 1 is considered, we get:

Tab. 10. Percentage, size-group 1 of Halibut caught by German Trawlers.

Months	Barents Sea		Bear Island		N W. Coast, Norway		North Sea	
	%	Voyages	%	Voyages	%	Voyages	%	Voyages
January	17	833	27	18	47	185	12	610
February	16	624	29	10	39	406	18	627
March	18	407	?	0	25	487	16	718
April.....	19	129	?	0	14	221	21	560
May	28	47	13	3	72	53	22	402
June	34	11	17	13	30	8	27	384
July	38	16	28	51	?	0	34	197
August	43	61	33	86	?	0	34	92
September ..	37	183	35	203	?	0	13	103
October	31	409	33	311	?	0	9	168
November ..	22	597	19	340	15	13	12	526
December ..	15	755	15	123	30	86	11	559

The table also indicates the corresponding number of trawling voyages. The percentage figures in the table are rendered as curves in fig. 11. The part made up of big, mature fish caught in the North

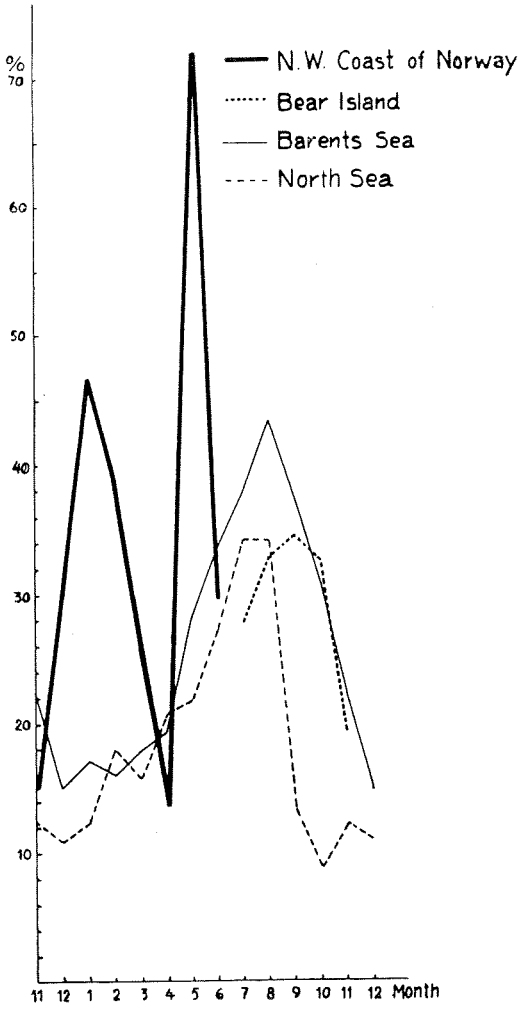


Fig. 11. Percentage, size-group 1 of Halibut caught by German Trawlers by months.

Sea increases from January to July by from 12 to 34 %. It constitutes 34 % in August also, but in September it falls again to only 13 % of the catch. At the same time the great halibut fishing off Møre sets in, where mostly big mature halibut are caught. We note that big halibut begin to be more frequently met with in trawl catches from April onwards in the North Sea.

In the Barents Sea the halibut appear in a like manner in the German trawl catches. During the months of January, February, March and April they constitute less than 20 % of the halibut catch. The

percentage is rising in the months of May, June, July and reaches its maximum of 43 % in August, then the numbers decline towards a minimum of 15 % in December. The figures for June and July are less representative, but the regular course of the curve points in the direction of reality, and not merely a chance circumstance.

The figures relating to the Bear Island area are insufficient for the first half of the year, but from July onwards when there are reliable figures to build on, we note that for this area we get a picture like those for the Barents Sea and the North Sea. The maximum appears here as late as September.

The curve representing the north west coast of Norway shows, on the other hand, quite a different picture. Unfortunately there are at hand data for 8 months of the year only. We get a secondary maximum in January when the big halibut constitute 47 % of the German trawlers' halibut catch. The percentage decreases up to April to only 14 %. But then again in May increases to no less than 72 %, only to fall again to 30 % in June. We have, unfortunately, no records as to what course the curve from then onwards takes. In November the percentage is 15 % and in December 30 %.

Supposing the catches of the German trawlers give an approximately correct picture of the stock of halibut on the fishing banks in the areas here discussed, then it appears as if the mature halibuts migrate on the approach of winter. At the same time as the big halibut become rarer on the banks in the North Sea, great numbers of mature halibut appear on the Møre coast and in North Norway great numbers of halibut congregate in spawn, particularly in the deep fjords from October onwards. The curve for the N.W. coast of Norway so strange at first glance, becomes explicable if ve assume that the mature halibut from the Barents Sea and the Bear Island area migrate into the fjords in order to spawn. At the end of April spawning is at end, and the halibut like the winter codfish, return to their feeding grounds in the Barents Sea where they find plenty of nourishment. *It is the halibut migrating northwards after spawning, that are responsible for German trawl catch of big halibut in May, and the influx of halibut to the spawning grounds is the cause of the gradual increase in the catches of big halibut from November and up to January.*

It is known from a number of investigations that the average size of the place depends on the depth, the older, bigger fish being generally found in deeper water than the younger. This may also be the case with halibut, and a general shifting of the trawler fleet to deeper water in summer, and in the winter to the shallower banks, may be the reason why big halibut appear more rarely in the winter catches.

The statistics do not supply any information as to the depth fishing takes place. Dr. LUNDBECK who works up the German fishery statistics has kindly placed some data at our disposal.

Dr. LUNDBECK writes: »Aus meinen statistischen Übersichten berechne ich folgende %-Verteilung der Fangreisen:

Tagebuchauszüge 1927—33.

Monat	I	II	III	IV	V	VI	VII	VII	IX	X	XI	XII
Flachwasser	72	58	30..	4	37	0	(49)	(100)	85	86	88	86
Tiefwasser..	28	42	70	96	63	100	(51)	(0)	15	14	12	14

By »Flachwasser« is here understood fishing grounds with less than 100 metres depth in the Barents Sea. By »Tiefwasser« the deeper lying banks (about 250 metres' depth). Accordingly fishing takes place at approximately the same depth during the months September to December, but the category 1 of halibut decreases during these months from 37% to 15%. We cannot, therefore, accept the explanation that shifting the trawling fleet from deeper to shallower water is responsible for the course of the curve.

Dr. LUNDBECK has also been kind enough to place at our disposal records relating to the average quantity of halibut caught by the trawlers per day, in shallow and deep water, pointing out, however, that these figures are not always to be depended on as the material is small. The average halibut catches per fishing day are seen in the following table:

Monat	I/II	III/IV	V/VI	VII/VIII	IX/X	XI/XII
Flachwasser (Kanin)	3	1	?	23	7	7
Tiefwasser..	28	43	52	?	35	14
Bäreninsel .	28	?	162	142	133	101

The catches of halibut increase in shallow, as well as deep water in summer. The increased number of halibut on the grounds is presumably contributed by big halibut.

These facts do not, however, prove that the halibut migrate to the Norwegian coast in order to spawn. The places in the Norwegian fjords where they are caught spawning lie at a depth of some 300—700 metres. It might be thought that they also migrate to other spawning grounds. JESPERSEN (4) and TAANING (13) give the temperature of water for spawning halibut to about 5°—7°. The only places at which such temperatures are met with within a reasonable distance are in the North Norway deep fjords from Hammerfest and southwards and at the edge down to the great depth of the Norwegian Sea. In the Varangerfjord we find depths of rather more than 400 metres. The sketch chart fig. 12 shows the areas which have soft bottom (according

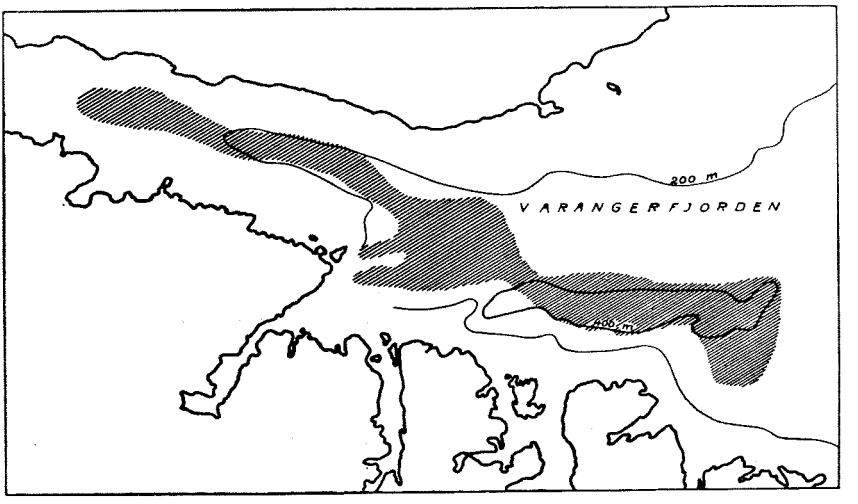


Fig. 12. The soft Bottom in Varangerfjord.

to SUND's investigation with echo sounding machine). The temperature, however, is rarely above 3 degrees. Attempts to catch halibut with nets in this area were negative.

One can only arrive at definite results as to migrations by marking fish on a large scale. In case of halibut one ought preferably to mark fish of such a size that one was more or less sure of their being mature. The immature halibut seem, according to statistics, to remain on the banks during spawning time, similar to what has been shown by American workers with regard to our halibut's near relative in the Pacific (*Hippoglossus stenolepis*).

For Icelandic waters also it can be proved by the German statistics that the appearance of big halibut in the trawls varies with the season. From the 1929—1936 catches the following percentages of size-group I may be calculated:

Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
10.4	6.7	22.3	23.0	24.0	26.6	19.2	21.6	26.5	28.0	26.0	17.8

According to this the greater part of the spawning of the Icelandic halibut takes place in January and February.

Norwegian Markings of Halibut.

Mr. THOR IVERSEN, of the Norwegian Fisheries Directorate, has carried out marking of halibut on the Bear Island Bank, and off the south east coast of Greenland. He has kindly permitted the publishing of the Bear Island marking experiments.

The table is a survey of recaptures up to January 1938.

Tab. 11. *Norwegian Halibut Marking 1929—30—31 near Bear Island.*
(carried out by Thor Iversen)
Total number marked 315

Liberations				Recoveries		
Position		Date	Size	Position	Date	Size
			cm			cm
74,27	16,44	8. VII 1929	57	16' NW of Bear Island	31. VIII 1929	
—	—	9. VII 29	70	74,25 E 16,17, 110 f.	20. VII 29	71
—	—	8. VII 29	78	*Sotbakken, 70 f.*	29	
74,26	16,43	12. VII 29	73	16' NW of Bear Island	1. VIII 29	74
74,35	16,47	12. VII 29	90	32' NW of Bear Island	27. VII 1930	
74,24	16,48	10. VII 29	77	28' NNW of Cape Bull	2. VIII 1929	
74,39	17,48	3. V 1930	68	74°36' N 17°26' E	15. VII 1930	
—	—	3. V 30	74	20' NW of Cape Duner 80 f.	4. VII 30	
75,05	16,24	6. V 30	81	72' NW ½ N of Bear Island	? 30	
74,26	16,48	8. V 30	67	20' NW of Cape Duner	1. VII 30	
74,24	16,50	9. V 30	75	27' NWtW of Bear Island	18. VIII 30	
74,26	16,48	8. V 30	72	20' NW of Bear Island	12. VIII 30	
74,24	16,50	9. V 30	56	31' W of Cape Bull	28. VII 30	
74,03	20,50	13. V 30	85	32' StE of Cape Bull	26. VI 30	86
74,28	16,41	11. IV 1931	71	*Fugløybanken*	16. V 1931	
—	—	11. IV 31	71	19' NW of Cape Duner	? 31	
74,23	16,44	16. IV 31	76	17' NW ½ N of Cape Duner	25. VI 31	
74,03	19,45	23. IV 31	77	73°44' N 18°05' E	19. VIII 31	85
—	—	23. IV 31	74	74°15' N 20°57' E, 100 f.	15-20. VIII 31	81
74,12	21,26	4. V 31	88	*Sleppen 3' NE of Helnes fyr*	27. VIII 31	
73,55	20,06	28. V 31	79	35' SW of Bear Island	19. VI 31	84
74,34	17,01	31. V 31	86	28' WNW *of Sørfugløy*	21. II 1932	
74,03	19,54	23. IV 31	85	British Trawler, no informations	?	

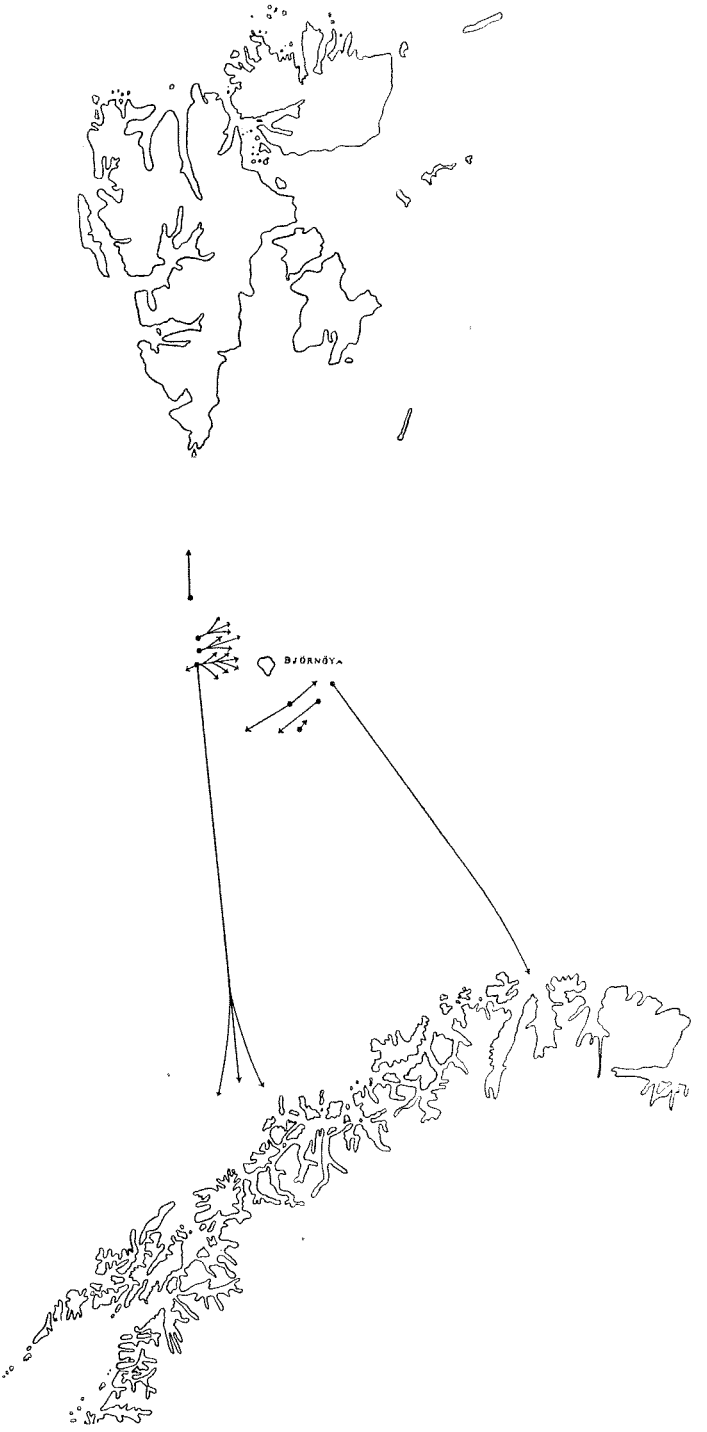


Fig. 13. The Halibut Marking near Bear Island.

The chart fig. 13 shows the places where the fish were liberated and where recaught. Most were recaptured near the place where they were marked, and shortly afterwards. Four specimens were taken on the Norwegian coast, i.e. about 17 % of all fish recaught. This seems to show that migration of halibut to the Norwegian coast from the Bear Island Bank is not uncommon. They were recaught at a time of the year that would seem to be natural, if the migration is assumed as directed towards the Norwegian coast for spawning purposes. To judge by the size they may very well have been mature males. We have, unfortunately, no information as to the sex. They were not recaught on typical spawning grounds, the marking experiment therefore affords no proof of spawning being incentive of the migration. The material is also too small to permit any definite conclusions.

The great increase in the catch of halibut caused by the net fishing — as mentioned in the introduction — made it possible to devote closer investigation to the halibut and marking of halibut was, therefore, carried out in two fjords:

(1) G l å m f j o r d during the latter half of December, 1936, where a total of 29 halibut were marked. Only 2 of these were recaught, 19 and 27 days, respectively, after being marked, both in the same fjord where they were marked. Halibut fishing in the Glåmfjord, which had been excellent during the first days of December, was practically at an end when marking operations were commenced.

(2) S ø r f o l l a was the other fjord chosen for marking. Here we had occasion to mark 68 halibut 13.—18. January, 1937. The great fishing in Sørfolla had ebbed out around the new year, but a few boats went on into 1937. A total of 19 fish were recaught, and 2 of these during the net fishing in the autumn of 1937.

All the halibut marked in Sørfolla were caught in nets at a depth of about 500 metres. We had no experience as to whether a halibut would stand such rough treatment as it must be to entangle it in a net and haul it up to the surface from such a depth. In order to get information hereon, 8 of the halibut made use of for marking were liberated in shallow water. All at once made for the bottom where they remained at rest for some minutes. Six of them then made for deep water but the other two remained lying on the bottom and when taken up later they were dead. We must, therefore, unfortunately assume that some of the halibut marked have not endured the treatment.

It was interesting to watch these halibut that were put out in shallow water. All were, when liberated of very dark colour. But after recovering a bit they assumed little by little the light colour of

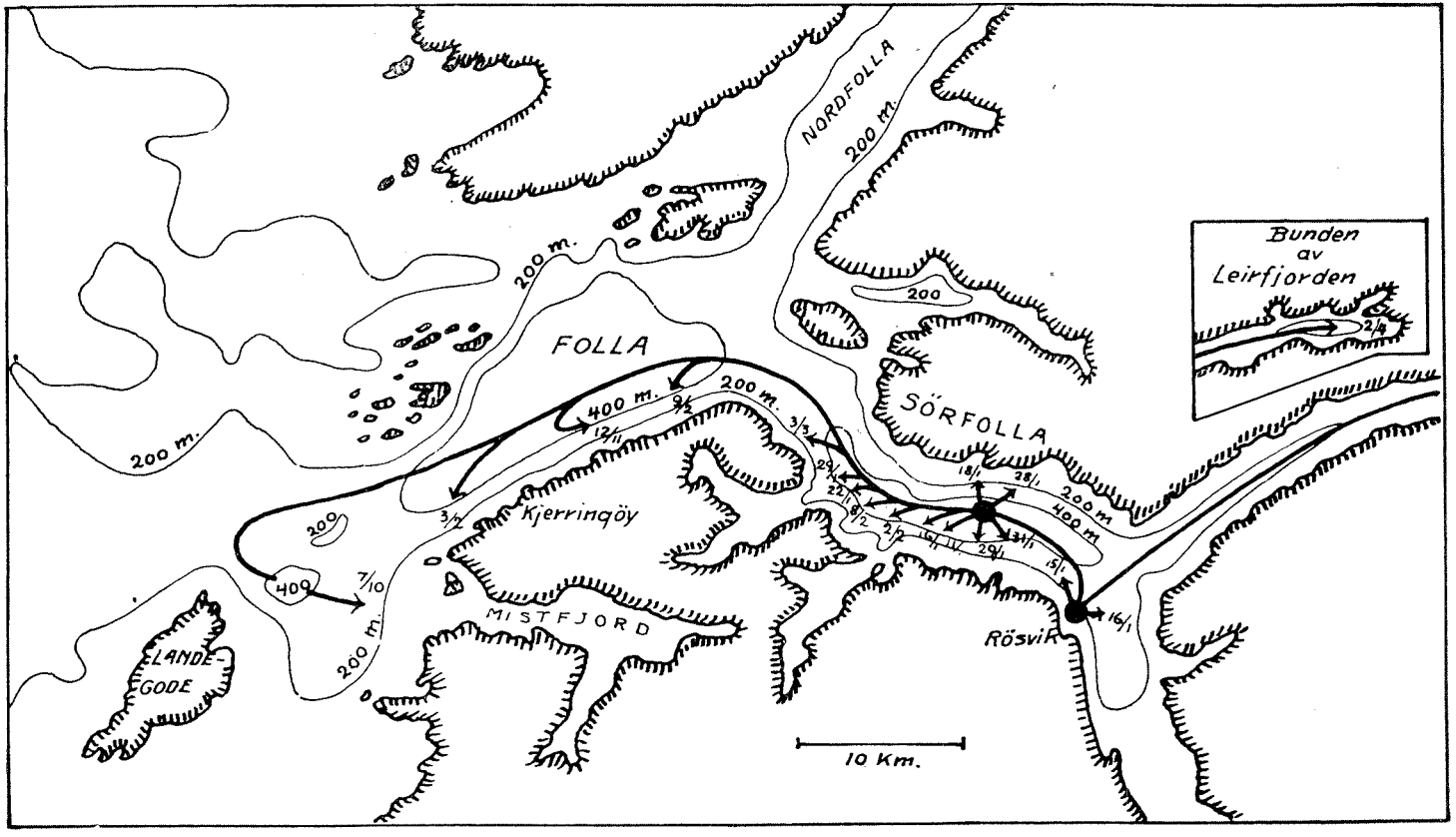


Fig. 14. Halibut Marking in Sørfolla.

Tab. 12. Halibut Marking Experiment, Sørfolla Jan. 11-18. 37.

(Carried out by the Author)

Total number marked 68.

Tag nr.	Liberation				Recoveries		
	Position	Date	Sex.	Size	Position	Date	Days
				cm			
1201	Off Skarvstein	11. I 1937	♂	119	Off Skarvstein	3. II 1937	23
1207	—»—	13. I 37	♂	116	—»—	3. II 37	23
1208	—»—	13. I 37	♂	130	—»—	2. II 37	20
1211	Røsvik	13. 1 37	♂	85	Kjelvik i Leirfjord	2. IV 37	79
1218	—	14. I 37	♂	160	Off Gjeitnes	29. I 37	15
1223	Off Skarvstein	15. I 37	♂	119	Off Skarvstein	18. I 37	3
1224	—»—	15. 1 37	♂	118	4' NE of Kjerringøy	12. XI 37	301
1232	—»—	15. I 37	♂	122	Sørfolla	16. I 37	1
1234	—»—	15. I 37	♂	105	1' SE of Tårnvik	3. III 37	47
1235	—»—	15. I 37	♂	117	1' NW of Jovikneset	22. I 37	7
1236	—»—	15. 1 37	?	150	Off Eide i Kjerringøy	9. II 37	25
1237	Røsvik	15. I 37	?	147[1]			
1242	—	15. I 37	♂	90	Landegodfjord	7. X 37	265
1249	Off Skarvstein	16. I 37	♂	99	Off Skarvstein	29. I 37	13
1252	—»—	16. 1 37	♀	172	—»—	18. 1 37	2
1254	—»—	16. I 37	♂	110	Off Korsvik	31. I 37	15
1256	Røsvik	16. I 37	♀	195[1]			
1267	Skarvstein	18. I 37	♀	169	Bjørnsvik	28. I 37	10
12??	Sørfolla	13-18. I 37	?	?	2' SW of Kjerringøy	3. II 37	ca.18

[1] Tag number 1237 and 1256 liberated in shallow water, and later picked up as dead.

the sandy bottom on which they were liberated. This change of colour took about 5 minutes.

The map fig. 14 shows the place were liberated and where recaught. The percentage recaught is 28 %. Two of eight specimens marked did not survive the marking operation. It may, therefore, be assumed that 25 % of the halibut marked do not survive the marking. This works out to only 51 out of the 68 marked becoming effective. The number recaptured of these 51 was 17 i.e. 33 %. As before mentioned the netting of halibut in Sørfolla was nearly at an end when the marking was carried out. If it had commenced at the beginning of fishing we would in all probability have got a considerably higher percentage of recaptures.

All halibut recaught in January were taken in the same deep basin where they were marked. The first specimen recaptured outside the threshold of the fjord was taken south of Kjerringøy, on Feb. 3 and another on Feb. 9. this one also outside the threshold. On April 2. the last specimen to be recaught was taken inside the threshold, and after that no more were reported until Oct. 7, and another on Nov. 12. These last two may very well have been far away. They were recovered outside the threshold of the fjord, and may have been on their way into the fjord in order to spawn.

From these finds it might perhaps be assumed that the halibut after spawning in the deep basin in Sørfolla, leave the fjord returning next autumn to the same fjord to spawn again. The evidence is, however, too slender to allow any definite conclusion. No fish marked in Folla has been recaught on the ocean banks.*)

We had much interest also in carrying out marking on the ocean banks too as fish from these places recaught on the spawning grounds in the fjords would conclusively prove that the migration theory is correct. At the request of the Director of Fisheries a sum of 3000 kr. were placed at disposal for this purpose. The Røst Bank was chosen for the experiment which was eventually carried out in May 1937.

Altogether 88 halibut were caught and marked on the Røst Bank. It proved, however, to be impossible — within reasonable time — to secure a sufficient number of halibut big enough to be taken for adults. We were obliged to mark all the halibut in good condition we could lay our hands on. The size grouping is shown in fig. 15. The sizes of net caught halibut prove that the male is mature even at about 70 cm, therefore one may hope that some, at any rate, of the halibut marked were mature.

*) After this being written halibut tag number 1245 was recaptured $^{11}/_{3}$—38, on bank off Røst.

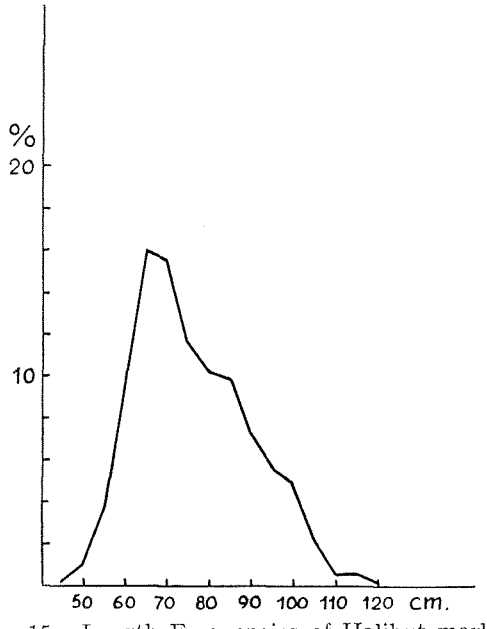


Fig. 15. Length Frequencies of Halibut marked on the Røst Bank.

Up to date only 3 have been recaught. The table shows the spot where marked, and where recaught.

Tab. 13. Recoveries of Halibut marked at Røst.

No.	Marked		
	Position	Date	Length
1326	67 10' N. 12 00' E	25. V	76
1371	67 24' N. 10 11' E	30. V	72
1372	67 24' N. 10 11' E	30. V	93

No.	Recaught			
	Position	Date	Miles	Days
1326	67 05' N. 10 35 E.	19. VI	33	25
1371	66 43' N. 12 30 E.	8. VIII	65	70
1372	67 12' N. 10 11 E.	19. VIII	12	81

The halibut carrying the tag 1371 is interesting inasmuch as it has wandered across the Vestfjord being recaught at Myken. This specimen was sent to the Fishery Directorate and proved to be a male, at stage 3, i.e. one about to spawn that season.

In the period 8.—19. July, the author marked 25 halibut near the Faroe Islands, at 62° 10' N. and 4° 05' W. The length of the halibut caught here varied between 70 and 205 cm, i.e. mostly mature fish. Whether they spawn there or migrate to the slopes leading down to deep water of the Atlantic Ocean, to the Norwegian Channel, or to the west coast to spawn, we do not know. We have not yet received any reports on fish recaught from this marking experiment.

As will be seen later on, the growth of the male and female respectively is so greatly different among the north Atlantic halibut that if further marking be carried out in the future, information on the sex of the recaught fish ought to be secured.

Length and Weight of Halibut.

The material here discussed was collected from Nov. 20. to Dec. 12, 1936. Measurements and weights were taken at the following places in North Norway: at Svolvær from Nov. 20.—28., at Botnhamn Dec. 4.—5., at Skrolsvik Dec. 8.—9. and at Skånland in Salten on Dec. 12. It would occupy too much space to consider each place separately, and as far as can be seen there is no particular difference.

The specimens were measured and weighed whole and intact and also gutted and headless. Fig. 16 shows the results regarding the male halibut and fig. 17 for females.

It will be noticed that the weight of males and females of the same length is approximately the same. Common to both is that they weigh approximately the same number kilos as their lenghts in cm exceed 100. This holds good in the interval between 130 and 150 cm.

The Age and Growth of Halibut.

The age is determined by means of the otoliths. The same method is applied as that made use of by mr. G. ROLLEFSEN for the age of cod. The otolith is broken through the nucleus and the broken surface polished. By sending converging light on to the convex side of the otolith simultaneously screening the polished surface from incident light, then the growth zones in the otolith appear clearly. Using a microscope one can then determine the age fairly correctly. This is the only method with any degree of certainty of assesing the age of such old halibut as those treated in this work.

The actual work of reading the halibut otoliths was performed by Mrs. ALVÆR who has great experience in the reading of cod otoliths. The readings were controlled by the writer and if differences arose the

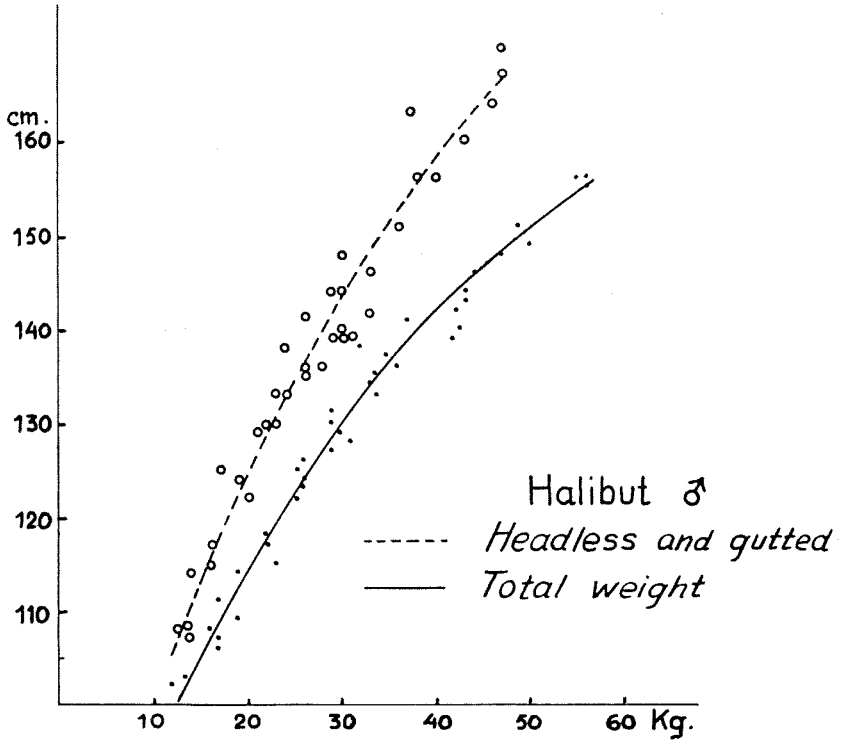


Fig. 16. Length and Weight of Halibut ♂.

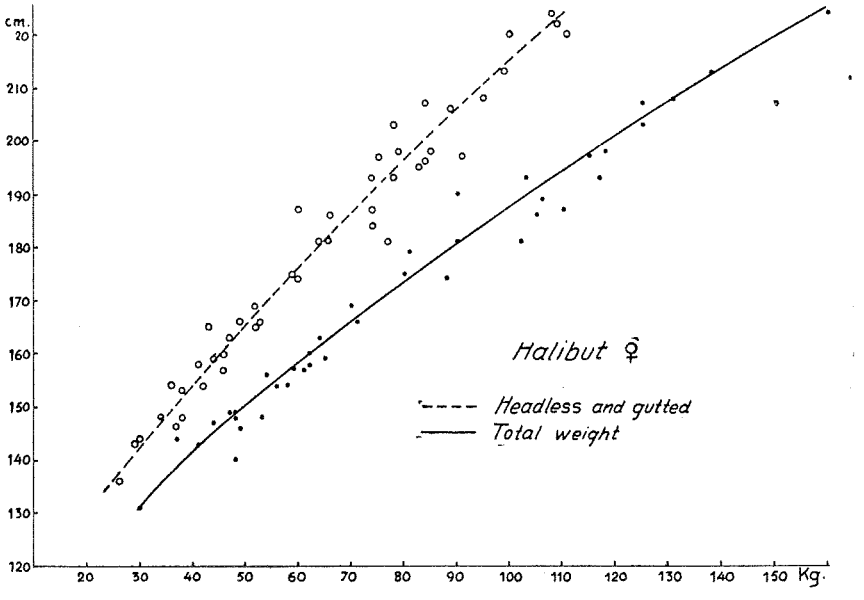


Fig. 17. Length and Weight of Halibut ♀.

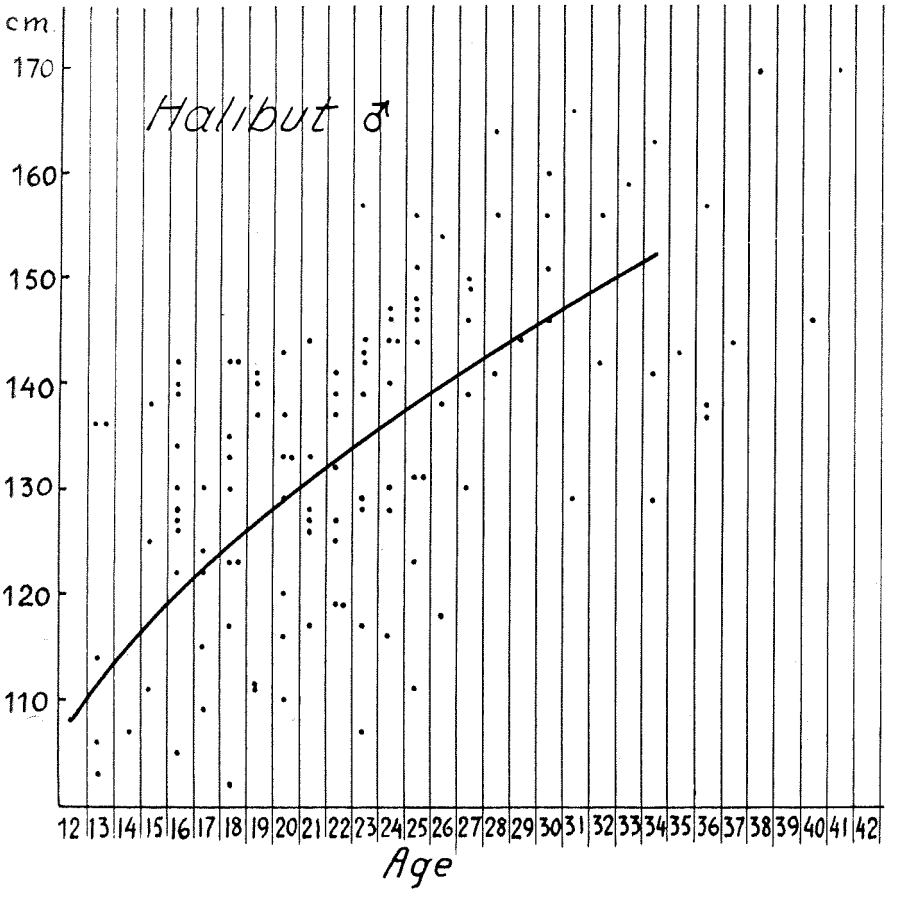
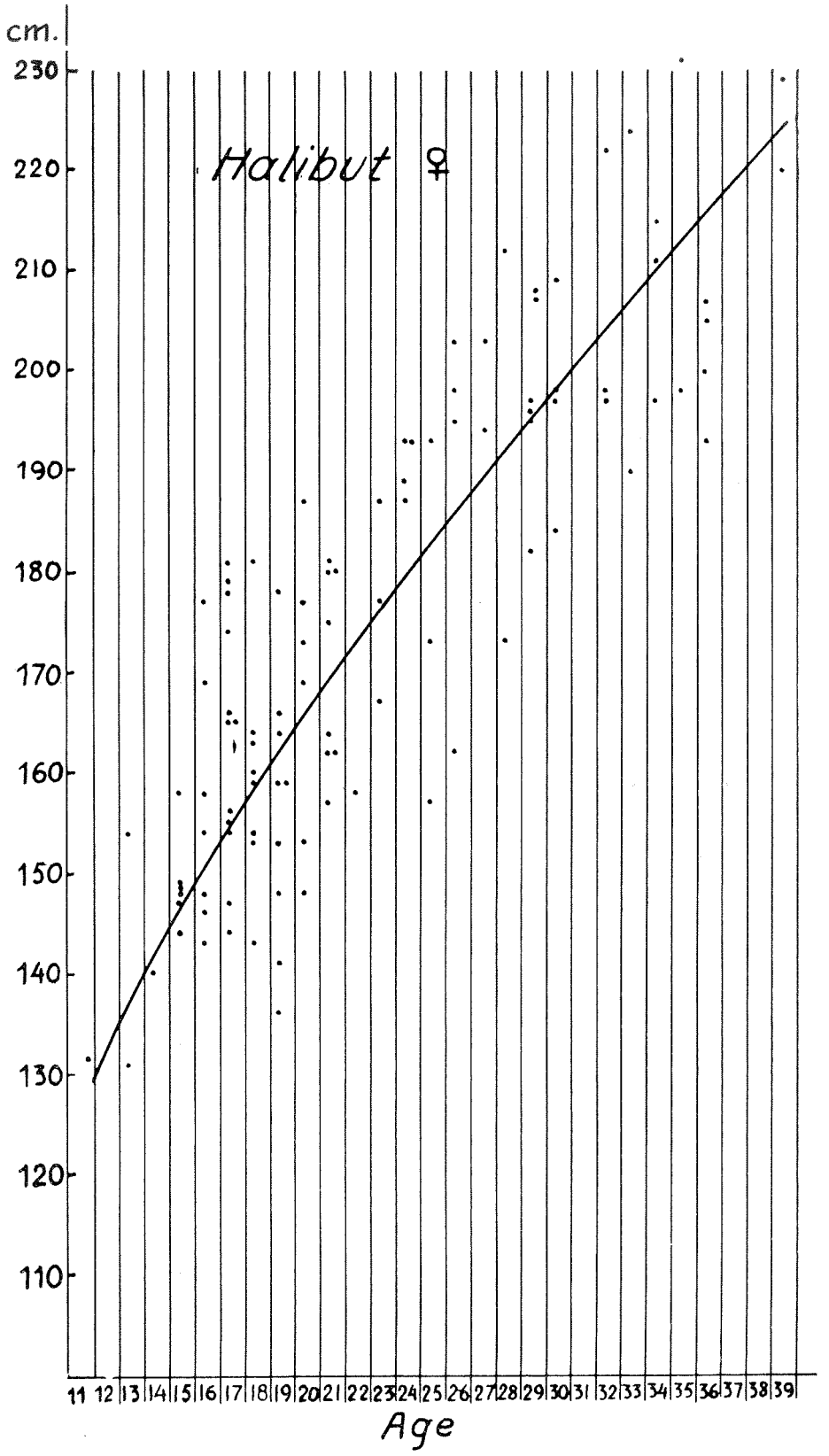


Fig. 18. Age and Length of Halibut ♂♂.

otoliths were subjected to fresh examination. In by far the greater number of cases the same result was arrived at, but some few otoliths had to be disregarded as undeterminable.

Fig. 18 shows the relation between age and length of the male halibut, and fig. 19 the same for females. Each dot stands for a fish. The curves are drawn on the basis of the averages calculated from these observations. There is, as will be seen, a great difference in the growht of males and females. The results are shown in the table below:



Fig, 19. Age and Length of Halibut ♀♀.

Tab. 14. Relation between length and weight.

Males				Females		
Age Years	Length cm	Weight (kg.)		Length cm	Weight	
		Total	Cutted Headless		Total	Cutted Headless
12	106	16	12	132	31	21
13	112	18	14	136	34	25
14	115	20	16	142	41	29
15	118	22	17	147	46	33
16	120	23	18	151	51	37
17	123	25	19	155	56	40
18	125	26	20	159	61	44
19	127	28	21	164	67	48
20	129	29	22	167	71	51
21	131	31	23	170	75	54
22	133	33	24	173	79	57
23	135	35	25	177	85	61
24	137	36	26	180	89	64
25	138	37	27	183	93	67
26	140	39	28	186	98	70
27	142	41	29	190	103 ?	73
28	143	42	30	193	108	76
29	145	44	31	196	112	79
30	146	45	31,5	198	117	81

The size variations of halibut within the several age classes are, however, so great that the curves we have been able to draw on the basis of this material, become perforce somewhat hypothetic and must be looked upon with some reserve.

The edible portion of a male halibut increases by one kilo per year from the age 14 until 29 years while the useful weight of a female halibut increases by about 4 kilos per year from 12 to 16 years and then only a little less rapidly until between the ages of 25 and 30 the yearly increase is still about 3 kg per year.

Mr. GUNNAR ROLLEFSEN has found that the annual rings in the cod otoliths change character at a certain age. The wide growth zones, opaque in transmitted light become from a certain year narrow and sharp, and it is the hyaline part of the zones which in the ensuing years contribute most of the growth of the otolith. Corresponding to this change in the otolith the growth of the cod is considerably reduced. ROLLEFSEN interpretes these changes as a result of maturity setting in (10, 11, 12). This phenomenon was pointed out by A. C. JOHANSEN with regard to plaice as long ago as 1912 (7). O. NORDGAARD mentions that the interoperculum shows a reduced growth from the year the plaice commences spawning in the Trondheimfjord (9).

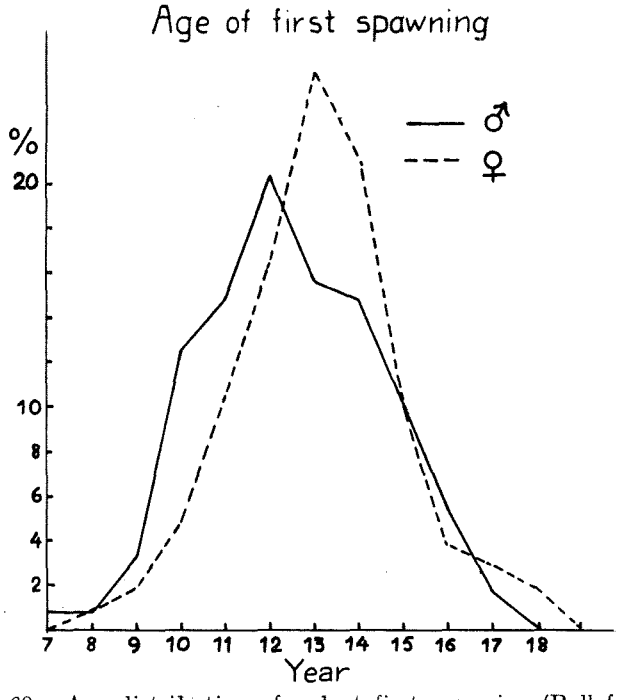


Fig. 20. Age distribution of ~~cod~~ halibut at first spawning ~~(Rollefsen)~~.

Consequently one would expect such a change in the halibut otoliths and in the greater number of cases one can indeed see a similar change as in the cod otoliths. All the zones in the halibut otoliths are, however, very narrow, and to determine with certainty what year in each case the change sets in is, therefore, considerably more difficult than is the case with the cod.

Fig. 20 shows the age when maturity is attained, assuming that the change in the structure of the otolith means that maturity has set in. If so males become ripe between the 7th and the 17th year and most have reached maturity at the age of 12 years. The females become mature at an age between 8 and 18 years, the greater number becoming ripe when about 13 years old.

Spawning of the Halibut.

There exist few certain data as to the spawning of the North Atlantic halibut. We know from the Danish finds of halibut eggs and larvae, (TAANING 13) that halibut spawn on the slope leading down to the Atlantic deep along the ridge connecting Greenland, Iceland, Faroe and Scotland. The material at hand is, however, far too insufficient to determine the time of maximum spawning.

It has long been known by fishermen that halibut spawn in Norwegian waters. An unfailing fishing takes place in the autumn off Sunnmøre. J. HJORT (1) writes about this in »Norges Fiskerier«, part 2, page 64: »From the month of September the halibut begin to seek towards the bank, and, similar to the ling in spring, it is also assumed that they approach the entire length of the bank, as it is fished for over the whole of Storeggen during the autumn. At certain places they are, however, caught in greater quantities. Such special halibut grounds are west and north of Koralnesset, west of Sørmannsnesset and at a spot 73 miles WN of Runde, at which place there is yellow sandy bottom. This spot which is included in the area named Aktivnesset in the chart, is not large. At Koralnesset, on the other hand, little fishing takes place in the summer. The halibut collect more and more until November when they spawn. At Christmas time the halibut is scarcely edible as it is »spent««. HJORT further states that the best depth is 250—300 fathoms. This was written in 1905. We still have the same fishing for the big spawning fish at these places.

Some fishermen in 1934 pointed out on the chart to Mr. GUNNAR ROLLEFSEN the spawning ground of the halibut which was supposed to be situated between Svendsgrunnen, and Malangsgrunnen off Troms. The fishermen I had the opportunity to interview during the net fishing in the winter of 1936—37, told me that at the places where they now were carrying on net fishing, they had for many years practised line fishing (gangvad) and that they had caught big ripe halibut every year. Halibut in spawn began to appear about Christmas.

When marking halibut at Sørfolla, the sex of the fish in most cases could be determined merely by external appearance. Among the halibut caught during the marking experiments, one spent female was caught in january 15. Among the female fish caught there two had running roe to such a degree that the boat's deck was covered with quite clear roe. Nine spawned when being pressed gently over the ovary, but nine others still had hard roe.

Out of 43 halibut that left no doubt as to their being males, 41 discharged the milt by slight pressure on the gonads. In five out of a total of 68 halibut the sex could not with certainty be determined. The marking took place between January 13—18, 1937. Halibut roe was sent, however, to the Fishery Directorate from the same area as late as April. This was still only at stage 4—5. The spawning covers, therefore, a fairly long period. The material at hand does not, however, allow to determine the time of maximum spawning.

The depth at which spawning takes place in the north Norwegian fjords is 300—700 metres. The temperature south of the Vestfjord is

between 6 and 7 degrees. The most northerly point where we have certain records about the spawning of halibut is Sørøysund—Stjernesund, and the entrance to the Altafjord where the depth is 400—600 metres, and the temperature at the bottom approximately 5° in April.

At all places in the north of Norway where big catches of halibut in spawn are made, there was soft clay, or mud bottom. By means of echo sounding one can easily delimit the grounds where halibut fishing in spawning time may be tried with hope of success. A number of such places were charted during the spring and summer of 1937 by the »Johan Hjort« and in Febr. 1938 mr. Sund actually succeeded in finding the halibut eggs in all the three places where a suitable fishing method was tried — townetting of long duration in deep water — namely in the Trondheim fjord, the Glaamfjord and Økssund.[1])

The Effect of Net Fishing on the Stock of Halibut.

As before mentioned the quantity of halibut exported to England gives a fairly correct idea of the catch. During the last 4 years the following quantities of halibut were exported to England.

Sept. 1. 1933 — Aug.	31. 1934	.....	2846 tons
» 1. 1934 — »	31. 1935	.....	2111 »
» 1. 1935 — »	31. 1936	.....	2628 »
» 1. 1936 — »	31. 1937	.....	4723 »

It will be noted that the quantity is almost doubled the last year. This is due to the new form of fishing halibut, i. e. net fishing. It is the same stock of fish which is fished for from September 1936 with nets also. We have seen earlier that everything pointed in the direction that the stock of halibut was decreasing, before nets were made use of. It was pointed out when describing the fishing of halibut with nets, how quickly the numbers were reduced on the several fishing grounds. It ended first at those places where it first commenced, and it may be said that the duration of the fishing was proportional to the extent of the grounds.

It might be supposed that the fishing declined so quickly because the halibut, after spawning, went out to sea again. If so be the case then the spawning time of the halibut that collect in the Vestfjord area must, mainly, be as early as the middle of December. After that time only small numbers were caught in that area. Farther south on the coast of Helgeland, where their presence was first discovered in February, good fishing continued as late as into March. But the assumption that the halibut in the Vestfjord area spawned about three months

[1]) The author succeeded, in the same way, in finding halibuteggs in Malangen and Stjernsund February 1938.

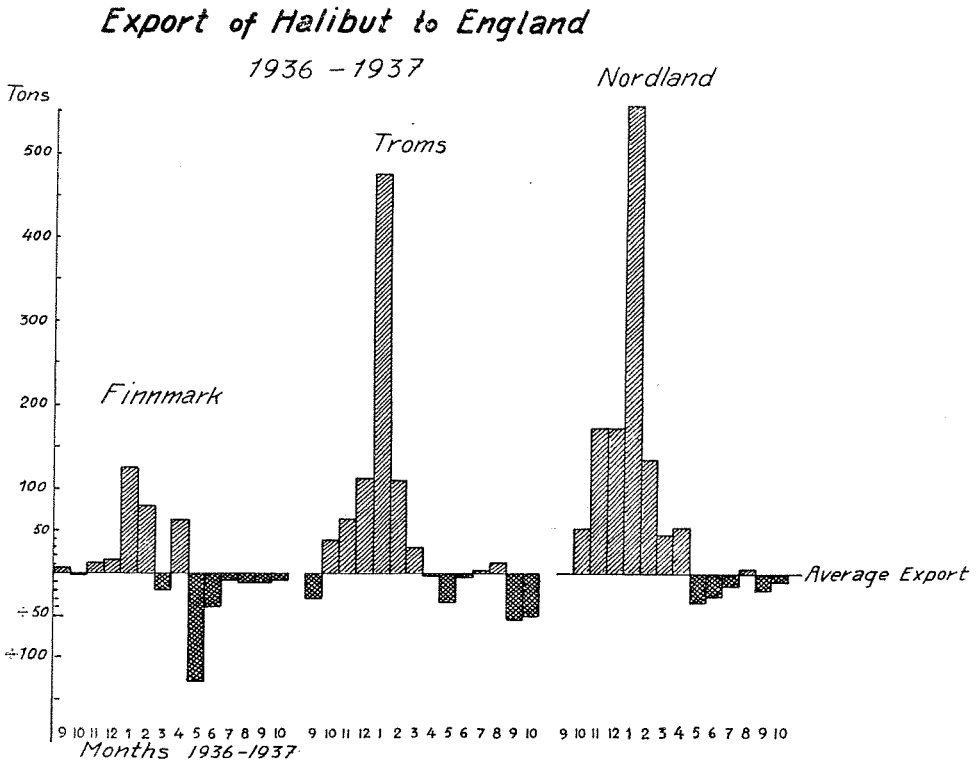


Fig. 21.

earlier than farther south is hardly probable, it would be more reasonable to assume early spawning farther south on the coast on account of the somewhat warmer water. The explanation is, taking all things into consideration, that the nets are so effective that at the limited places where halibut have collected, they succeed in a month's time in catching the majority of halibut that are present in the locality.

Considering the average exports to England calculated for the several months for the period Sept. 1933 to aug. 1936 incl. (fig. 9 page 20) as the normal exports we get a background for the exports from the northernmost counties since net fishing started, or since September, 1936, see fig. 21.

The huge surplus that was exported in January was, however, partly caught in December as the British import quota was complete before the end of the year. During the period December 19.—31, 1936, there was no export of fresh fish to England. The net fishing ended at the last places in April. Thus it looks as if net fishing has had a very perceptible effect on the catches of the line fishers even after the first

season. One must bear in mind that the line caught halibut in the summer months are mostly small immature fish which, therefore, have not been affected by the nets. The decline in the fishing is, nevertheless, obvious. From September onwards most halibut caught are mature fish, and we note that despite some 3.000 men joined in the net fishing in the autumn of 1937, even so they did not succeed in getting the average quantity caught on lines by a modest number of fishermen in the corresponding months of the period Sept. 1933 to Aug. 1936. During the autumn of 1937 many more nets were employed than the number which in the preceding autumn had been capable of doubling the annual output of halibut, and that in only a couple of months.

If we compare the quantity caught in Nordland and Troms in 1936, with that obtained by a far greater number of fishermen in 1937, during the months of October and November, on the evidence of the export to England, we get:

Tab. 15. Net caught Halibut in Tons exported to England:

Year	From Troms			From Nordland			Both. counties
	Oct.	Nov.	Tot.	Oct.	Nov.	Tot.	
1936....	126	167	293	106	253	359	652
1937....	45	56	101	40	141	181	282

The decline in the fishing would appear still more conspicuously if the number of nets used in 1936 were known, but unfortunately, no such records exist. The catches in the Vestfjord area for the autumns up to December 1 of 1936 and 1937 were, according to records kindly submitted by the firms exporting halibut from this area.

Where landed	1936	1937
Vaagan and Svolvær	239 tons	17 tons
Bodø—Lødingen	368 »	89 »
	Total 607 tons	106 tons

We must here consider that in 1936 the fishing developed very gradually. Most of the fishermen did not join in until late in November. In 1937, on the other hand, the fishermen had their nets ready as early as the beginning of September, and they were also armed with the experience of the previous year.

The heavy quantities of halibut that were landed during the winter of 1936—1937 brought about a great fall in prices. At this season the price uses to be somewhat over 1 kr. per kilo in the three northern counties. In December and January that winter the price fell so much that the fishermen got no more than 20—50 øre per kilo.

PROTECTION.

Evidently something had to be done to safeguard the stock of halibut by law, and to reduce the fishing. Experience was, however, slight and very incomplete, there was not even one full season's fishing to build on. Even so the Storting as early June 17, 1937, passed a »temporary act for the protection of halibut«, which in translations runs as follows.

§ 1.

It is prohibited to sell halibut measuring less than 50 cm from the tip of the snout to the tip of the tail. Below this size halibut caught with any kind of gear and capable of surviving shall at once be thrown over board.

§ 2.

In the halibut fishery it is prohibited to use nets with smaller meshes than 3 knots pr. ell (8 norw. inc. or 20.88 cm between knots) in new nets.

§ 3.

Before 2 o'clock p. m. on Fridays the halibut nets are to be handed granted that the weather does not prevent this and the nets must not be put into the sea again before 10 o'clock a. m. on Mondays.

Nets which on account of bad weather have not been handed within the hour fixed must be handed as soon as the weather permits.

Otherwise the restrictions established in the Common Fishery Statutes concerning fishery on holidays shall also be in force regarding halibut fishery.

§ 4.

In the period December 15th—February 28th (29th), both days included, halibut must not be caught with nets.

§ 5.

By The King's decision the protective measures in § 3 and 4 can be expanded or restricted if the fish trade makes this necessary.

§ 6.

Trespassing against this law or against regulations issued in agreement with this law shall be punished by fines.

Unlawful catch — or the value of such catch — can by court decision be confiscated for the benefit of the Treasury.

§ 7.

This law shall temporarily be in force from July 1st 1937 but not after December 31st 1940.[1])

At present it looks, however, as if these regulations are not sufficient to protect the halibut stock. Even prior to the advent of net fishing everything indicated that the stock of halibut was greatly on the decline. The great number of old fish caught in the nets may be explained by the fact that the really big halibut generally seek deeper water than the trawlers and most line fishers (J. HJORT I.). They are, therefore, protected from the trawlers and also from the greater number of the line fishermen's onslaughts during this part of their life.

In connection herewith it may be worth while drawing attention to the restrictions which the U. S. A. and Canada have made in order to preserve and restore the Pacific halibut fishery. Trawling for halibut has been tried, but is not carried on as it proved unprofitable. Netting is totally prohibited. So only line fishing is left, and even this method is prohibited during the main spawning time, in fact all halibut fishing. This protection has been enacted for 1937—38 to cover the period from midnight on Oct. 19. to Feb. 15. i. e. nearly four months. Further, the quantity permitted to be caught within each area is fixed in advance, and when such a quantity has been reached further fishing in that area is forbidden. Since the International Fisheries Commission who have been studying the matter since 1924 were in 1930 empowered to limit the halibut fishing, the catch per line unit has risen from 35 lbs. to 60 lbs. on the southern banks, and on the western banks from 65 to 90 lbs. (W. F. THOMPSON 18).

Sooner or later it will be imperative for European lands also to take up the question of protecting the North Atlantic halibut. They are found chiefly in international waters. It looks as if the precautions adopted by Norway in order to protect halibut will, to an even greater degree, benefit also the international trawling fleets. The preservation of the halibut stock is, therefore, to be considered an international question, and it is to be hoped that as many as possible become aware that it is a question which should be urgently handled.

[1]) This law is now repealed but regulations of about the same content are taken up in the new temporary act of May 6, 1938 about »protection of fish«.

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APPENDIX

The Bottom Temperatures

By

JENS EGGVIN

A. A GENERAL SURVEY OF THE DIFFERENT WATERS.

In connection with the paper of Mr. FINN DEVOLD: The North Atlantic Halibut, a short survey of the bottom temperature will here be given. Adapted to its purpose the different types of water in the area considered will then first be mentioned.

It is well known that a submarine ridge, leading from Scotland past the Faroes, Iceland to Greenland separates the Norwegian Sea from the Atlantic Ocean. As the saddle-depth is scarcely 600 m only, the bottom waters of those two, comparatively deep oceans, are kept apart. In a depth of 1000 m the temperature of the Norwegian Sea is below 0°, whereas the temperature round Greenland, S of the threshold, is 3—4° in the same depth. The bottom water of the Norwegian Sea (about — 1.3°) is also bounded in the north, by a threshold, Nansen-ryggen, which keeps it apart from the warmer bottom water (about — 0.7°) of the Polar Basin. The greatest depth on this threshold between Western Spitsbergen and the North-eastern part of Greenland, is, according to FRIDTJOF NANSEN'S conclusions, supposed to be about 1100 m, whereas the depth on both sides of the ridge attains over 3000 m.

With a thickness corresponding to the saddle-depths, Faroes—Scotland, Faroes—Iceland, the atlantic water overflows the cold bottom water of the Norwegian Sea. The temperature of the latter is below — 1°, and the salinity 34.9 $^0/_{00}$, whereas the water flowing in, has a salinity of more than 35 $^0/_{00}$. The Atlantic current, being pressed towards the Norwegian coast by the deflecting force of the earth rotation and the prevalent south-western winds, has its greatest force just outside the slope of the continental platform down to the great deeps, and from there it wedges westward. To some extent the two types of water are mixed in the moving direction, the result being that the limit of the two layers sinks northwards. Thus a temperature of 0° will be found in depths of about 600 m off Møre, and about 800—900 m off Lofoten and Vesterålen.

Currents of fresher water are running both along the western and eastern edge of the Norwegian Sea, namely the East Greenland stream, bringing southward cold watermasses of low salinity from the Polar Basin, and the Norwegian coastal current running North. By the deflecting force of the earth rotation both these currents are pressed towards the coast, Greenland and Norway respectively, and consequently attain greatest thickness near the land, and from there wedge out outward.

The Norwegian coastal current consists of fresh water from the Baltic (the Baltic current), and water from the North Sea. To these are added important masses of fresh water, carried from land out to the Norwegian coast. The transport of fresh water is of comparatively greater importance from the Vestland with its heavy precipitation, and is decreasing northward.

The coast water mixes with the underlying, heavier Atlantic water, thus bringing about an assimilation of salinities northward, as the salinity of the coastal water to some extent increases, and that of the Atlantic water decreases. The limit between the two types of water thus sinks northward, just like the limit between the Atlantic water and the bottom water. The water along the East-Finmark is therefore very homogeneous during spring with only a slight difference in salinity as well as in temperature from the surface to the bottom.

As a rule the salinity of the coast water increases northward, but sometimes the transport of fresh water from the Vestland will be so great that the salinity in the surface is lower here than farther south. This effect can be traced far out in the northern part of the North Sea, as was the case during the intensive snow-melting in the spring of 1937.

The general rise of temperature during spring and early summer also causes the surface waters to get lighter and flow farther out, while the thickness of the coast-water near the land decreases simultaneously. Consequently a movement of Atlantic water will start towards the land, along the bottom of the banks, while at the same time this water will come higher up in the sea. (HELLAND-HANSEN and NANSEN 1909). In autumn and winter the case will be the opposite. The coast-water cools and is carried nearer to the shore, the thickness decreasing at the same time. This movement to and from the shore being dependant on the season, is, however, influenced by the prevalent northerly coastal stream. The movement of the coast-water therefore, in its broad features, will be a spiral movement.

The limit between Atlantic and coastal water is farther subject to the tidal wave as well as to quite unperiodical movements caused

by the wind. If the wind direction is such that the surface-waters are carried out from the shore, these waters generally must be replaced from deeper strata, frequently by waters of quite differrent temperature. In summer this may cause the surface-temperature, e. g. off Jæren and Lista, to sink 10—11° in the course of a couple of days.

B. THE IMPORTANCE OF THE COAST-BANKS AND THE FJORD-TRESHOLDS FOR THE THERMIC ECONOMY OF THE FJORDS.

In the part of the Norwegian Sea which is limited by the continental platform along the Norwegian coast, we may, as shown above, recognise three water-types, the light coast water, the heavier Atlantic water, and the bottom water of the Norwegian Sea, which is the heavies .

As everywhere the depth of the continental platform is smaller than the deep where the last mentioned type of water is found, this cold bottom water (below —1°) will not reach the continental platform or the coast-banks. Consequently it will not come into our fjords either, even if the depth, e.g. of the Sognefjord is greater than that corresponding to the upper limit of the bottom water in the sea outside.

On the top of the bottom water lies the Atlantic water, which, outside the slope, comes right up to the surface. On the coastal banks it comes in below the coast water and covers the bottom of the banks if these are not so shallow that the coast water may reach right down to the bottom.

Most Norwegian fjords have a threshold at the entrance, and the greatest depth of this threshold, the saddle depth, decides the type of the deep water in the fjord. If the saddle depth is smaller than the deep where the Atlantic water in any season is found outside the threshold, this water cannot possibly intrude into the fjord, which, for this reason, is filled to the bottom by coast water. With a great saddle depth the deepwater of the fjord would consist of warm Atlantic water.

Even in the absence of a threshold at the entrance to the fjord, the banks outside can be so shallow, or the coast water so thick that it reaches to the very bottom, thus preventing the Atlantic water from flowing into the fjord. In spite of the absence of a threshold at the entrance to the great Finnmark fjords, where the depth at the mouths is 200—300 m, Atlantic water never occurs there. By the term »Atlantic water« we then mean water having a salinity of over 35 $^0/_{00}$, regardless of temperature, according to O. PETTERSON'S definition. The bottom water lies between 34.4 and 34.9 $^0/_{00}$ in the deepest parts of the fjords, that is to say Atlantic water to some extent mixed with coast-water.

C. CHARTS OF THE BOTTOM TEMPERATURE

1. Lindesnes—Trøndelag.

In the fig. 1 is shown the bottom temperature from Lista to Trøndelag, westward to Scotland and Shetland, and farther north-eastward to 20—30 nautical miles off the Storegga. The observations were made during spring 1937 (12/4—7/5) by the Fisheries Directorate of Bergen. The small cirkles indicates the position of the stations.

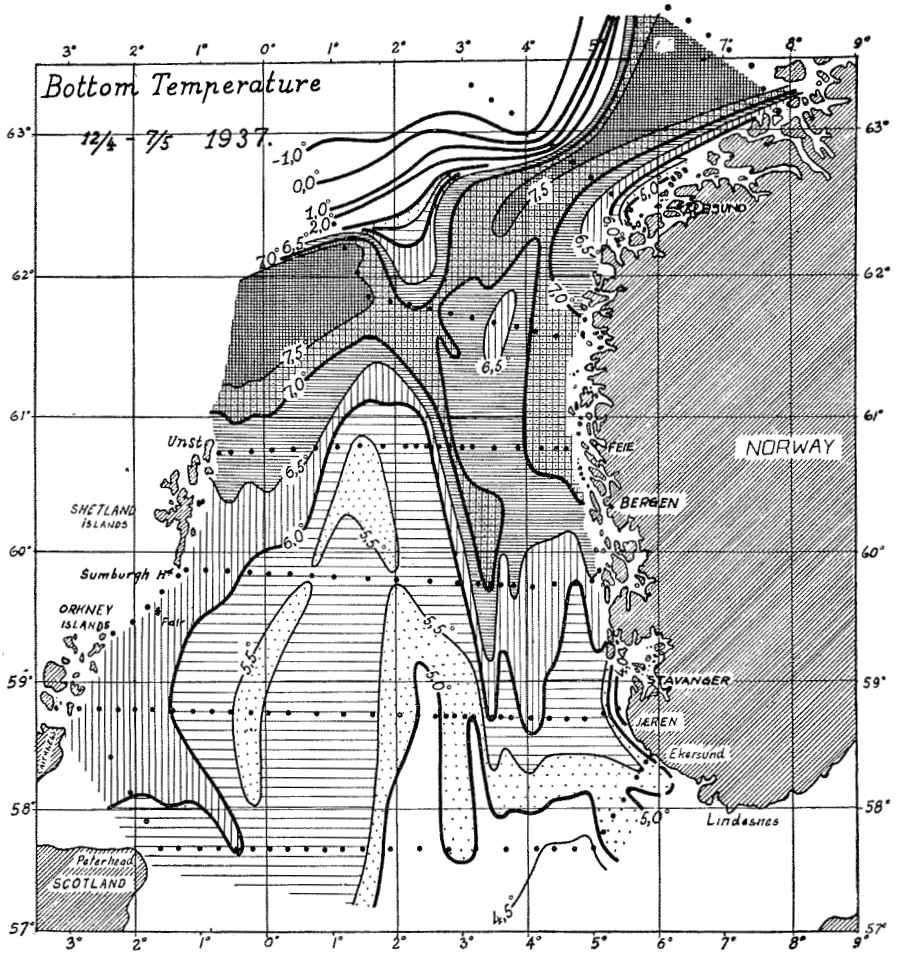


Fig. 1.

It will be seen that the temperature is highest on the banks north of Shetland and farther towards north-east to a point off Møre and Trøndelag, showing areas with a temperature between 7.5 and 8°. This is the region of the bottom where the effect of the Norwegian Atlantic current (The Gulf Stream) is most conspicuous. Therefore it is to be expected

that the temperature in this area of the bottom will decrease northward as well as southward. This is also the case. As we see the temperature is less than 5° in the southern part of the area in question. On the slope of Storegga the temperature decreases very rapidly from 7° to below — 1°, as we have here to do with the cold bottom water of the Norwegian Sea.

Where the Norwegian Channel at a latitude of about 62° N opens out into the Norwegian Sea, the isotherms make a bend southward, generally following the depth contours. Further we notice that along the western part of the Norwegian Channel an offshoot of warm water presses southward. This is a branch of the Atlantic current which flows into the Norwegian Channel towards south. It will be seen that the temperature of the shallow North-Sea plateau is lower than that of the Norwegian Channel. It is in the central parts of the North Sea that the bottom temperature in this season is lowest, for this is the area where the water is shifted out most slowly.

2. Northern Norway.

From Trøndelag to Lofoten the decrease of temperature is slight. At Folla it is comparatively warmest, the bottom temperature in 1927—1937 having been between 7° and 7.9°. In 1922 (15/7), it was somewhat lower, namely 6.76°.

From the figure 2 it will be seen that the bottom temperature in the West Fjord is 6.7—7.1° in depths over 200 m in spring 1937. It is warmest in the south-western part; likewise there is an area between Øksnes and Skrova with somewhat higher temperature than in the inner and outer parts of the fjord.

The Atlantic water, flowing northward along the coast, has its greatest velocity just outside the edge. It splits into two arms off West-Finnmark. One arm follows the edge northward to Svalbard, while the other is deflected to the right on the more shallow plateau north of Finnmark and runs into the Barents Sea.

The fig. 3 showing the bottom-temperature from Andenes to the Fishermans Peninsula in the spring 1936, shows that the temperature decreases eastward from 6° off Andenes to 1.5° at the mouth of the Varanger Fjord. It will also be seen that the isotherms have a distinct bend eastward, at some distance off the coast of Troms and Finnmark.

Calculations of the current show that this is the area where the east-flowing current is strongest in the deep, conveying warm Atlantic water eastward. Consequently the temperature here must be highest; this is expressed in the deflection of the isotherms above mentioned.

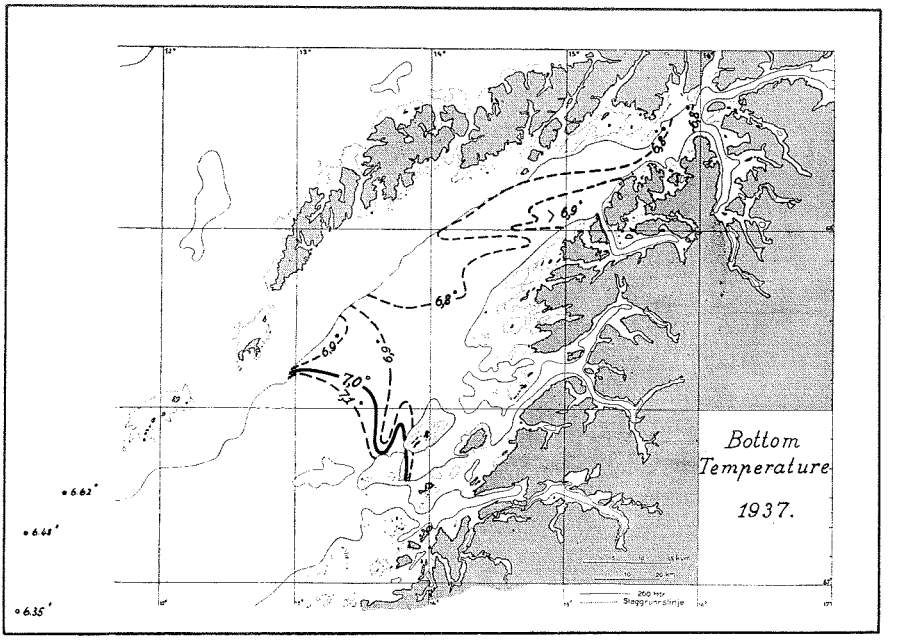


Fig. 2.

In a certain region north and east of Vardø, the temperature decreases very rapidly, sinking from 3.5° to 2.5° along a comparatively short distance. Here is the area namely, of an extensive mixing of fairly warm Atlantic water with colder eastern waters. The course of the isohalines also characterise this region as an area of mixing waters. The position of this area is shifted east- or westward, the movement being caused by variations in bulk and force of the current in the Atlantic water as it flows east and afterwards south-east. Thus in 1936 the limit was found much farther to the west than in 1934 and 1937 (see the figs. 3, 4 and 5). During the two years last mentioned there was more Atlantic water off Finnmark than in 1936. In the spring of that year the 3° isotherm did not reach east of Vardø. Further, a belt of cold water, (of about 3°), ran along the coast from the shore to some distance outside the land-slope, right west to Honningsvåg (fig. 3). And the 4° isotherm did not reach farther east than Nordkyn, while in the two other years mentioned it reached east of Vardø, and 3° isotherm had moved eastward to the North-east-bank.

The observations show that a belt of comparatively warm water is found in the deep off the coast of Finnmark, whereas there generally is colder water both nearer to the land and farther out. The salinity as well as the calculated current show that the warm water is an off-

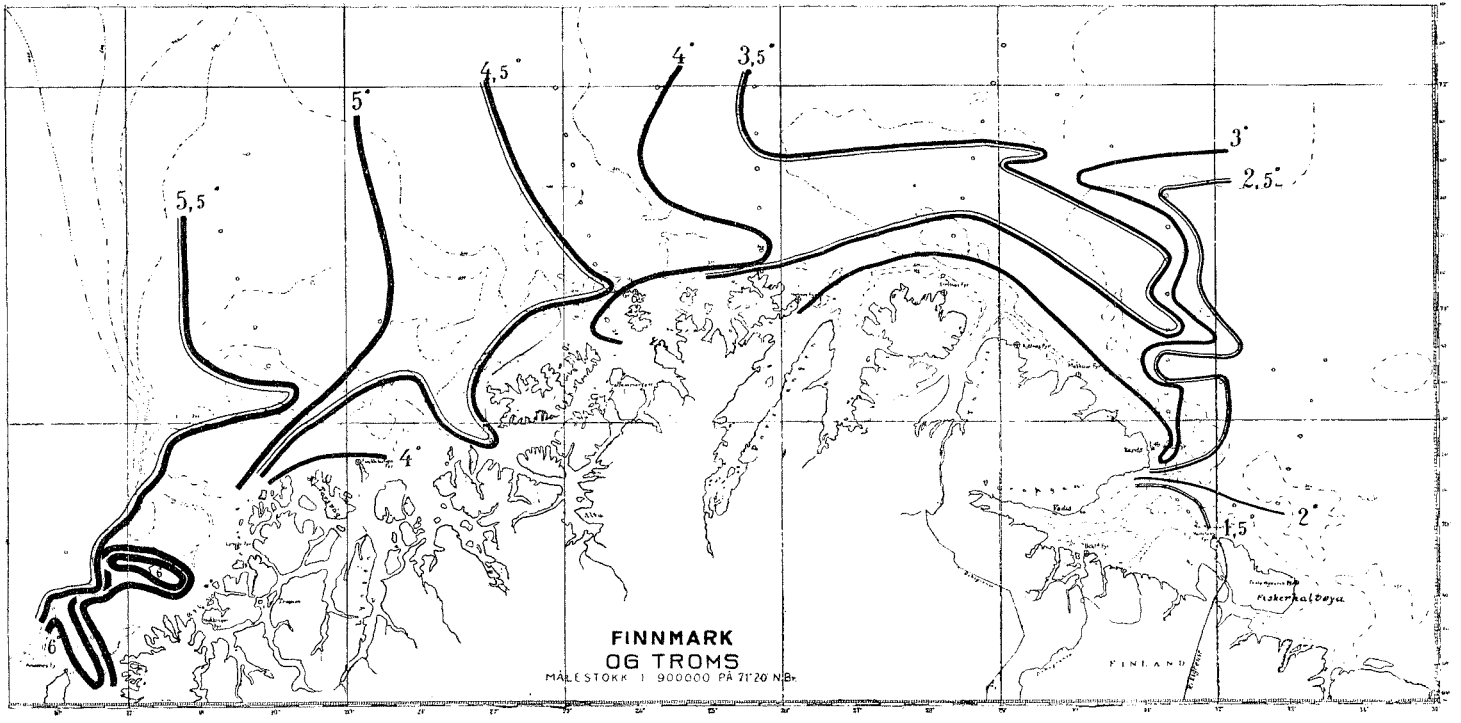


Fig. 3. Bottom Temperature off Troms and Finnmark sprens 1936.

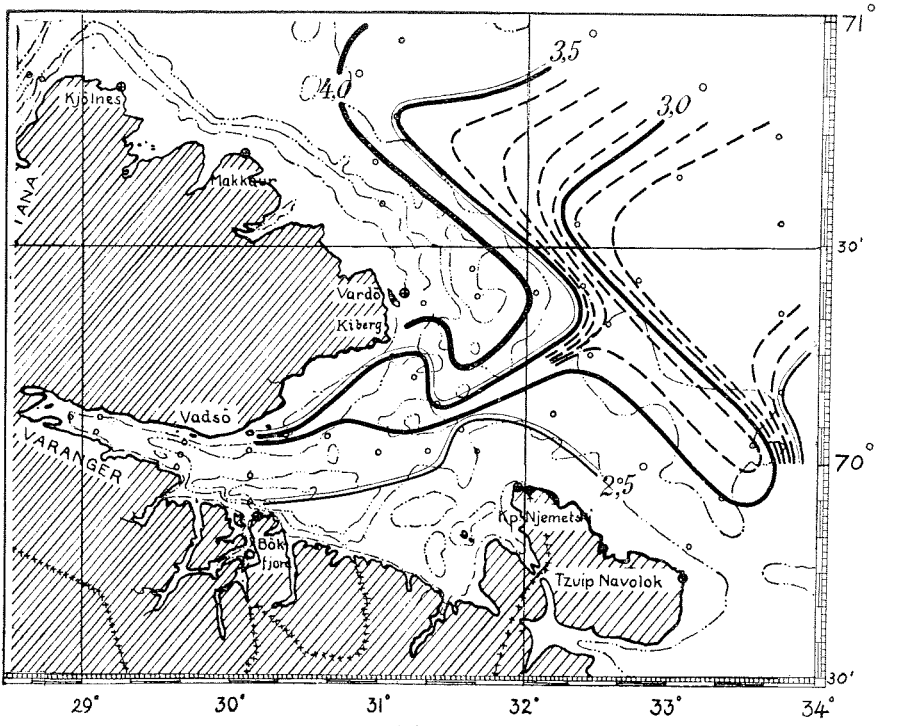
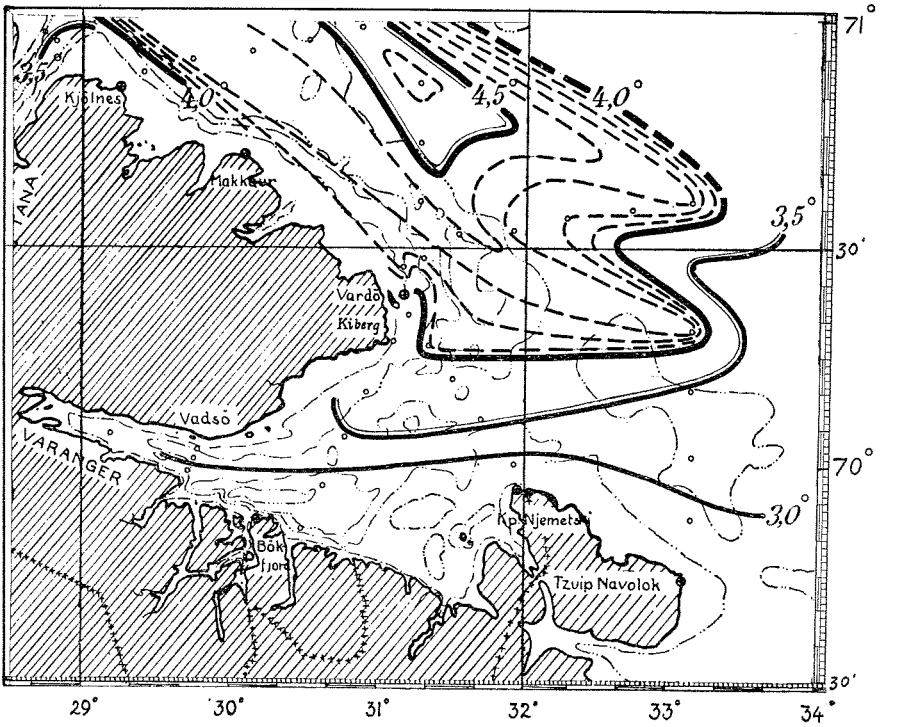

71°
30'
70°
30'
29°
30°
31°
32°
33°
34°
4,0°
3,5°
3,0°
2,5°
Kjölnes
Makkaur
TANA
Vardö
Kiberg
Vadsö
VARANGER
Kp Vjemetski
Tzvip Navolok
Bök fjord

Fig. 4.


71°
30'
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4,0°
3,5°
3,0°
Kjölnes
Makkaur
TANA
Vardö
Kiberg
Vadsö
VARANGER
Kp Vjemetski
Tzvip Navolok
Bök fjord

Fig. 5.

shoot of the Atlantic current. Some years this east-flowing offshoot has been so much deflected to the right that the warm water reaches right in to the land slope, (as was the case e. g. in 1934), certain isotherms e. g. 3° and 4° being at the same time pushed far to the east as a consequence of the stronger current. And this seems to have consequence for the output of the Finnmark codfishery (2).

5. The Varanger Fjord.

As the mouth of the Varanger Fjord lies near the boundary-region described, the oceanographic conditions in the fjord are strongly influenced by the changing position of this region far to the east or west respectively. Therefore the fjord during the codfishing season in spring may be filled with water of very different temperatures in the various years according to the shift of the boundaries. In spring 1937 and 1934 there was definitely warmer water in the fjord than in spring 1936. Off Kiberg in the direction towards Cape Nyemetzki the temperature on the land slope from 65 to 200 m depth, was 3.0 to 2.2° in 1936, 4.0 to 3.5° in 1934 and 4.1 to 3.8° in 1937. The bottom temperature also was much lower in 1936 than in the two other years mentioned as indicated by figs. 3, 4 and 5.

From the two sections across the mouth of the fjord (figs. 6 and 7) it will be seen that in 1936 about 88 % of the section had a temperature below 3°, but about the same date the following year only 5 % had such a low temperature. The greatest area of the section was then occupied by water between 3.9° and 4.5°.

The water is very homohaline in this area, especially it will be seen from fig. 6. From surface to bottom the salinity varies only with 0.03 to 0.08 $^{0}/_{00}$ at the different stations.

Further it will be seen that there is colder water in the southern than in the northern part of the fjord. This is caused by the current conditions, as part of the comparatively warmer water which flows towards SE along the Varanger Peninsula, bends into the fjord along the north side.

When we compare the observations taken by *The Fisheries Directorate* in the Varanger fjord during May—June 1923—37,[1]) it will be seen that the bottom temperature was lowest in 1923 with 1.19° in the middle of the fjord between Kiberg and Cape Nyemetzki. Then comes 1936, 1929 and 1927. The highest bottom temperature was observed in 1925 with 3.92°. Then comes 1937, with 3.84° and 1930 with 3.44°. The corresponding observations in the depth off Bøkfjord, a branch of

[1]) In the years 1924, 26, 31 and 35 no observations were made.

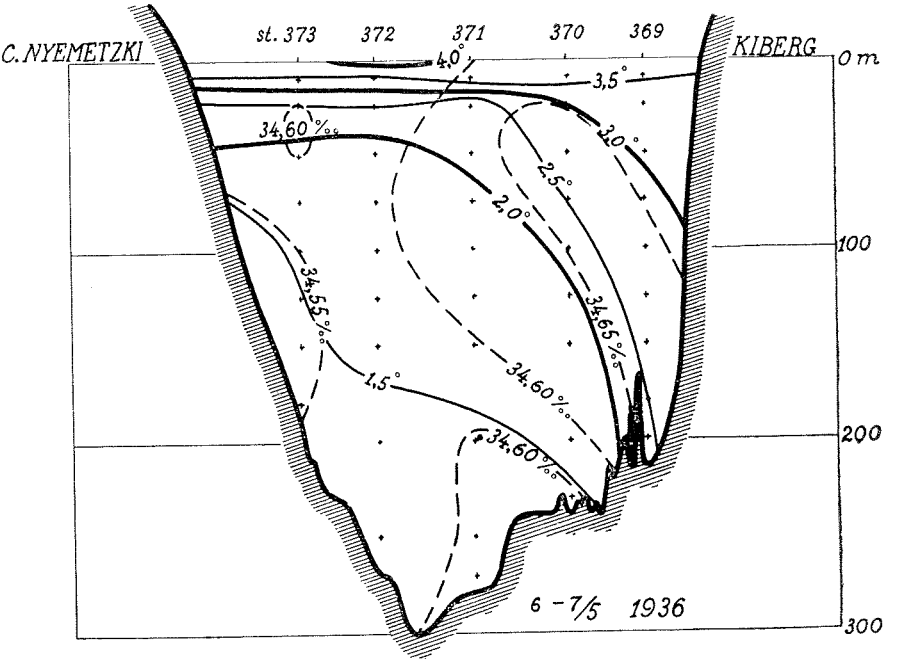
C. NYEMETZKI
st. 373
372
371
370
369
KIBERG
0 m
100
200
300
4,0°
3,5°
34,60 ‰
3,0°
2,5°
2,0°
34,55 ‰
34,65 ‰
1,5°
34,60 ‰
6 - 7/5 1936

Fig. 6.

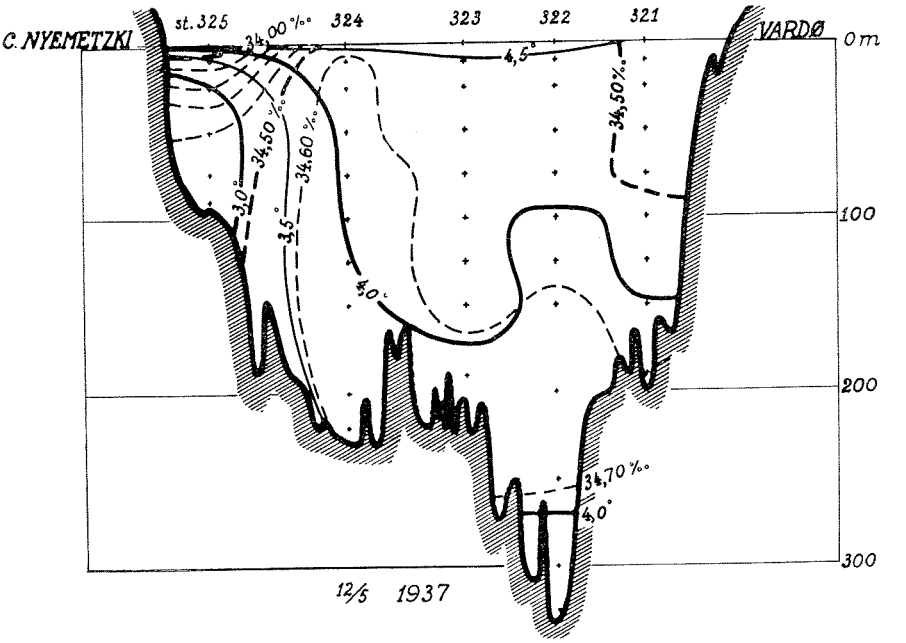
C. NYEMETZKI
st. 325
34,00 ‰
324
323
322
321
VARDØ
0 m
100
200
300
4,5°
34,50 ‰
34,50 ‰
34,60 ‰
3,0°
3,5°
4,0°
34,70 ‰
4,0°
12/5 1937

Fig. 7.

the Varanger Fjord, show a similar course. The lowest temperature also here was found in 1923 and 1929 with 1.75° and 1.62° respectively. The highest in 1930 with 3.45°. In August 1875 MOHN found 3.1° in 224 fms. depth here, with a Miller-Casella thermometer and in 1876 5.7° in 230 fms. was found by »Hansteen« in the depth of the fjord south of Vardø with the same instrument. And in 1881 the French Expedition with the »Coligny« under the leadership of professor POUCHET found as low temperature as 1.3° in 200 fms.

From what has been said, it will be seen that the temperature in the Varanger Fjord varies rather much from one year to the next. Further that the Varanger Fjord itself is an area of mixing, with comparatively warm water on the N side and colder water on the S side of the fjord.

D. SEASONAL VARIATIONS OF THE BOTTOM TEMPERATURE.

It is a well known fact that seasonal variations of the temperature decrease with the depth, and also that the seasonal effect occurs later in the deeper layers than in the surface.

To show the seasonal variations of the bottom temperature figure 8 is given containing the pertinent observations from the four permanent oceanographic stations of the Fisheries Directorate, namely: 1) Sognesjøen, lat. 61°, 2) at Eggum outside Lofoten, lat. 68°, 3) at Skrova at the inner side of Lofoten, and 4) at Ingøy in the Vest Finnmark, lat. 71° long 24° E. The observations are made every forthnight throughout the year if the weather permits, occasionally every week. Water samples are taken and observations of temperature are made in all standard depths from the surface to the bottom, 200—300 m. The material is sent at once to Bergen where it is worked up at the Fisheries Directorate. At all stations Nansens waterbottles, each with 2 reversing thermometers, are used.

The places of observation off Eggum and Ingøy are in the open sea on the banks more than 3 n. m. from the coast, whereas those of Skrova and Sognesjøen are more sheltered. Regular observations throughout the year in the open sea have never been made before in Norway.

In the table the month means have been calculated. From this it will be seen that the minimum as well as maximum of temperature occurs much earlier on the banks than in the more sheltered waters.

At Eggum and Ingøy the lowest bottom temperature occurs in April—May, whereas at the Sognesjø not till in June—August and in

the West Fjord (Skrova) till November—December. The same is the case with the maximum temperature. On the banks it occurs in November—December, on the Sognesjø and at Skrova not till after New Year, (January—February on the Sognesjø, and February—April at Skrova). The reason must be found in the stronger current in the bottom water on the banks than in the more sheltered places, (the West Fjord and Sognesjøen), both these places lying behind a threshold, the saddle depth of which is 227 and 100 metres respectively, thus preventing the bottom water from circulating freely; in addition to this the water on the banks is more homogeneous from the surface to the bottom with only slight stability. Consequently the heat-conditions in the surface will more easily and rapidly be transmitted to the bottom through turbulence and »ungeordnete Bewegungen«.

It will be observed that the annual amplitude at 300 m in the West Fjord is comparatively small, only 0.35° and 0.18° in 1936 and 1937 resp., whereas on the banks it lies between 1.5° and 2.0°. The annual amplitude here calculated is fairly well in accordance with that found by H. Mohn from the observations of Telegraph Inspector Lie, from the surface down to 100 fms. depth off Lødingen in May 1879 — January 1881, namely 0.2°—0.3° in 100 fms. Observations were not taken in February, March and April, and Mohn in his calculations gave to these months the same weight as January. In this depth, 188 m the maximum will occur just in one of the months without observations, particularly in February, so that the amplitude found, 0.2°, probably is a bit too small. According to the available observations the annual amplitude will generally be greater in 188 m (100 Norw. fms.) than deeper down, e. g. in 300 m.

From the table it will further be seen that the max. temperature is higher, and the min. temperature lower outside than inside the Lofoten, further that the min. temperature on the Sognesjø and off Skrova is about the same, and just like the max. temperature off Ingøy; and that the min. temperature in the West Fjord will occur almost simultaneously with the max. temperature on the banks off Lofoten and Finnmark.

Bottom Temperature.

	Anno	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Okt.	Nov.	Dec.	Year
	1935	(8,60)	(8.43)	8.05	7,60	7,55	7,47	7,40	**7,34**	7,61	7,86	7,86	8,23	7,83
Sognesjøen	1936	*8.50*	8.35	7.77	6,97	6,76	**6,63**	6,70	6,83	7,01	7,21	7,32	7,51	7,30
BN: 60° 01′,4	1937	7.76	*7.80*	7.47	7,40	6,93	6,53	**6,39**	6,48	6,65	6,56	6,98	7,56	7,04
LE: 4° 50′,5	1938	(7.60)												
	1935		(6,56)	6,79									7,74	
Eggum.....	1936	7,66	7,20	6,57	6,29	**6,07**	6,65	6,88	7,06	7,21	7,47	*7,75*	7,43	7,02
BN: 68° 23′,2.....	1937	7,04	6,68	6,22	**6,03**	6,24	6,46	6,61	6,80	6,97	7,29	7,72	*7,83*	6,82
LE: 13° 41′,0	1938	7,17												
	1935		7,06	7,15							6,86	6,92	6,95	
Skrova	1936	7,00	*7,07*	7,06	7,05	7,04	7,04	6,98	6,99	6,91	6,85	6,80	**6,72**	6,96
BN: 68° 07′,7	1937	6,73	6,68	6,76	6,85	6,84	6,80	6,76	6,75	6,73	6,67	**6,67**	6,68	6.74
LE: 14° 40′,0	1938	6,77												
Ingøy	1936	(5.37)	(5,20)	4,87	**4,61**	4,74	5,20	5,33	5,63	5,68	6,47	*6,63*	6,55	5,52
BN: 71° 09′,5	1937	5,91	5,61	5,25	**4,88**	5.06	4 95	4,70	5,66	5,48	6,62	*6,62*	6,43	5,60
LE: 24° 05′,0	1938	6,28												

E. VARIATIONS OF THE BOTTOM TEMPERATURE FROM YEAR TO YEAR.

From the figure 8 it will be seen that there are some variations in the bottom temperature from one year to the next. This is obvious in particular as regards Sognesjøen. An important decrease from 1935 to 1936 will be noticed here, and a somewhat smaller decrease in 1937. The annual average temperature in these 3 years is 7.83°, 7.30° and 7.04° (the table p. 63). From Oct. 1935 to Oct. 1937 the decrease is as great as 1.3° (from 7.86° to 6.56°).

The decrease in the temperature on the Sognesjø which occured in March and in the first half of April in 1935—36, took place in May in 1937. This caused the April and May temperature to lie higher in 1937 than in 1936, but yet lower than in 1935. But the years average was, as mentioned, lowest i 1937.

Also in the north the temperature both outside and inside the Lofoten was observed to decrease from 1936 to 1937, though not so much as on the Sognesjø. As regards West Finnmark there is no particular difference between the 2 years. It is surprising that the average temperature of 1937 is higher here than the preceding year.

The limits now will be mentioned between which the bottom temperature have been observed in other characteristic coastal districts. At Breisund at Møre the Fisheries Directorate has during the last 12 years made observations every year at the end of February and in the beginning of March. The lowest bottom temperature was observed in 1928 on the 2nd March, with 6.94° and the highest 8.04° in 1933, 27th February. The mean of all observations is 7.56°.

Off Skrova the lowest temperature, which has been observed, is 6.56° in 1924 and the highest 7.18° in 1935. If we go back to the observation above mentioned, off Lødingen 1879—1881, the lowest temperature lies still lower than in 1924, with 6.3° in 100 fms. depth.

In the Vågs Fjord a little farther to north-east the bottom temperature (450 m depth) is observed to lie between 6.29° (7/12 — 28) and 6.88° (2/12 — 30), and at Færder Lighthouse in the mouth of the Oslo fjord where the bottom depth is the same as in Vågsfjord the temperature range is 6.10—6.69° 1933—34 according to observations taken by the Biological Laboratory of the University of Oslo (1).

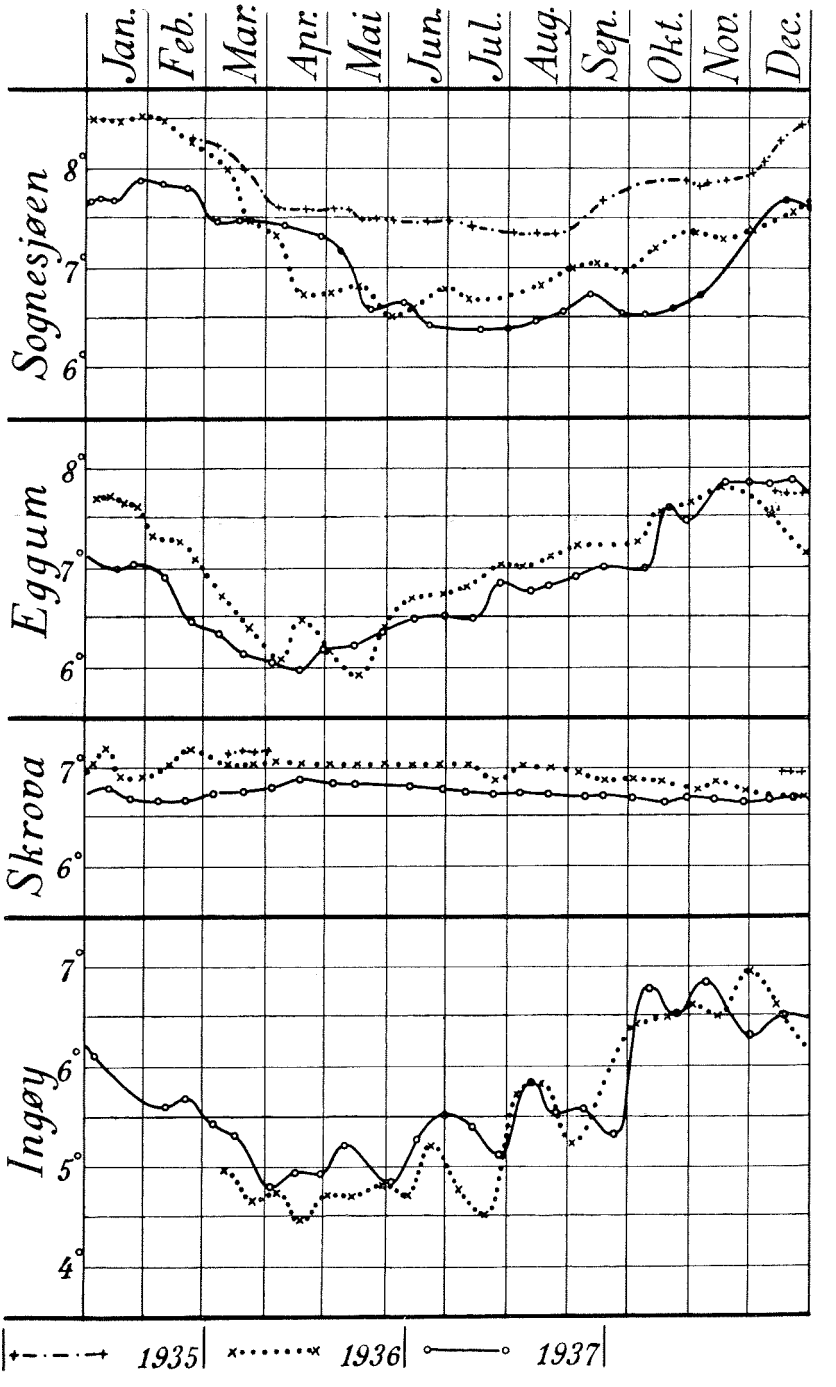
Jan.
Feb.
Mar.
Apr.
Mai
Jun.
Jul.
Aug.
Sep.
Okt.
Nov.
Dec.
Sognesjøen
8°
7°
6°
Eggum
8°
7°
6°
Skrova
7°
6°
Ingøy
7°
6°
5°
4°
1935
1936
1937

Fig. 8.

THE SKJERSTAD AND SALTEN FJORDS.

The great basin of the Skjerstad Fjord with extensive areas of more than 500 m depth is connected with the Salten Fjord outside through shallow straits, the greatest threshold-depth of which is only 26 m. Therefore only coastal water can come into the Skjerstad Fjord, and consequently this makes the bottom water. The Salten Fjord on the other hand, has such a deep connection with the West Fjord that the bottom water is made up of Atlantic water. Consequently the bottom temperature here is comparatively high. Observations made by the Fisheries Directorate from 1923 to 1938 show that the bottom temperature is between 6.4° and 7.32° (1928 and 1934). O. NORDGÅRD, who made investigations in both these fjords in 1900, found on the 5th of April 6.65° at the bottom of the Salten fjord. If we compare the investigations made in the Skjerstad fjord to the Norwegian »Nordhavsekspedisjon« in 1877, to NORDGÅRDS in 1900 and to those of the Fisheries Directorate in 1927, 1928 and 1934, we find that the bottom temperature in 1877 and 1900 lay between 3.05° and 3.35°, and the salinity between 33.99 and 34.09 $^0/_{00}$. The corresponding observations of the later years above mentioned, are 3.95° (1927) and 4.86° (1934), and the salinity 33.73 and 33.62 $^0/_{00}$.

THE TRONDHEIM FJORD.

Observations of the bottom temperature of the Trondheim Fjord in 1881—1883 showed 6.6°—7.2° (565—600 m). In 1872 MOHN found 6.5° in 320 m off Trondheim. At Hambåra near the mouth of the fjord the temperature in 300 m was 6.7° in 1906, on 5/12 (NORDGÅRD). From 1928 to 1935 the Fisheries Directorate has in the same depth found 7.14° (1928) and maximum 7.77° in 1932 (3/11).

Thus the observations mentioned show that the temperature of the deep water in the Trondheim Fjord, in depths of 300 m or more, has varied between 6.2° in 1883 and 7.77° in 1932. Further that the temperature during the last years from 1928 has been much higher than observed before say 1907.

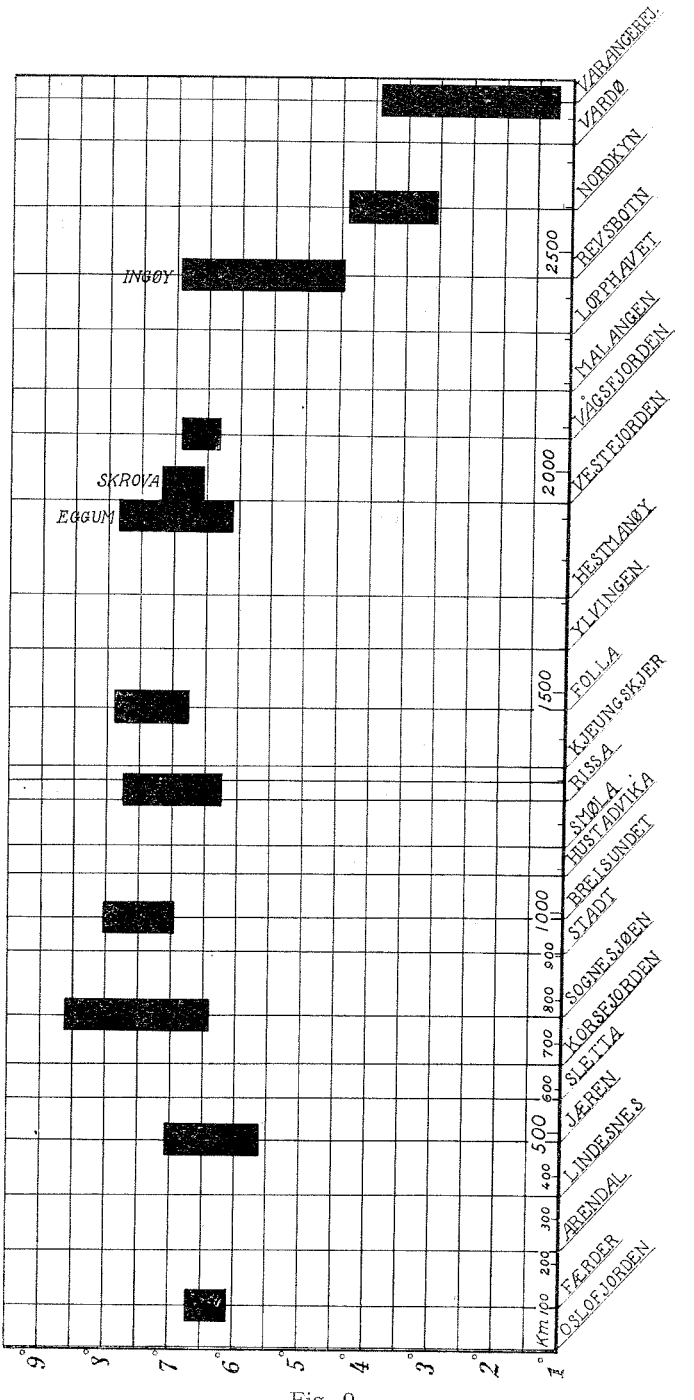
INGØY
SKROVA
EGGUM
VARANGERFJ.
VARDØ
NORDKYN
REVSBOTN
LOPPHAVET
MALANGEN
VÅGSFJORDEN
VESTFJORDEN
HESTMANØY
YLVINGEN
FOLLA
KJEUNGSKJER
BISSA
SMØLA
HUSTADVIKA
BREISUNDET
STADT
SOGNESJØEN
KORSFJORDEN
SLETTA
JÆREN
LINDESNES
ARENDAL
FÆRDER
OSLOFJORDEN
Km/100
2500
2000
1500
1000
900
800
700
600
500
400
300
200
100
9°
8°
7°
6°
5°
4°
3°
2°
1°

Fig. 9.

The above mentioned range of the bottom temperature observed at some characteristic places is shown in fig. 9, page 67. As the different observations have not been made in the same year or in the same season they cannot be compared directly, although it may be seen that the bottom temperature is highest in the section Sogn—Folla, as a result of the heavy influx of the Atlantic current. It decreases northwards as well as southwards, and the range is greatest in Finnmark in accordance with the instability of the water here and the shifting limit between Atlantic and eastern waterbodies.

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