

The Fleetwood Exploratory Voyages for Hake.

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The object of the exploratory voyages was an endeavour to extend the areas available for hake trawling, and so give some relief to the more heavily worked fishing grounds. The voyages were organised by the Fleetwood Fishing Vessel Owner's Association, and financed jointly by that Association and by the Development Commission, a grant for the purpose having been obtained at the instigation of the Ministry of Agriculture and Fisheries.

The steam trawler "Florence Brierley" was taken over as she returned from an ordinary fishing voyage, and fitted with certain special equipment, including a winch said to be the largest ever fitted on a commercial vessel, capable of carrying 1,500 fathoms of warp on each drum, and a great quantity of spare trawls and otter boards, besides 2,200 fathoms of spare warp. Other equipment included a steam sounding machine, lent by the Fisheries Department, a chronometer, lent by the Admiralty, and Negretti and Zambra reversing thermometers.

Besides her crew, the ship carried a navigating officer, an advisory fishing skipper, a representative of the Fleetwood owners, and the writer as naturalist.

The ship sailed on Tuesday, March 22nd. Her course may be followed on the Chart, Figure 1. A departure was made from the Butt of Lewis, in dull and cold weather, on the morning of March 24th. Fishing was commenced at 5 p. m. on the afternoon of the same day, the trawl (of the Vigner-Dahl type) being shot in 195 fathoms and hauled in 365 fathoms. From this point the ship worked eastwards along the edge of the deep water of the Faroe Shetland Channel, trawling by day, and usually steaming to the next station at night. The depths worked ranged from 89 fathoms to 560 fathoms.

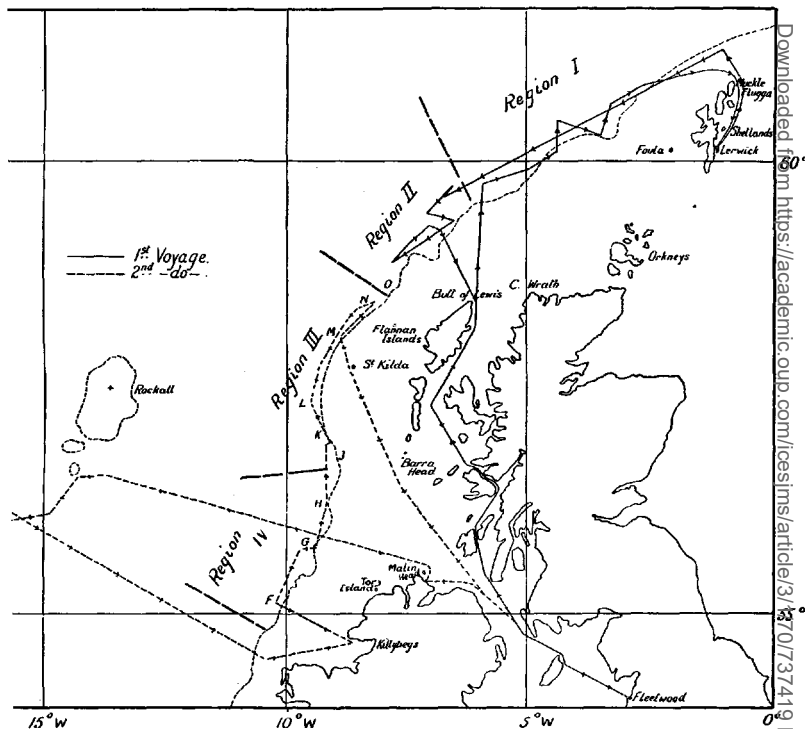


Fig. 1. The approximate course of the *Florence Briarley*. The boundaries of the four regions, discussed in the text, are given. F—O are the approximate positions of the hydrographical stations.

The deeper water in the Faroe Shetland Channel proved very barren of fish life. Only 28 species of fish occurred in the catches; but even more impressive than this was the actual quantity of fish taken. Time after time the cod end would come up so empty that it could be hauled aboard by hand, giving perhaps two baskets full of fish, or even less, for a two hour haul. None of the members of the crew had ever seen poorer fishing. The most abundant species were the Coalfish (*Gadus virens*) and the Spur-dog (*Acanthias vulgaris*).

The Vigner-Dahl type of trawl is unsuited to giving a sample of the bottom fauna, but the coral *Lophohelia prolifera* and the sponges *Phakellia* and *Poecillastra* were very abundant in places, and caused much damage to the gear.

An experimental haul of $1\frac{1}{2}$ hours duration was made, the trawl being shot in 505 fathoms and hauled in 560 fathoms, with 1000 to 1075 fathoms of warp paid out from the winch. Only three fish were taken, namely, one *Lycodes Esmarckii*, which came aboard very much alive and lived for some time, and two small specimens of *Raia hyperborea*.

This fruitless exploration of the deeper waters of the Faroe Shetland Channel continued until March 31st, when a point had been reached roughly N. by W. of Muckle Flugga. Only occasional specimens of hake were taken, with the exception of a haul in 100 fathoms N.W. of Foula, when a score of hake were caught in a $2\frac{1}{2}$ hours tow. We learned later that Aberdeen trawlers were catching a certain quantity of hake in this locality. These hake were found to be feeding on herrings, and apparently also on mackerel, and, as the herrings were spawning at this time, the small concentration of hake, indicated by this haul off Foula, would point to a local concentration caused by feeding on these herrings. The fact that, even so, only one score of hake were caught in $2\frac{1}{2}$ hours, might perhaps be regarded as additional evidence of the scarcity of hake in the Faroe Shetland Channel.

Herring spawn was found in the stomachs of *Gadus virens* (coalfish) as far west as Lat. $60^{\circ}08' N.$, Long. $4^{\circ}17' W.$; it occurred in increasing quantities in the stomachs of these fish as we worked eastwards, until in Lat. $60^{\circ}18' N.$, Long. $3^{\circ}30' W.$, as much as 120 grams of spawn were found in a single stomach. At this last station the eggs were developing, and the eyes could be clearly distinguished. As stated in the previous paragraph, female herrings in stage VI (i. e. actually running) were caught off Foula, and finally, in approx. Lat. $60^{\circ}40' N.$, Long. $3^{\circ}20' W.$ a considerable quantity of herring larvae were taken 20 metres below the surface, at midnight, with a plankton net. The greatest depth of haul from which coalfish, containing herring spawn, were taken, was in a haul shot in 195 fathoms and hauled in 365 fathoms, but the greatest quantity of spawn was found in fish taken in a haul shot in 150 fathoms and hauled in 115 fathoms. Since the sea bottom slopes very steeply however, at these depths, so that it is but a short distance from 100 fathoms to 200 and 300 fathoms, the spawn found in the stomachs of these fish need not have been deposited at as great a depth as that at which the fish were caught.

In this region also a specimen of the Greenland shark, *Somniosus*

microcephalus (Schneider) Goode and Bean, 3.4 metres in length, was taken in a haul shot in 295 fathoms and hauled in 340 fathoms. The temperature was 8.4° C. The stomach contained the remains of ling.

On March 31st the ship steamed into Lerwick, to take aboard some thermometers which had been ordered by wireless.

After a discussion, it was decided to try no further to the eastward. Hake was known to be present in quantity in the Norwegian Deep Water, but the fact that we had only found very small quantities of scattered hake in the Faroe Shetland Channel convinced us that there was no continuous distribution of hake between the Norwegian stock and the main Atlantic Slope stock. Having regard to the time already spent, and the supply of coal and provisions, it was decided to return to the western side of the Wyville Thompson Ridge.

Accordingly, after one more haul in 90—102 fathoms due north of Muckle Flugga Light, the ship steamed away on a course W. by S., and at 3.45 p. m. on April 3rd the trawl was shot in 135 fathoms on the western slope of the Wyville Thompson Ridge (Region II, Chart I), and the rest of the voyage was spent working in a westerly and southerly direction along the edge of the deep water. Hake were found in good quantity, and some excellent catches were made. The depths fished ranged from 118 fathoms to 520 fathoms, but the nature of the bottom made working here a matter of great difficulty. This is best illustrated by the fact that 14 of the 32 hauls made in this region were more or less profitless on account of splits, the chief causes of these casualties being stones, and great bushes of the "pudding" sponge *Poecillastra compressa* (Bowerbank).

Fish were much more abundant, both in number of species and in actual quantity, on the western side of the Wyville Thompson Ridge than on the eastern side of the Ridge at comparable depths. It appears that 49 species were taken in hauls from the former region whereas only 28 species were found in the latter region. Of these, 18 species were common to both regions.

A list of the species found is to be published in a separate paper.

The ship returned to Fleetwood with a good voyage of hake aboard, on April 13th.

The second voyage was commenced on the afternoon of April 19th. We ran into bad weather almost at once, and, on the 20th, put into Portaleen, under the lee of Malin Head, and anchored for the night in a hard breeze, with continual squalls of rain. On April 21st we resumed our course for the Rockall Bank, but bad weather continued, with westerly winds, so that the ship was eased down for many hours, and it was not

until Saturday, April 23rd, that the Bank was found with the lead at 150 fathoms. The trawl was shot at this depth and hauled in 240 fathoms.

For the next two days the vessel worked, when weather permitted, round the southern slopes of the Rockall Bank, in depths ranging between 132 fathoms and 285 fathoms. Five hauls were made, and a fair quantity of fish was taken, but no hake.

On the evening of April 24th it was decided that, since there was no sign of hake at this, the warmest and most southerly point of the Rockall Bank, and since the weather was steadily growing worse, we had better abandon further work in this region. We therefore steamed for Donegal Bay. On April 25th it was blowing a full gale from the N.W., and a heavy tumbling sea got up, but towards evening the wind veered to the N.E. and moderated considerably. We picked up Eagle Island Light at 10 p.m. and anchored in Killybegs Harbour, Co. Donegal, early on April 26th.

On April 27th we steamed out of Killybegs. The programme was now to fish northward along the slope, at depths greater than those usually worked by steam trawlers, partly to try to establish the maximum depth at which it is profitable to fish for hake, and partly to find whether there were any areas suitable for trawling between the well known deep-water grounds W.N.W. of Tory Island, and W. from Barra Head.

This programme was carried out in fairly fine weather, and 54 hauls were made at depths ranging from 120 fathoms to 440 fathoms. The continental slope between Tory Island and Barra Head proved too precipitous to be important for trawling.

May 8th found the ship working N.W. of St. Kilda, where the supply of coal and stores compelled us to abandon further work. We returned to Fleetwood on May 10th.

In all, 31 days were spent in fishing, and 118 hauls were made: namely 26 hauls in Region I, 33 in Region II, 5 on the Rockall Bank, 35 in Region III, and 19 in Region IV. Of these 118 hauls, 41 were more or less foul, the gear being torn or the bridles broken, or even in some cases, the whole trawl, including the boards, being lost. These figures give a good idea of the nature of the sea bottom on the northern deep water fishing grounds, and of the labour, patience and skill required to work them successfully.

Temperature Observations during the Voyages.

Messrs. NEGRETTI and ZAMBRA's reversing thermometer frame (Admiral MAGNAGHI's Patent) was used in these observations. The thermometer was graduated to $0.5^{\circ}\text{C}.$, but the temperature was read to $0.1^{\circ}\text{C}.$, with the aid of a lens, by eye-interpolation. During the first

voyage, when Regions I and II were investigated, temperatures were taken only at the sea bottom, except, of course, where the lead failed to find bottom; but, during the second voyage, 14 stations were worked from surface to bottom, usually at 100-metre intervals.

The five stations worked over the tail of the Rockall Bank were of especial interest. The position of these stations is given in Figure 2,

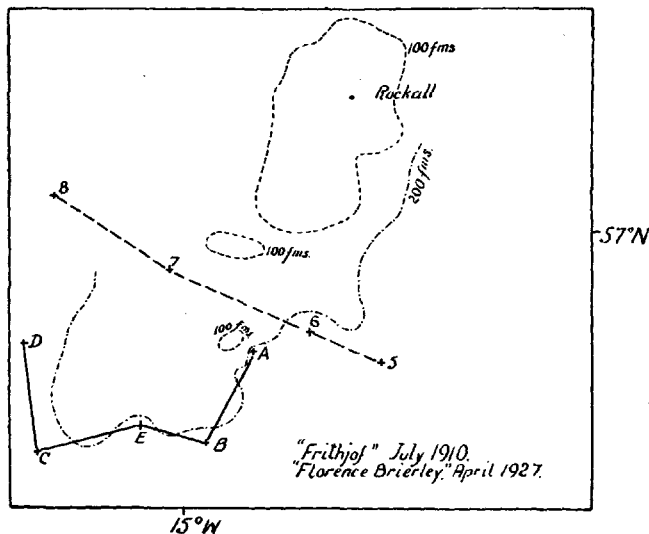


Fig. 2. The 100 and 200 fathom contours on the southern slopes of Rockall Bank. A—E are the positions of the *Florence Brierley* hydrographical stations, April 1927. 5—8 are the *Frithjof* stations, July 1910.

and the hydrographical section obtained is drawn in Figure 3. It appears that the deeper portions of the eastern slope of the bank carry cold water, of a temperature as low as 8.2°C . The western slope, however, carries warmer water, viz. 8.7°C ., and there is a well marked tendency for the isotherms to slope downwards steeply towards the west. There is a heaping up of colder water, therefore, on the south eastern slopes of Rockall Bank.

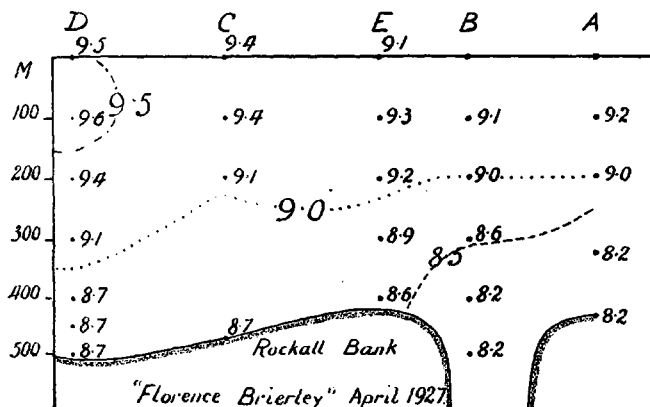


Fig. 3. Hydrographical section of the southern slopes of Rockall Bank. *Florence Brierley*, April 1927. Depth in metres. Stations as in Fig. 2.

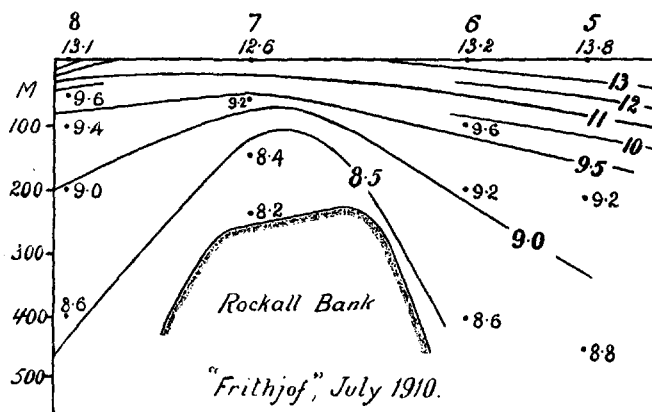


Fig. 4. Hydrographical section of Rockall Bank. *Frithjof*, July 1910. Depth in metres. Stations as in Fig. 2.

These observations agree with the results, published by NANSEN¹⁾ of the stations worked in this region by the "Frithjof" in July 1910. His stations 5, 6, 7 and 8 are shown on the chart in Figure 2 and the hydrographical section obtained from his data, drawn to the same scale as Figure 3, is given in Figure 4. The presence of cold water on the bank is clearly indicated, but the isotherms, in this case, fall away more or less symmetrically, and there is no indication of a heaping up of colder water on the eastern slopes. NANSEN's *surface* temperatures are much higher than those found by the "Florence Brierley", since the "Frithjof" visited Rockall Bank in July, when surface heating was taking place,

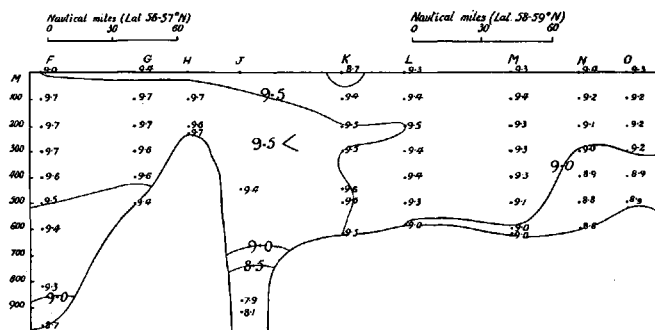


Fig. 5. Hydrographical section along Continental Slope. Position of stations as in Fig. 1. Depth in metres.

but there is good agreement between the temperatures found in the deeper water.

Nine stations were worked along the edge of the deep water, from Lat. $55^{\circ}07' N.$ to Lat. $58^{\circ}40' N.$ The hydrographical section obtained from them is drawn in Figure 5, and the position of the stations is indicated in Figure 1 (F—O). There is strong surface cooling everywhere, which is especially noticeable in the more southerly stations. For example, at station K, when this station was worked, the wind was easterly and the air at $6.2^{\circ} C.$; the water about 1 metre below the surface was $8.7^{\circ} C.$, a temperature low when compared with other stations. The section shows the obvious tendency for the water to become colder from south

¹⁾ The waters of the North Eastern Atlantic. Internationale Revue der Ges. Hydrobiologie u. Hydrographie. Hydrographical Supplement to Vol. IV.

to north and from surface to bottom, but the most important point to be noticed is the great uniformity in temperature. Indeed, the difference between the highest observation, off Tory Island, and the lowest observation, off Muckle Flugga, was only 1.6°C. , though these stations are approximately 500 miles apart.

The bottom temperatures found in Region I agree in every respect with the temperature charts published in the Report of the North Western Area Committee for 1924 and 1925¹⁾. At depths shallower than about 150 fathoms, the temperature at the sea bottom gradually became lower, in the Faroe Shetland Channel, from 8.7°C. at the western end to 8.1°C. at the eastern end, off Muckle Flugga. The deeper water of the channel, however, was much colder, two observations at 300 and 343 fathoms giving temperatures of 6.6°C. and 6.0°C. respectively. The corresponding depths on the western side of the Wyville Thompson Ridge carried water of much higher temperature namely, 8.7°C. to 8.9°C. This phenomenon is very well known.

From the nature of the data, no hydrographical section can be drawn for Region I.

Effect of Depth on the Catch of Hake.

The considerable number of hauls made (118) allows of a quantitative examination of the effect of depth on the catch of hake.

The hauls have been treated in the following way. For every haul, records have been kept of the time of hauling and shooting, and the catch, in scores of big hake, and baskets of "chat hake" (i. e. smaller hake). Now, a number of counts showed that an average of 10 fish per basket would give an approximately correct figure for the total number of chat hake caught. For every haul, therefore, the number of scores of big hake multiplied by 20, and the number of baskets of small hake, multiplied by 10, added together, give the approximate number of hake caught. This figure, divided by the number of hours, or fractions of hours, during which the trawl was on the bottom, gives the catch per hour.

The hauls have been grouped, according to their mean depths, in 20-fathom categories, and for each category the mean catch per hour has been calculated. The "mean depth of haul" is the mean of the depths at which the trawl was shot and hauled respectively. It is the only figure, representative of the depth at which the trawl has been fishing, which

¹⁾ J. P. JACOBSEN & AAGE J. C. JENSEN. Rapports et Procès-Verbaux, Vol. XXXIX, May 1926.

one is entitled to assume, but it may obviously lead to error where the sea bottom is very uneven. These data are set forth in Table I, and the curve obtained by "smoothing in 3's" is drawn in Figure 6. Unfortunately, both in very shallow and very deep water the number of hours' fishing is statistically inadequate, but over the greater range of depth the number of hauls is sufficiently large to discount, to a considerable extent, inaccuracies due to splits, foul hauls, and differences in the time of day, as well as those due to an untrustworthy "mean depth" of haul.

Table I.
Variation in Catch of Hake per Hour's Fishing with Mean Depth of Fishing.

Mean Depth of Haul, = Mean of Soundings at Shooting and Hauling, in Fathoms.	Regions I and II				Region III				Region IV				Total all Regions			
	No. of Hauls	Hours of Fishing	Catch per Hour	Catch Smoothed in 3's	No. of Hauls	Hours of Fishing	Catch per Hour	Catch Smoothed in 3's	No. of Hauls	Hours of Fishing	Catch per Hour	Catch Smoothed in 3's	No. of Hauls	Hours of Fishing	Catch per Hour	Catch Smoothed in 3's
80—100	2	3.0	2.0	..	..	..	..	..	..	..	..	..	2	3.0	2.0	..
100 < 120	6	12.5	1.9	1.4	..	..	..	..	..	..	..	..	6	12.5	1.9	1.8
120 < 140	5	7.25	0.3	1.2	..	..	..	..	3	3.25	4.6	..	8	10.5	1.6	2.3
140 < 160	5	6.75	1.3	0.5	..	..	..	..	1	1.25	14.4	..	6	8.0	3.4	1.7
160 < 180	1	1.0	0.0	0.7	..	..	..	..	..	..	..	..	1	1.0	0.0	4.7
180 < 200	3	3.5	0.9	1.2	..	..	..	..	1	1.5	33.3	..	4	5.0	10.6	6.7
200 < 220	3	3.75	2.7	7.8	..	..	..	..	7	9.75	12.2	81.8	10	13.5	9.6	23.8
220 < 240	2	3.75	19.7	11.4	3	4.5	44.4	..	1	1.0	20.0	78.3	6	9.25	51.2	28.9
240 < 260	4	6.75	11.9	44.5	4	8.75	37.7	38.8	3	3.0	22.7	75.9	11	18.5	25.8	55.0
260 < 280	14	24.0	102.0	47.5	2	3.5	34.3	37.3	2	1.75	5.1	38.6	18	29.25	88.1	52.7
280 < 300	2	3.5	28.6	80.7	7	12.5	40.0	31.8	2	2.5	88.0	..	11	18.5	44.3	53.2
300 < 320	4	7.75	51.6	45.1	14	30.5	21.1	27.0	..	..	..	..	18	38.25	27.3	31.7
320 < 340	1	2.0	55.0	43.2	4	8.5	20.0	..	1	2.25	8.9	..	6	12.75	23.5	24.1
340 < 360	3	5.25	23.1	45.3	..	..	..	..	1	1.75	17.1	8.7	4	7.0	21.6	25.2
360 < 380	1	2.25	57.8	27.0	..	..	..	..	1	2.0	0.0	7.4	2	4.25	30.6	22.4
380 < 400	..	..	..	(19.3)	1	2.0	25.0	..	1	2.0	5.0	..	2	4.0	15.0	(15.2)
460 < 480	1	1.75	0.0	..	..	..	..	..	..	..	..	..	1	1.75	0.0	..
500 < 520	1	1.0	0.0	..	..	..	..	..	..	..	..	..	1	1.0	0.0	..
520 < 540	1	1.5	0.0	..	..	..	..	..	..	..	..	..	1	1.5	0.0	..

The maximum catch of hake per hour occurred at 260—280 fathoms mean depth (at 240—260 fathoms in the smoothed figures) and from this depth the catch per hour decrease both towards shallower and deeper water. A surprising fact is, that at a mean depth of 380—400 fathoms there was still, apparently, an appreciable quantity of hake, but at the next depth-category for which a figure is available, viz., 460—480 fathoms, no hake were taken.

The two deepest hauls, in which hake were caught, were shot in 247 and hauled in 520, and shot in 350 and hauled in 425 fathoms respectively.

If these figures are to be considered reliable, this means that hake may be caught on the northern grounds as deep as trawlers can fish with their present equipment. Needless to say, there is very great seasonal variation in the optimum depth for hake.

In figure 6 there is also inserted the curve for the variation of catch with depth in Regions I and II, which include the new extension of the

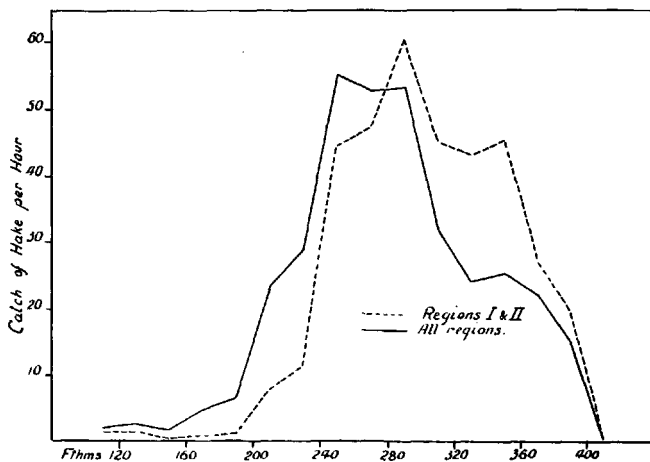


Fig. 6. Variation in catch of hake per hour, with increase of depth, in Regions I and II, Fig. 1, and in all regions. Depth in Fathoms. Catch in Number of hake per hour. Data in Table I.

hake grounds. It is seen that the peak is reached at 260–280 fathoms (280–300 in the smoothed figures).

COLLETT¹⁾ (1896) states that the “Travailleur” and “Talisman” caught hake at 640 metres (350 fathoms) off Cape Bojador (Sudan), and GOODE²⁾ (1881) states that the hake has been recorded from depths of 115 to 487 fathoms on the edge of the Gulf Stream off the New England coast.

¹⁾ Campagnes Scientifiques. Monaco. X, Poissons.

²⁾ Proc. U. S. National Museum. Vol. III, 1881.

Effect of Temperature on the Catch of Hake.

It seemed worth while to make as extensive observations as possible on the temperature of the sea bottom, in order to discover if any relation could be found between the temperature there and the catch of the hake.

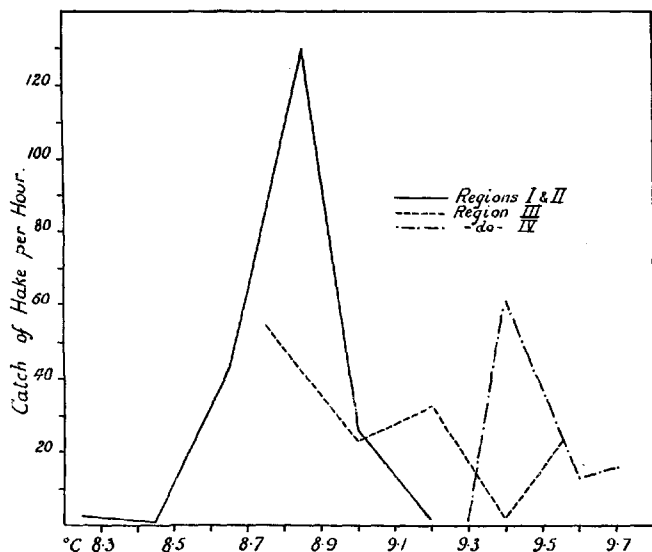


Fig. 7. Variation in catch of hake per hour, with temperature, in Regions I and II, III, and IV, respectively. Temperature in degrees centigrade. Catch in numbers of hake per hour.

An observation was made at almost every sounding. The improvised instrument used during part of the voyages is described elsewhere¹⁾.

The figures for catch of hake per hour were obtained in the same way as in Table 1, and give the mean catch of hake per hour for each 0.1°C. The figures for Region I and II, Region III, and Region IV, have been worked separately, and the three curves are shown in Fig. 7.

¹⁾ Journal du Conseil. Vol. II. No. 2. 1927.

In Regions I and II, there is a definite crest shown in the curve for variation of catch with temperature, such that the largest catches were made at 8.8—8.9° C. The catch is almost nil from 8.2° to 8.6° C., and then there is a sharp rise to the maximum at 8.9° C., after which the catch per hour falls away again.

In Region III hake were caught most abundantly at about the same temperature as in Region I and II, namely, 8.7—8.8° C., and there was a marked tendency to a falling off below this temperature, though the curve is irregular.

In Region IV no hake were taken at a temperature below 9.4° C. This temperature was the optimum, after which catches fell away once more.

The writer feels that the results of this comparison of catch of hake with temperature may be taken as indicating that further work with a more sensitive thermometer, graduated to 0.1° C. and reading, say, from 6° C. to 16° C. is very desirable and might give more promising results. The difficulty lies in the very slight differences in temperature at different depths over a wide area. This has already been referred to.

The Food and Feeding of Hake.

The main portion of the work done on hake during the voyages was the routine weighing and measuring of the whole fish, and of its liver and gonads. The results will be published in a future paper, with those of the rest of the writer's voyages on commercial trawlers. The food found in the stomachs of these hake was examined, and it was at once evident that the Blue Whiting (*Gadus poutassou*) was by far the most important item of food. Whereas 20 specimens of all other species were found, no fewer than 434 specimens of blue whiting were found in the stomachs of 955 hake. Only specimens were counted as food which showed definite signs of digestion, and absolutely fresh specimens, which might have been gulped up during the hake's struggles in the trawl, were rejected. The remaining food of these hake included 7 specimens of *Argentina silus*, 3 *Gadiculus argenteus*, 4 herring and 2 mackerel (found in hake caught off Foula) and 4 large specimens of *Scopelus Müller*.

If one examines the food found in hake from the various regions, one sees that the quantity of food eaten by hake in Region II is very much greater than that eaten in the other three regions. In order to express this in terms of weight of food per fish, the method, of weighting used in Fisheries Investigations, Series II, Vol. X No. 2, has been adopted. The number of specimens of each species found in the stomachs

of hake is multiplied by a number which represents the mean weight of that species, the result being a figure which represents the total weight of food eaten by a known number of hake. From this, one finds the weight of food per fish by a simple calculation.

On comparing the mean weight of food per fish in the four regions, it is seen that by far the heaviest feeding took place in Region II, where 171.0 gms per fish were found. In Region I there were 46.9 gms per fish, in Region III 30.3 gms per fish, and in Region IV 24.9 gms per fish.

All the hake examined in Regions II, III and IV were spent, or in the earliest stages of recovery, except for a few advanced stages in Region IV; the four regions may therefore be justly compared with one another in the matter of the feeding of hake; and since these hake will tend to have been in their hungriest condition, the quantity of food eaten may be taken as a direct index of the quantity of food available.

It has been pointed out that, except in Region I, blue whiting form the enormous bulk of the food eaten, the quantity of other kinds being negligible. One may therefore deduce that blue whiting were exceptionally abundant in Region II, less so in Region III, and still less so in Region IV.

If one compares these data for food per fish in the four regions (i. e. abundance of food) with the mean catch of hake per hour, it is seen that there is a correlation between these figures. The very high rate of feeding in Region II is associated with a high value for "mean catch per hour" (Figure 8), and the catch of hake per hour in Regions III and IV falls away just as the rate of feeding falls away. In Region I a high rate of feeding, as compared with the rate of feeding in Region III and IV, is accompanied by a very low mean catch per hour, but the total number of hake to be caught in Region I hardly justifies a comparison with the much greater number of fish caught in other regions, and the question of hake in the Faroe Shetland Channel is dealt with in the discussion.

The figures on which Fig. 8 is based may be summarized as follows:—

	Region I	II	III	IV
Weight of Food per Stomach (Hake)	46.9 g.	171.0 g.	30.3 g.	24.9 g.
Mean catch of Hake per hour	1.5	62.6	28.7	23.7
Mean percentage of everted stomachs	54.1 %	17.5 %	49.8 %	52.0 %

The quantity of food per fish in Region II is the greatest the writer has ever seen in the deep water hake fishery, and, with the exception of hake feeding on small mackerel and herrings, in shallow water in Galway Bay, (September, 1925), the heaviest he has ever seen.

In the summary of these figures, given above, are also given the results

of counts on the numbers of hake which were found "everted", i. e. with the stomach, turned inside out, forced out of the mouth. This eversion is due to the sudden expansion of the gas in the gas-bladder, on hauling the fish rapidly to the surface. Now, as appears from Figure 8, there is a relation between the extent of feeding and the extent of eversion, such that heavy feeding is accompanied by a low percentage of eversion. It is certain that the ability to prevent eversion, by a rapid absorption

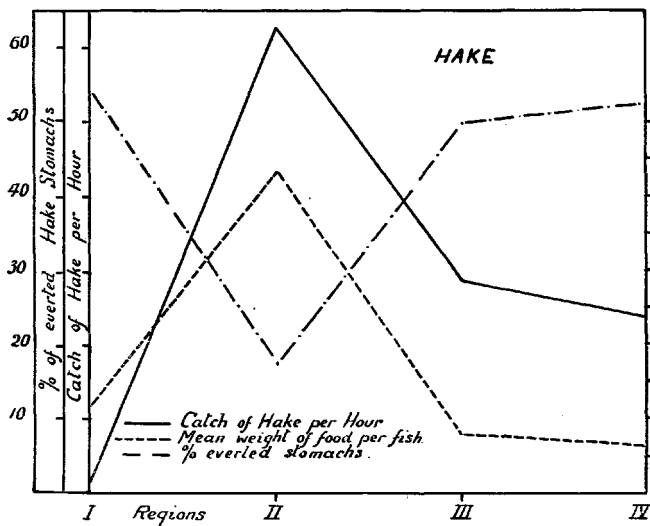


Fig. 8. Curves showing the mean catch of hake per hour, the mean weight of food for fish in hake, and the percentage of everted stomachs, in Regions I, II, III, and IV. Fig. 1.

of the gas, depends on the vigour of the fish. For this reason hake caught in the short hauls customary on the rough northern grounds present a much lower rate of eversion than those caught in long hauls on the fine grounds west of Ireland, since in the former case a greater proportion of newly caught, and therefore still vigorous, fish are present. But from Figure 8 it appears that the explanation, in this case, lies probably in the fact that a fish with a full stomach resists eversion better than a fish with an empty stomach.

Notes on the Blue Whiting.

The great importance of this fish as food for hake warrants a special note. The Blue Whiting was found in all four regions, and on the Rockall Bank. In Region I it was restricted to the western portion of the Faroe Shetland Channel, and specimens were not found in the trawl east of approximately Longitude $4^{\circ}56'$ W., while they occurred in the stomachs of *Gadus virens* as far east as Longitude $4^{\circ}27'$ W.

Evidence for the great abundance of blue whiting in Region II has just been discussed, and for its lesser abundance in Regions III and IV.

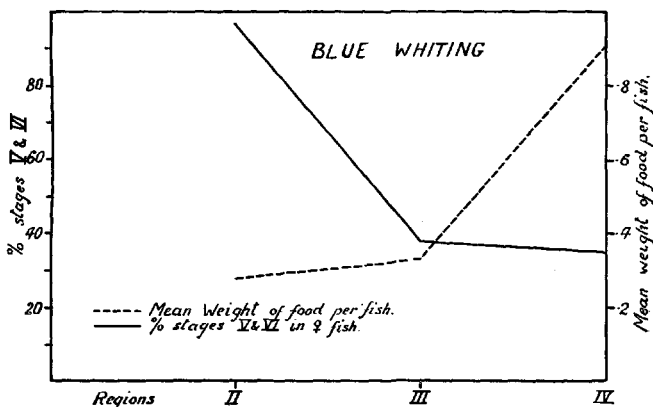


Fig. 9. Curves showing the mean weight of food per fish in blue whiting (*Gadus poulassou*), and the percentage occurrence of maturity stages V and VI among females, in Regions II, III, and IV. Fig. 1.

The blue whiting females in Region II were almost all in a maturity stage corresponding to HJORT's Stage V for herrings, that is, the roe was big, filling a considerable part of the body cavity, while the contained eggs were large and easily visible to the naked eye, though still opaque. A few specimens were met with in stage VI, i. e. with the ovary much swollen, its membrane tightly stretched, and the contained eggs large, and transparent. Still fewer specimens were found in HJORT's Stage VII, i. e. spent, in fact, 96.6% of the blue whiting females examined in Region II were in Stages V and VI.

In Regions III and IV a more advanced state was shown; here spawn-

ing was almost accomplished. In Region III only 37.4 % of the females were still unspent, and in Region IV only 35 %.

It is interesting to note that, in Region IV, where 65 % of the blue whiting were spent, there was a comparatively high rate of feeding, with an average of 0.9 grams of food per fish.

In Region III there was a low rate of feeding, namely, 0.33 grams per fish, though the percentage of spent fish was high (62.6).

In Region II there was a low rate of feeding, and spent fish were almost absent. These facts are shown graphically in Figure 9, and summarized below.

	Region II	III	IV
Number of ♀ Blue Whiting examined	148	131	103
% of ♀ Blue Whiting in Stages V & VI ..	96.6 %	37.4 %	35.0 %
Number of Stomachs examined	184	187	274
Mean weight of food per fish	0.28 g.	0.33 g.	0.90 g.

It is well known that the feeding function in fishes is inhibited at the time when the roes and milts are ripe; but here there seems to be "lag" in the resumption of feeding, so that in Region III, where there was a high proportion of spent fish, active feeding had not yet been resumed. The blue whiting caught on the Rockall Bank were apparently in the same condition; they were almost all spent fish, but contained little or no food, and appeared meagre and emaciated.

Regions II, III and IV seem to show an interesting progression in the spawning of blue whiting. In Region IV spawning was almost over, and active feeding had recommenced, in Region III also spawning was almost over, but feeding had not recommenced, and in Region II spawning had not yet fully commenced.

About 90 % by weight of the food of the blue whiting consisted of *Meganyctiphanes norvegica* ("Krill"); other organisms included the luminous fish *Maurolicus pennanti*, and young specimens of *Scopelus* sp.

Discussion.

The voyages can be considered a success to this extent, that the deep-water winter hake fishing grounds have been extended northward from off the Flannan Islands to the Wyville Thompson Ridge. On the negative side, they have proved fairly conclusively that the Wyville Thompson Ridge is the northern limit of the Atlantic deep water fishery, and that hake are not met with to the north and east of the Ridge, at

least not in sufficient quantity to attract a hake trawler, until the Norwegian Rinne is reached.

The proportion of the largest and most valuable sizes of hake was remarkably high on the new extension of the grounds, yet, having in mind the very narrow area of the steep continental slope between 260 and 320 fathoms (the optimum depth) and the resulting very intensive nature of the trawling there, one questions whether the hake stock visiting this area can long sustain this proportion of big fish. The relief given can only be regarded as temporary. But the very fact that there has been an extension of the area available for hake trawling means, on the average, less intensive trawling on all grounds and therefore a somewhat improved chance of survival for the hake.

The relatively high catches on the new grounds seem to be associated with the spawning of the blue whiting, the principal food of the hake. SCHMIDT¹⁾ shows that, though adult blue whiting are found all over the Norwegian Sea and in the northern North Sea, no spawning takes place to the eastward of the Wyville Thompson Ridge and the Faroe-Iceland Ridge. This clearly implies that, in order to spawn, blue whiting must migrate to the west of these ridges, and the relatively very great concentration of blue whiting found in Region II (chart 1) might perhaps be due to fish from the southern Norwegian Sea reinforcing the local stock of blue whiting during the spawning period. Since these blue whiting, the food of the hake, were also still in the ripe, though unspawned condition, and therefore probably in the densest concentration, these facts go far to explain the high average catch of hake per hour in this region, as compared with other regions investigated.

There is good reason, therefore, to believe that the deep water fishery on the new hake grounds is associated, even more closely than elsewhere, with the spawning of the blue whiting. If this is correct, the season will be found to range from late January to early May, with a maximum early in April.

This may also throw some light on the virtual absence of hake from Region I. The majority of the hake may have moved westwards after the blue whiting, with the exception of those few which remained in the neighbourhood of the Shetlands to feed on the herrings. It is tempting to think that the waters of the Faroe Shetland Channel, especially as one moves eastward, become too cold for hake, and this may be true of the greater depths, such as 300 fathoms, where we found a temperature of 6° C. But the presence of abundant hake in the Norwegian Deep

¹⁾ Rapports et Procès-Verbaux. Vol. X. 1909.

Water, where, according to the Hydrographical Bulletins¹⁾, the temperature at 80—100 fathoms is no higher than 8° C. even in May, July and September, and in the deeper portions as low as 6.5° C., weakens this point. The opinion we formed at the time was, that 8.7° C. represents the lowest temperature at which the hake, which is essentially a warm-water species, is found in commercially profitable quantities, and that the Norwegian hake must therefore represent an isolated local stock. This theory will be tested when opportunity offers.

The voyages cannot be said to have definitely disproved the presence of hake on the deeper slopes of Rockall Bank. At one position we found water at 8.7° C., a temperature at which we were getting considerable quantities of hake in regions II and III. The blue whiting is abundant on the Bank.

Hake are abundant on the Porcupine Bank in September, October and November, though at other times of the year they may be quite absent, and a comparison with Rockall Bank is obvious. In the case of Rockall, however, there is a much greater distance between the Bank and the nearest point of the 100 fathom line than in the case of the Porcupine, and NANSEN (*loc. cit.*) gives the temperature at 300 and 400 metres (164 and 218 fathoms respectively) on the western slopes of the Porcupine Bank, in the region where the hake are caught, as 9.9° C. Even if it is true that the hake is a midwater fish, independent of the sea bottom for its food, and capable of living over the great ocean depths, one doubts whether any but occasional specimens would wander as far west as Rockall Bank.

It gives me great pleasure to acknowledge here my thanks to Mr. LEECH and Mr. MASON²⁾, of the Fleetwood Fishing Vessel Owners' Association, for their ready help in recording, and to Capt. SANDHAM for his practical help, unceasing interest, and for many valuable suggestions.

Summary.

A report is given of the Fleetwood exploratory voyages for hake, March—May 1927. A northerly extension of the hake grounds was found and explored. Hake were rare in the Faroe Shetland Channel, and were not met with on Rockall Bank.

The best catches of hake were made between 260 and 320 fathoms.

¹⁾ Especially Bulletin Hydrographique Juillet 1908—Juin 1909. Conseil. Perm. Exp. Mer.

²⁾ since deceased.

Hake are apparently not present at depths greater than approximately 380 fathoms. The sea bottom on this new extension is extremely rough with stones and coral.

Investigations of the stomach contents of hake showed that the comparatively high catches made on the new grounds were associated with a very high rate of feeding. The Blue Whiting (*Gadus Poutassou*, Risso) was almost exclusively the food of the hake, was apparently present in remarkable abundance, and, at the beginning of April, was just about to spawn. It is therefore suggested that the spawning-concentration of blue whiting caused a feeding-concentration of hake, which was reflected in exceptionally high catches on the new grounds explored.
