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Performance and Biological Implications of a Multi-gear Fishery for Greenland Halibut (*Reinhardtius hippoglossoides*)

by

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Abstract

Simultaneous full scale fishing operations with bottom trawl, gillnet and longline for Greenland halibut (*Reinhardtius hippoglossoides*, Walbaum) were performed in the Barents Sea (ICES divisions IIa and IIb) for two weeks in October 1992. The mesh size in the trawl codend was 135 mm, and that of the gillnets 220 mm. (However, seven gillnet fleets of 180 mm mesh size were set for selectivity comparison.)

The catch rates and the length distributions of the halibut in the catches taken by trawl, longline and gillnet were different. Gillnets almost exclusively caught fish between 60 and 70 cm, mostly mature females (about 90 %). The size distribution taken by longline was wider than by gillnet. One third of the longline catches was males, and the proportion of immature individuals was larger (14-30 %) than in the gillnet catches. The trawls, however, caught large amounts of fish between 40 and 60 cm, consisting of almost equal amounts of males and females, and 30-40% immature fish. Gear specific selective properties were the main reasons for the observed differences.

It was concluded that the trawl, by the large proportion of immature fish in the catches, has a potential risk of overexploitating the Greenland halibut population, while gillnet and longline have selective properties that enables them to harvest the stock in a more biological optimal and balanced way.

Introduction

Due to a low historic level of the North-East Arctic Greenland halibut stock (ICES Subareas I and II), strict regulations of the fishery were introduced in 1992. In order to continue an established series of trawl catch data, and to improve the biological sampling as basis for the assessment, fishing vessels were contracted for commercial scale fishing, although restricted to certain time periods and areas.

The growth of male and female Greenland halibut is different, and fish larger than 70 cm and 4 kg are almost exclusively females (Bowering 1983, Kovtsova and Nizovtsev 1985). Male Greenland halibut also reach sexual maturity at younger ages and smaller sizes than females.

Godø and Haug (1987) have documented size-related geographic and depth distributions for the species. An optimal management do therefore depend on regulations taking these facts into consideration.

The present study made it possible to compare the performance of the different gears and their biological implications. Due to different selection properties it is expected that fishing gears harvest different parts of the stock with regard to length, age and sex composition. This has previously been documented through sampling of commercial landings in the ports (Figure 1), but the present study allowed simultaneous comparisons between trawl, gillnet and longline gear during a full scale fishing operation.

Materials and methods

In order to obtain information on how the fishery for Greenland halibut is conducted (e.g., to evaluate the quality of catch-per-unit-effort as a measure of the fishable stock size) and to get sufficient biological data to assess the stock, commercial fishing vessels were contracted to conduct regular fishing.

During 16 fishing days from 5 Oct to 21 Oct 1992, one freezer trawler (45.4 m LOA, 1500 HP, later called Trawl 1) one factory trawler (56.9 m LOA, 3300 HP, later called Trawl 2) and one longliner (37.7 m LOA, 1075 HP) were contracted to fish for Greenland halibut on the traditional fishing grounds. In addition a gillnet vessel (37.5 m LOA, 750 HP) was contracted for 12 fishing days within the same time period. The fishing was conducted in the official Norwegian statistical areas 12 and 39 in ICES Division IIa between N70°30' and N73°30', and areas 20 and 27 within ICES Division IIb which extends from N71°30' to N76° (Fig. 2). The vessels should spend the same amount of time in each of the areas, apart from area 27, in which the trawlers were only allowed to fish for one day.

The trawlers used standard cod bottom trawls. The factory trawler used two 135 mm (stretched mesh, measured to 137.5 and 139.6 mm at average) Alfredo 5 trawls with double cod-ends. The vertical trawl opening was about 4 m and the distance between the doors was on average 170-175 m. One of the trawls was equipped with bobbins gear, the other with rock-hopper. French Malo-doors (type R PS15E, 2700 kg) were used. The freezer trawler used two 135 mm (measured to 137.5 and 139.6 mm at average) Alfredo 3 trawls with double cod-ends and a lighter ground gear than the factory trawler. The trawl geometry was not measured. Both trawls were equipped with rock-hopper gear. Malo-doors were used also on this vessel, although of a smaller size (type R PS13, 2000 kg). The length of the gear from danleno to danleno was 106.7 m and 80.3 m on the factory trawler and freezer trawler, respectively. The sweep lengths used by the factory and the freezer trawlers were 128 m and 136.5 m, respectively, and the warp length during towing was 2.5-2.8 times the bottom depth, dependent on current and bottom condition. Towing speed was 4 knots (2 m/s), and towing duration usually 4-5 h. Sixty-two hauls were taken by the freezer trawler (trawl 1) and 79 hauls by the factory trawler (trawl 2). For statistical analyses each haul was treated as a unit.

The longliner used 7 mm (diam.) swivel longline with Mustad EZ-baiter hooks no. 12/0 at a spacing of 1.4 m. Each longline fleet consisted of 28 skates with a total of 5400 hooks. The hooks were baited with 1/3 squid, 1/3 mackerel and 1/3 herring, with an average bait width of 28 mm. The soak time varied between 6 and 24 h. A total of 87 fleets were hauled. One fleet was treated as one unit (called "station) in the statistical calculations.

calculations.

The gillnets used were made of monofilament with a mesh size of 220 mm (stretched mesh). Thirty nets, each 30 m long, were tied end-to-end to a fleet. In addition seven fleets of 180 mm nets were set during the experiment period to compare selectivity. The hight of the nets were 20 meshes, and the hanging ratio 60 %. The thickness of float and lead line were 14 mm. The total number of fleets hauled during the experiments was 128, with a variation in daily effort from 6 to 16 fleets. One fleet is treated as one unit ("station") in the statistical calculations. The gillnet fleets were bottom-set, anchored to bottom in one end only, letting the other end drift freely with the current.

Results

The length frequencies of Greenland halibut in the longline, gillnet and trawl catches were significantly different (Fig. 3). While the gillnets almost exclusively caught fish between 60 and 70 cm, with a maximun at 66 cm, the length distribution of the longline catches was wider and bimodal with one maximum at 50 cm and another at 65 cm. The length distribution of the trawl catches was broader than the other two, with a maximum between 40 and 60 cm. The 50% retention length for Greenland halibut in a 135 mm trawl is 43 cm (Nedreaas 1991), which fits well with the lower slope of the trawl distribution curve.

However, looking at number of fish caught per day by the different fishing vessels (Fig. 4), it is obvious that the catch rates of the trawlers, particularily the factory trawler, are much higher than that of the gillnet and longline vessels. In spite of the higher relative amount of large fish in the gillnet and longline than the trawl catches, the total number of fish larger than 60 cm was larger for trawl than for longline, and only slightly less than in the gillnet catches. The catches of fish smaller than 60 cm were almost exclusively taken by trawl (96% of total catch).

Although the fishing was restricted to certain statistical areas, the skippers were within wide limits left to choose their fishing positions. As can be seen in Figure 5, the trawlers chose longline and gillnet, while trawler 2 made a limited number of hauls between 500 and 600 m depth for gear comparison.

To compare catches taken at similar depths, stations between 530 and 630 m depth were selected (Fig. 6). The two trawlers caught somewhat less fish smaller than 55 cm at this depth interval than at greater depths, while the longline catches contained a slightly larger fraction of fish below 55 cm compared to those taken in more shallow waters. This indicates that there

was a change in size composition of Greenland halibut with water depths. However, although the difference between gears was less pronounced while fishing at similar depths, the main trends in catch caracteristics were still evident.

To search for geographical and temporal variations in fish distribution, the catch data were grouped according to area and location, and to first and second half of the experiment period. However, the main trends in differences between gears were evident within all statistical locations, and also in first and second half of the experiment. As an example, the length distributions for area 12, location 7 are given i Figure 7.

The length-weight and length-age relations are given i Figure 8 and 9, while the age compositions of the catches of different gears are shown in Figure 10. Gillnet catches mainly consisted of fish older than 6 years, while the trawl catches consisted of a broader age range, from 3 to 12 years. About 50 % of the Greenland halibut matures at 6 to 7 years (Kovtsova & Nizovtsev 1985), males earlier than females. Thus the fraction of mature fish are larger in the gillnet and longline catches than in the trawl catches (Table 1).

The growth potential of Greenland halibut differs between the sexes. From about age 5 (approximately 42 cm) the growth of females exceeds that of males (Lahn-Johannessen 1965; Kovtsova & Nizovtsev 1985). As a result of this, the sex composition of the catches varies between the gears. Thus, the trawlers caught an almost equal proportion of males and females, while the proportions of males were one third and one tenth in the longline and gillnet catches, respectively (Table 2).

Discussion

Why was the size composition of Greenland halibut in trawl, longline and gillnet catches different?

a. The gears fished on populations with different size distribution

The three gear types were mainly fishing at different depths; the trawlers in average about 150 m deeper than the other two gears. If the size distribution of the Greenland halibut population changed with depth, this might explain the catch differences. However, when selecting stations where both trawls, gillnets and longline had been fishing within the 530-630 m depth-range, a small shift in length distribution towards smaller fish for longline and larger fish for trawl was observed, while there was no difference for gillnet. Thus, differences in length distribution with depth had some effect on the catch composition, but the changes were far from large enough to explain the total observed difference between the gears.

However, the number of trawl stations taken in the same depth interval as longline and gillnet, was limited. In fact, the freezer trawler did not have a single haul as shallow as the deepest longline and gillnet stations. Therefore, even within the 100 m depth interval where all four vessels had been fishing, there was a difference in average fishing depth which might contribute to the observed difference between the gears.

The vessels were fishing within several statistical areas and locations during a two weeks period. However, splitting the catch data on location and time did not reveal any areal or temporal differences in fish and size distribution that could explain the difference in catch composition between the gears.

b. The gears had different selective properties

The selective properties of gillnets are well documented (e.g. Olsen 1959; Hamley 1975), and the narrow selection range of gillnets, mainly dependent on mesh size, is also reflected in the present experiment. Gillnet selection remains constant regardless of the size composition of the fish in the area. The mesh size mainly used in these experiments (220mm) had a distinct maximum at fish lengths of 66 cm. However, seven fleets consisting of 180 mm gillnets set during the experiments caught fish of a wider length range with a peak at 55 cm (Fig. 11). The wider range was probably due to tangling of fish larger than 60 cm (Olsen & Tjemsland 1963).

Longline catches fish which are actively seeking the bait, attacks and get hooked. Its selective properties are dependent on several factors such as the feeding motivation and hooking ability in different groups of fish, and competition between species and size groups when approaching the bait (Fernø et al. 1986; Bertrand 1988). How many fish, what species and size groups the longline will catch, are, therefore, influenced by a wide set of factors (e.g. Bjordal 1988). In this experiment, longline caught less small fish than the trawls, although the difference was slightly smaller while the gears were fishing at the same depth. The reason may, in addition to the fact that they were fishing at populations with slightly different size composition, be due to different swimming range with size, and to competition between fish of different size. If big halibut are able to swim for larger distances to seek for food, or if the largest ones win while competing for a bait, larger fish may be caught in relatively larger numbers than small ones. The longline catches, therefore, do not reflect the true size composition in the area (Løkkeborg & Bjordal 1992; Engås et al. 1993).

The trawl caught a much higher proportion of small Greenland halibut than longline and gillnet. The difference between gillnet and trawl is easily explained by the mesh selection properties of the gillnet. The trawl is, in contrast to gillnet and longline, an active gear, in principle harvesting all fish that happens to be between the trawl-doors in the trawl path if they are large enough to be withheld by the meshes in the cod-end. The trawl catches are, therefore, probably reflecting the true size composition of Greenland halibut larger than the 50% retention length (43 cm, Nedreaas 1991) in the area better than the other gears. However, avoidance reactions towards the approaching gear and escapement below the ground gear, that may differ between age groups, are known to bias in length composition also in trawl catches (Ona & Godø 1990; Engås & Godø 1989).

c. Biological implications of the catch differences

The fishery for Greenland halibut in Norway have traditionally been carried out by longline in restricted seasons and areas (ICES areas I and IIa). In the late 1960s a trawl fishery and in the 1970s a gillnet fishery for Greenland halibut were developed (Godø & Haug 1989). The

observed differences in CPUE and size composition of Greenland halibut in the catches taken by trawl, longline and gillnet, certainly are of importance when choosing optimal harvest strategy.

The longline fishery, to a large extent, exploits the adult population from 6 years and older, both males and females, although there is a slight predominance of females in the catches (Table 2). The amount of undersized fish is negligible, and the majority of both males and females are mature fish (Table 1). The size selectivity of longline may be somewhat altered by changing bait size, as mean length of the fish in longline catches is shown to increase with increasing bait size (Bjordal 1988; Løkkeborg 1990). Longline, therefore, seem to have a good potential for a balanced harvest of Greenland halibut, both with respect to size and sex composition.

The gillnet catches were almost exclusively mature females older than 8 years. Provided a natural mortality of M=0.15 (Anon. 1993), harvesting the Greenland halibut stock by gillnet of this mesh size will utilize the growth potential of the stock, but the sex ratio is far from optimal. Gillnet fisheries could easily be aimed at other size groups by altering the mesh size, and gillnets of 180 mm mesh size did not only catch fish of a smaller mean size and a wider length range (Fig. 11), but also containend a higher proportion of males.

Since the late 1960s, trawling has been the major fishing method for Greenland halibut in the Barents Sea. While longline and gillnet exploit mature fish, trawl catches smaller fish and a large fraction of immature individuals. That trawl is a less size selective gear than longline, has earlier been documented for cod and haddock (McCracken 1963; Sætersdal 1963; Hovgård & Riget 1992). The potential amount of fish that a trawler is able to catch per day, is far greater than for a longline or gillnet vessel. This is particularly true for young fish, who have not yet reached reproductive age. The "potential risk" of overexploitation is, therefore, significantly larger for trawl than for the other two gears.

In the Barents Sea region, the trawlers, in addition to exploit yearclasses that earlier was not caught, also have expanded the fishing areas to include the nursery grounds in the Spitsbergen-Bear Island area. This led to a decrease in CPUE and mean size of fish in the catches (Anon. 1984), and a decrease in stock level (Godø & Haug 1987). Trawl fisheries, at least in the way it has been carried out up till now, therefore do not seem to be an optimal way of harvesting the Greenland halibut stock in the Barents Sea.

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Table 1. The observed proportion (percent) of immature and mature males and females in the trawl, longline and gillnet catches.

Sex	Maturity	Trawl 1	Trawl 2	Gillnet	Longline
Females	Immature	38.8	40.4	1.6	31.5
	Mature	61.2	59.6	98.4	68.5
Males	Immature	25.3	32.4	3.3	13.8
	Mature	74.7	67.6	96.7	86.2

Table 2. The sex distribution (percent) in trawl, longline and gillnet catches observed during the experiments.

Sex	Trawl 1	Trawl 2	Gillnet	Longline
Females	50.6	48.5	86.4	66.5
Males	49.4	51.5	13.6	33.5

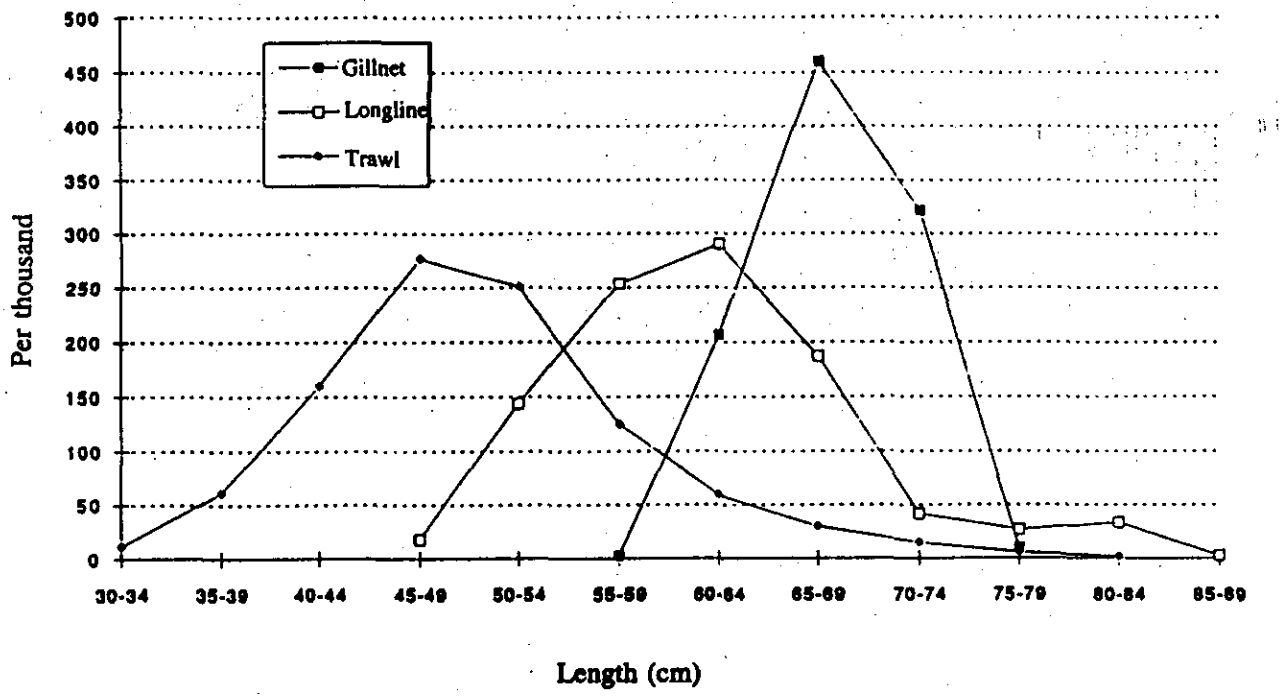

Figure 1. Length distribution of Greenland halibut from commercial trawl, gillnet and longline landings.

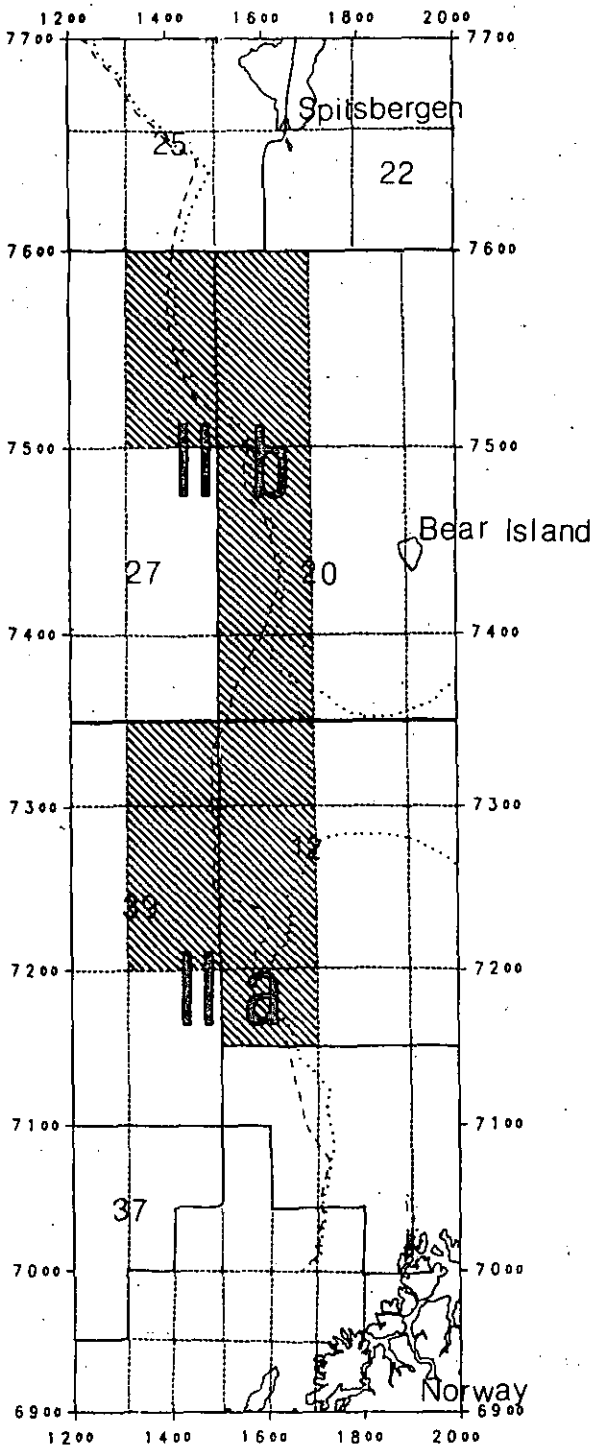

Figure 2. Experimental area (shaded) located with ICES Divisions IIa and IIb. Further division is off Norwegian stat. areas.

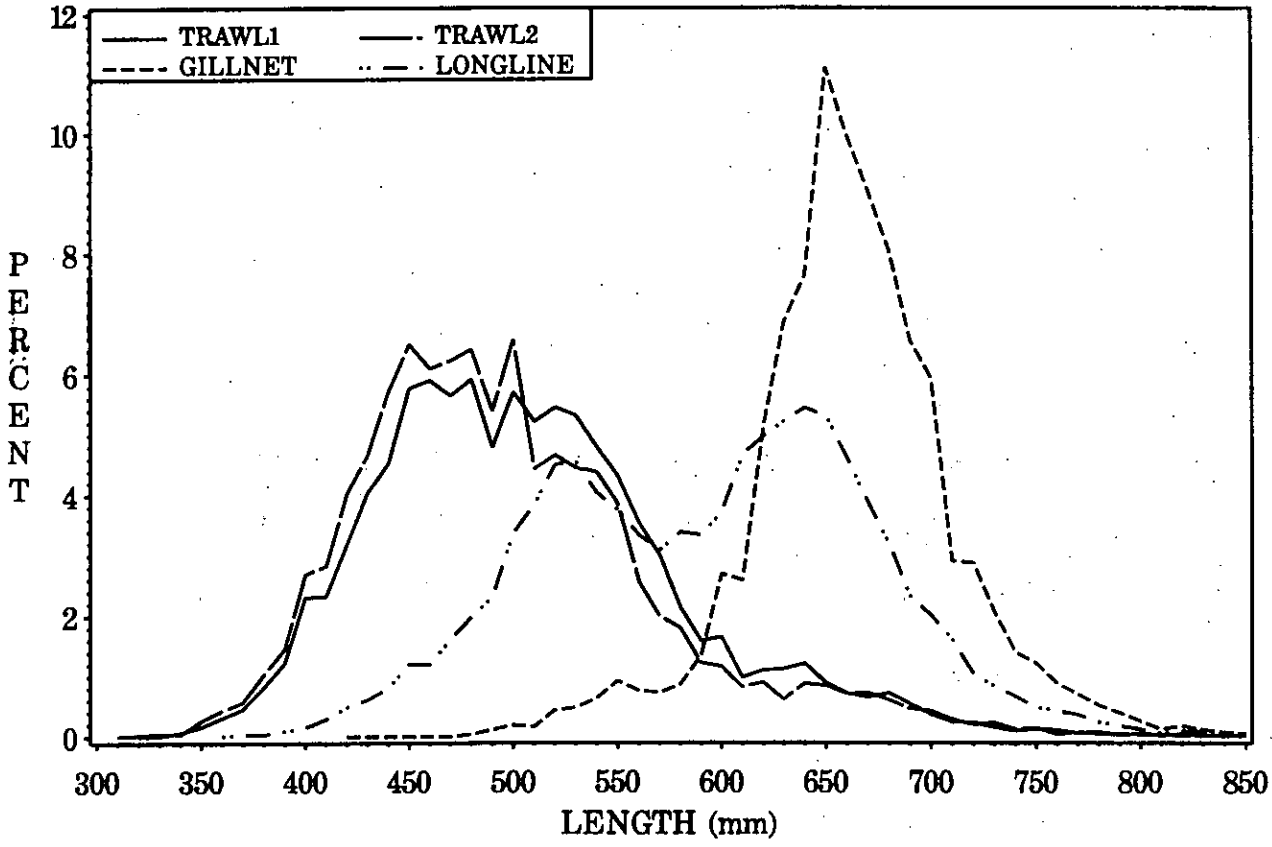

Figure 3. Length distribution of Greenland halibut caught by freezer trawler (Trawl 1), factory trawler (Trawl 2), longline and gillnets.

AVERAGE CATCH PER DAY

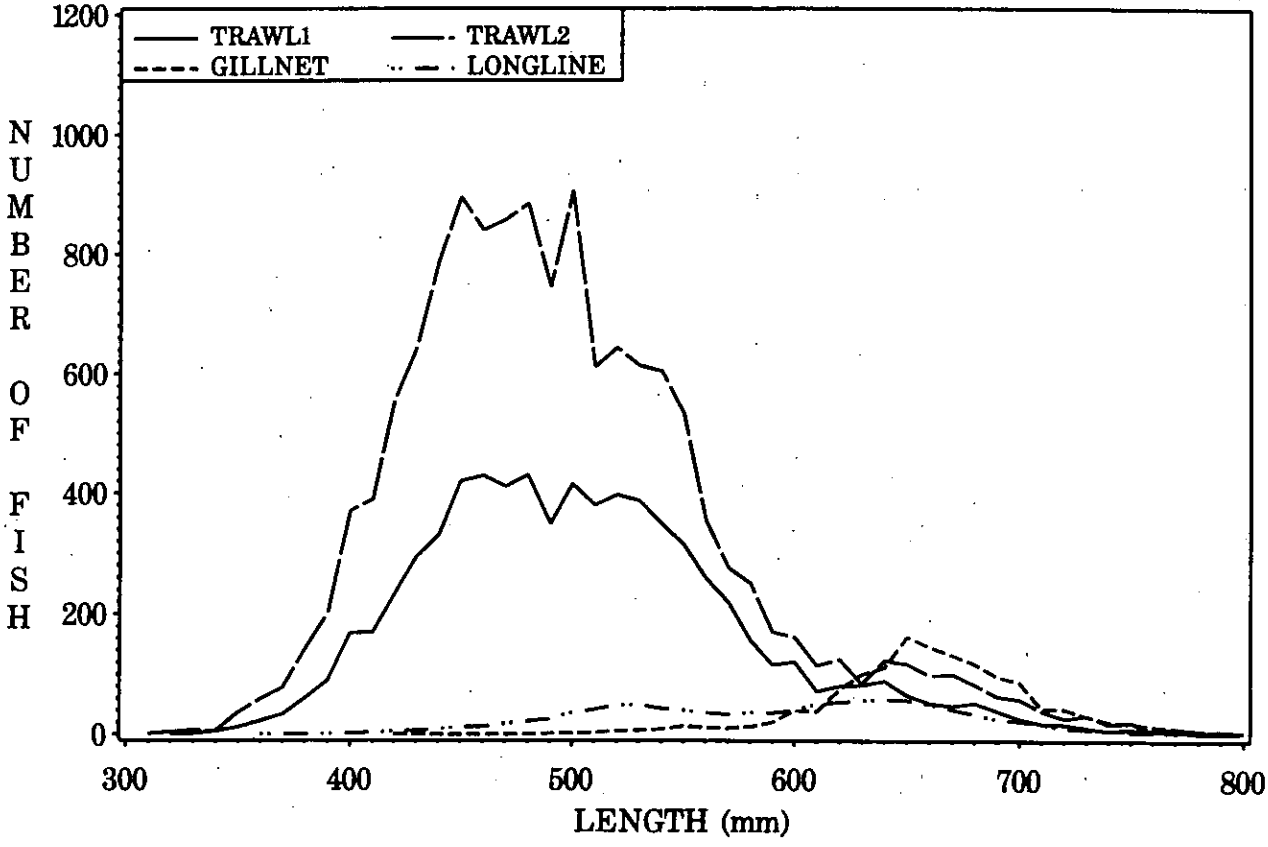

Figure 4. Average number of Greenland halibut taken per fishing day by trawls, longline and gillnets.

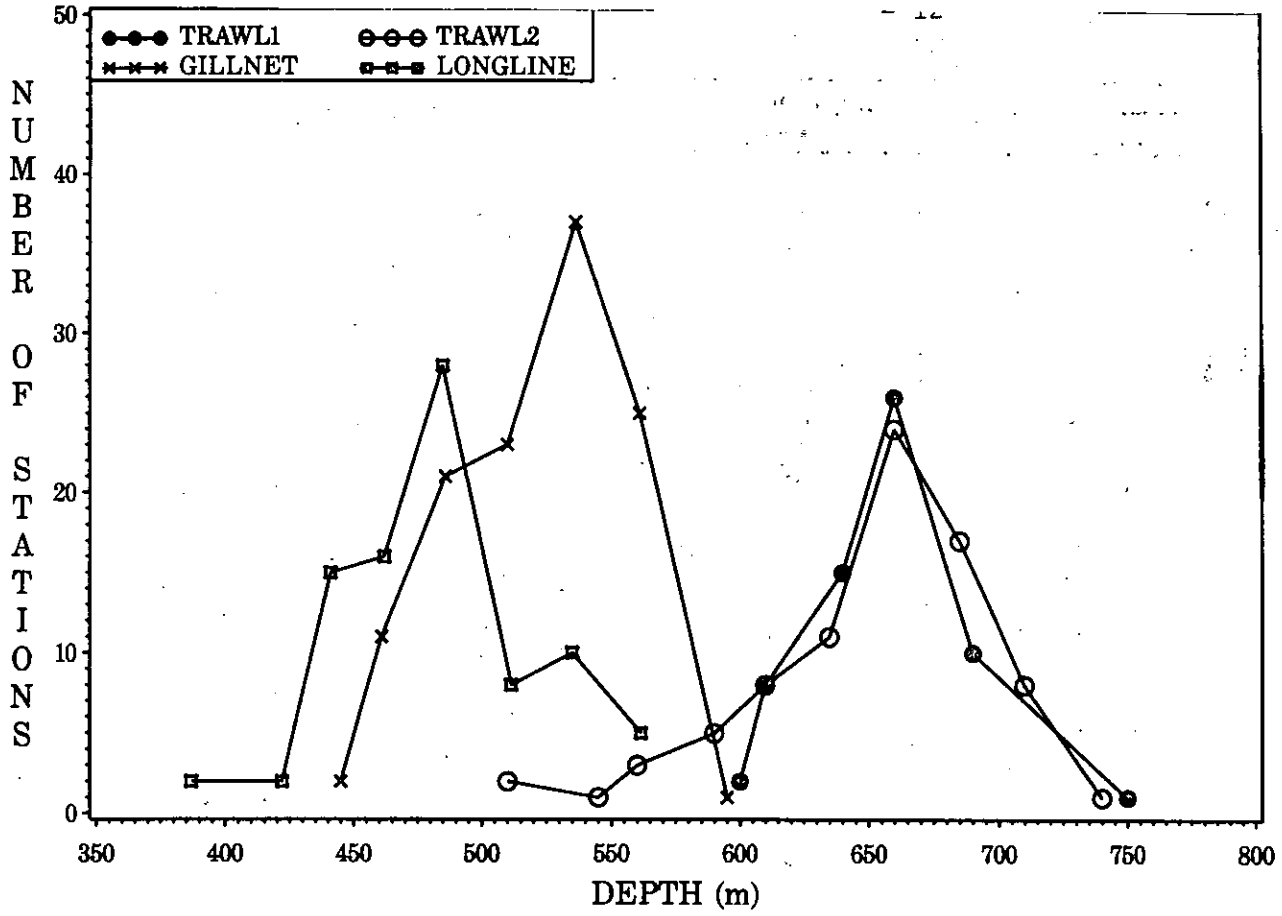

Figure 5. Number of fishing stations taken by trawls, longline and gillnets at different fishing depths (50 m intervals) during the experiments.

LENGTH DISTRIBUTION
at depths between 530 and 630 m

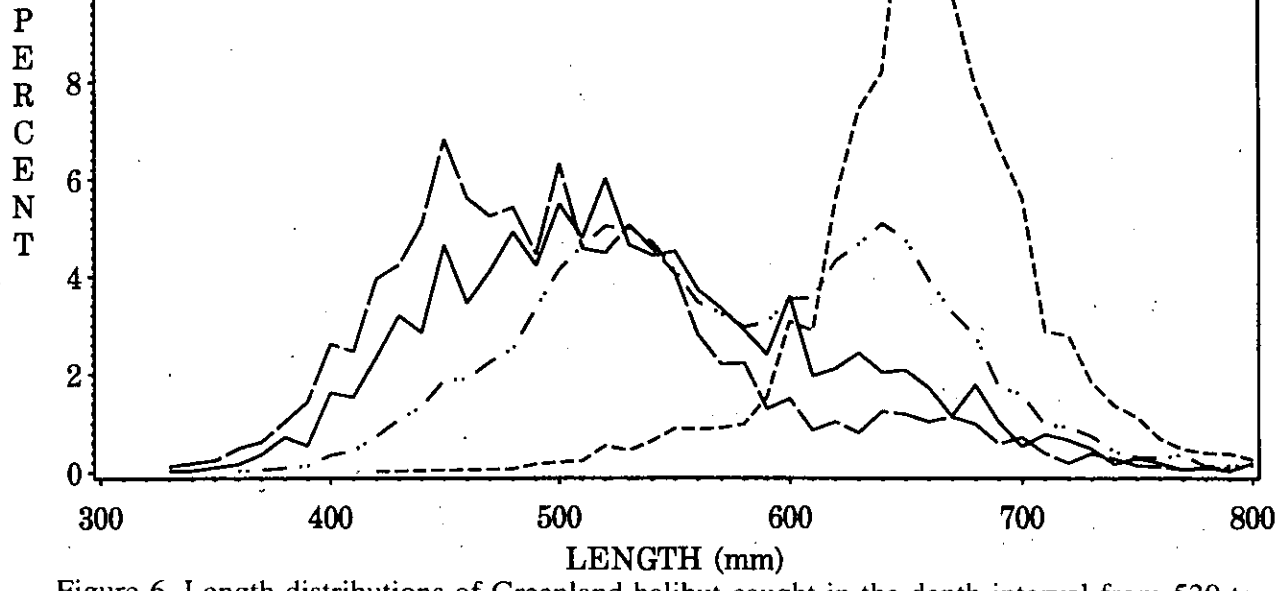

Figure 6. Length distributions of Greenland halibut caught in the depth interval from 530 to 630 m by trawl, longline and gillnets. Number of stations were 10 (Trawl 1), 18 (Trawl 2),

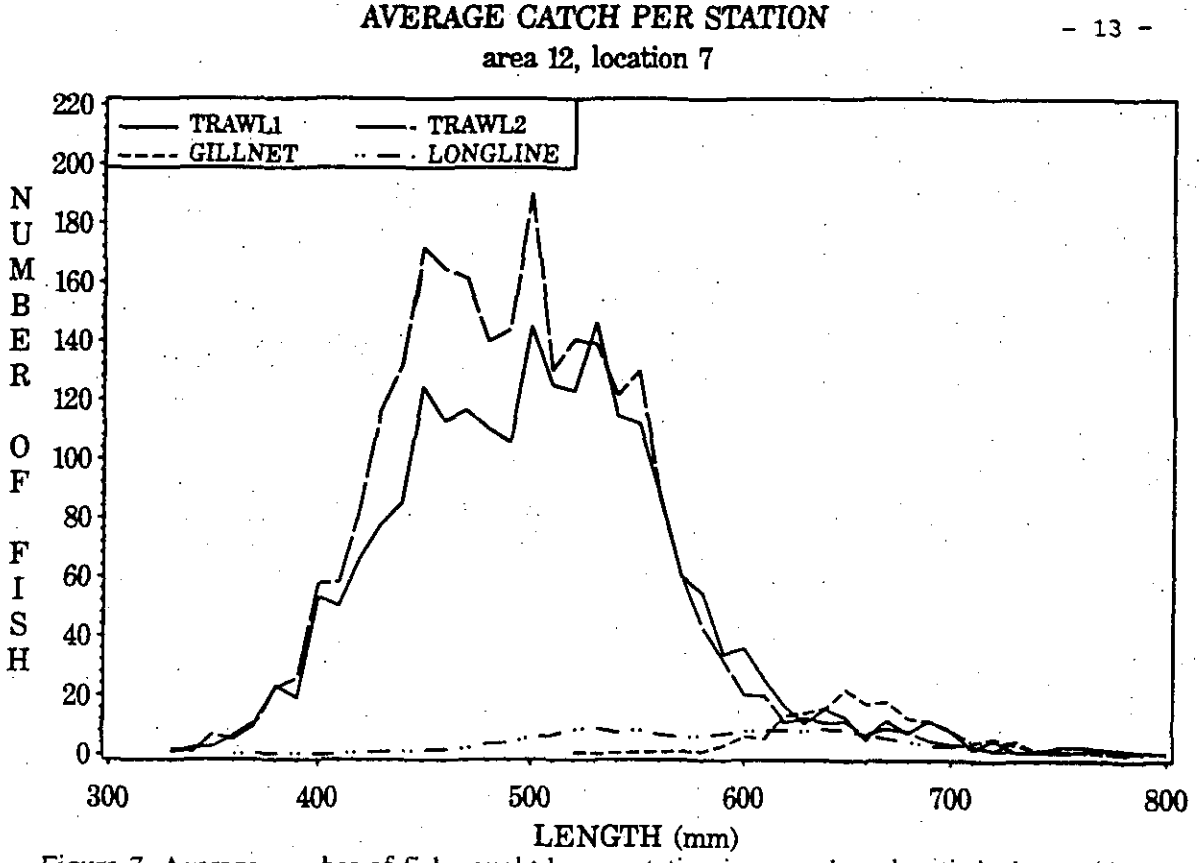

Figure 7. Average number of fish caught by per station in one selected statistical area (Area 12 location 7). Number of stations were 10 (Trawl 1), 17 (Trawl 2), 26 (longline) and 7 (gillnets).

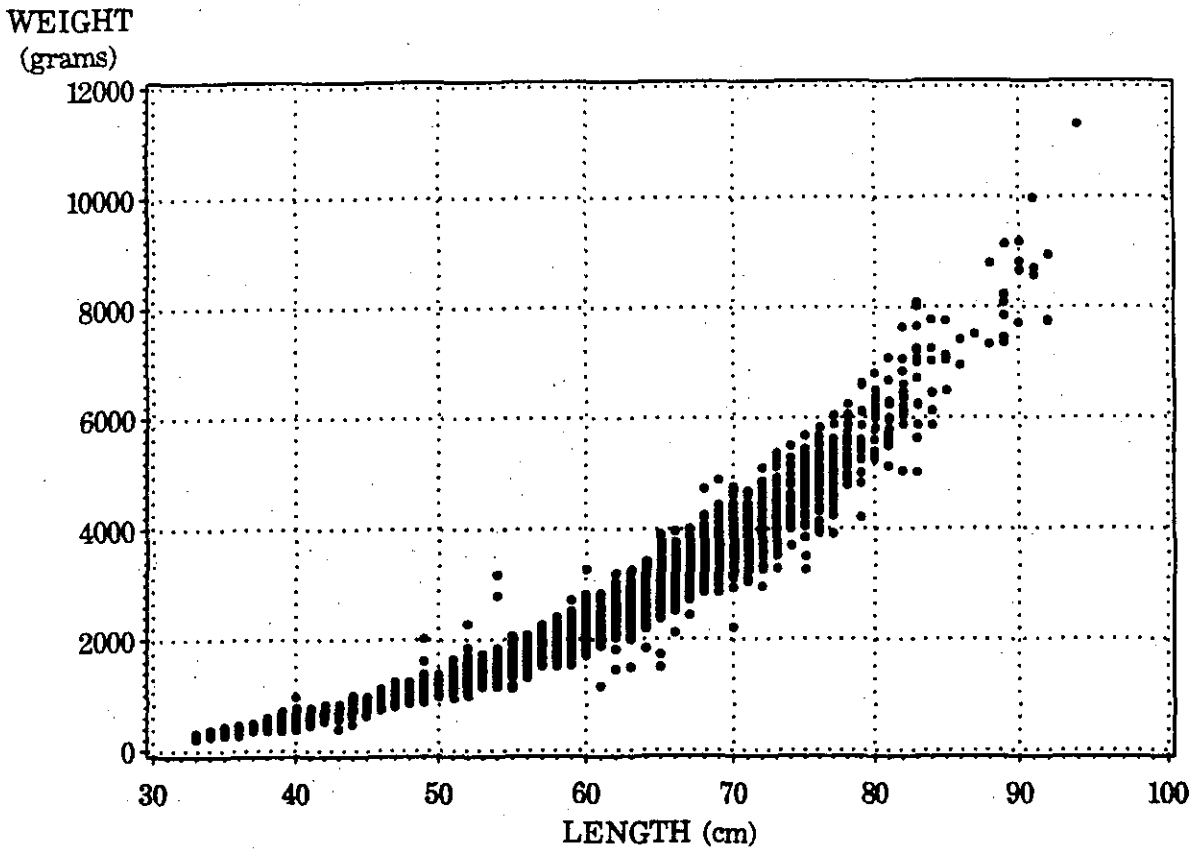

Figure 8. Measured length/weight relation for Greenland halibut (both sexes) during the experiments.

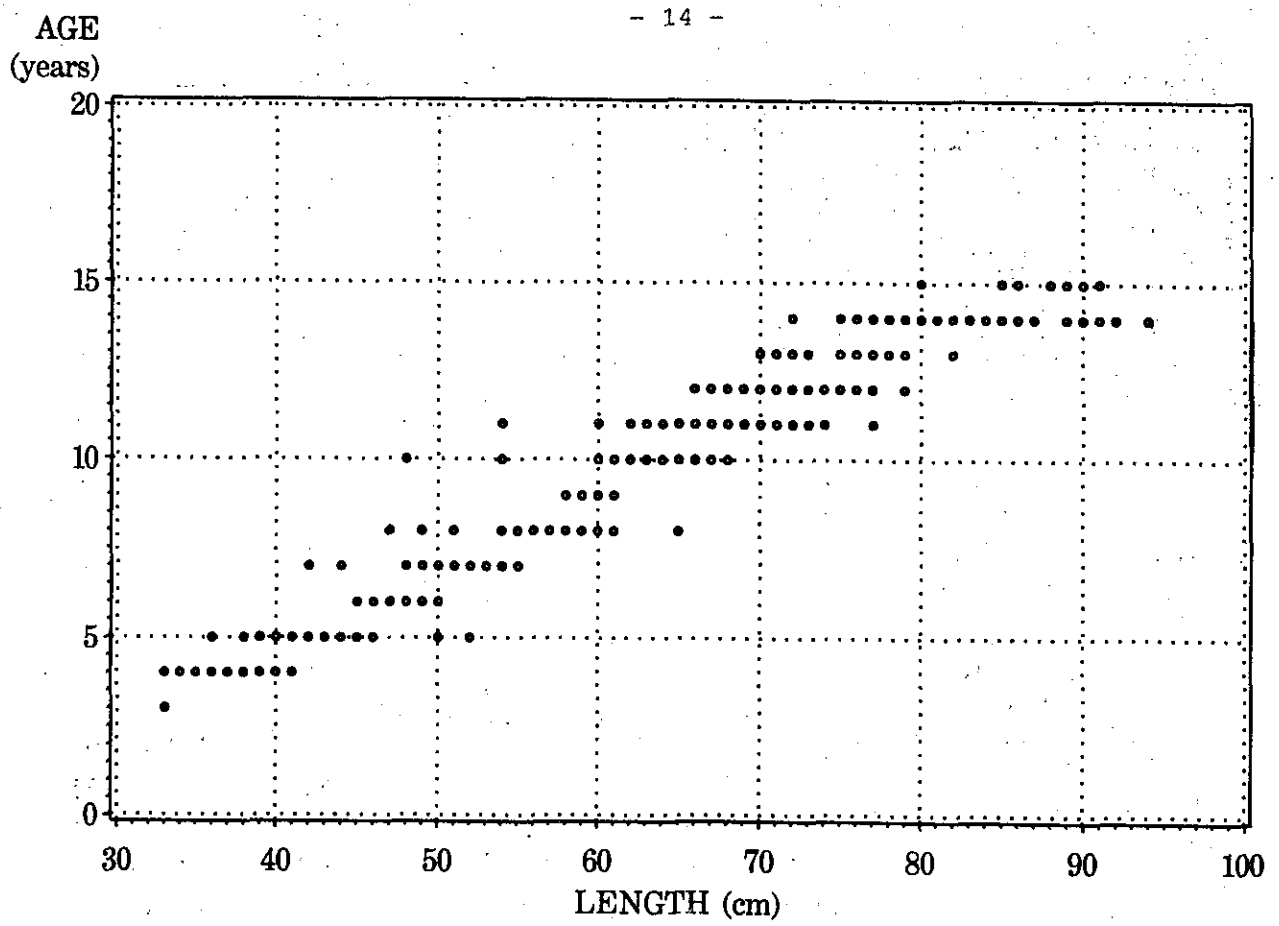

Figure 9. Length/age relation for Greenland halibut caught during the experiments.

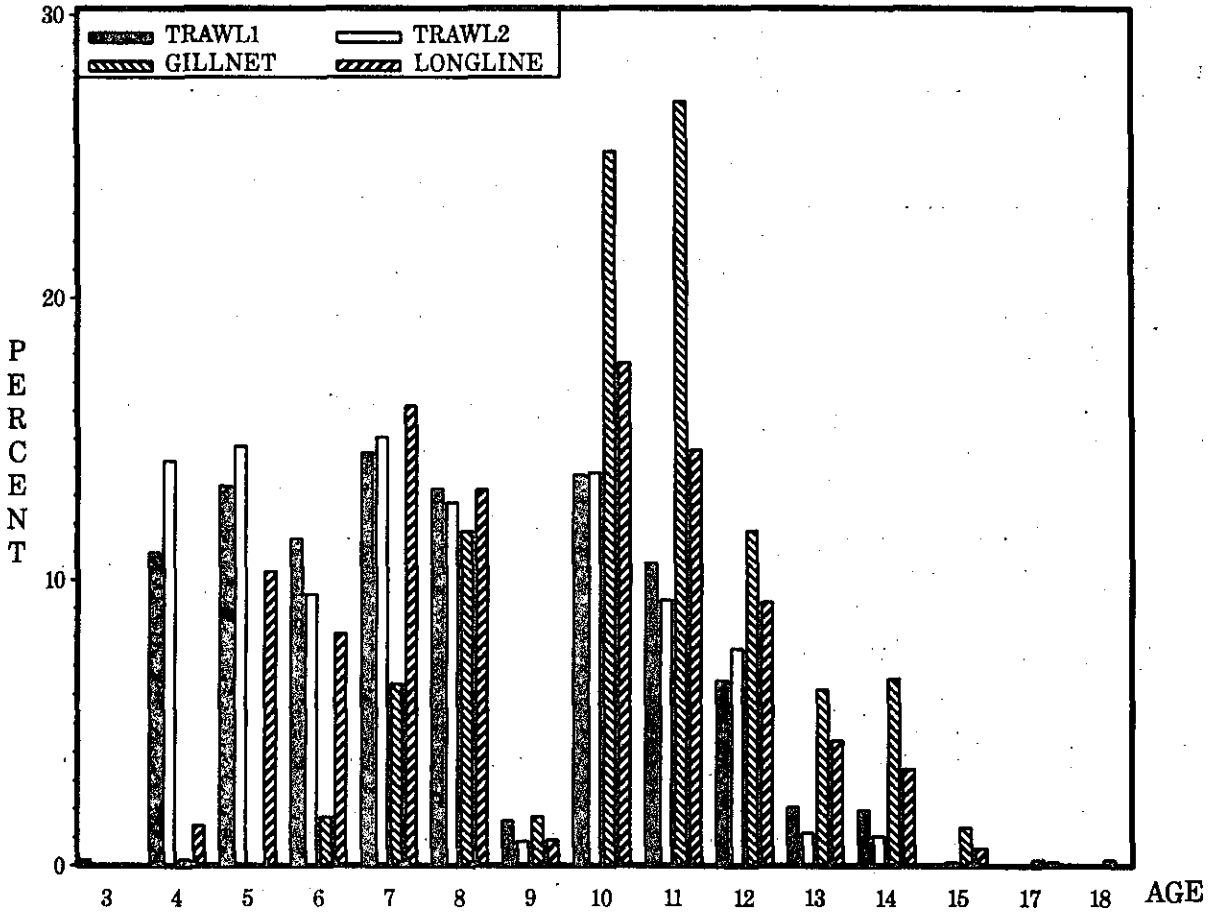

Figure 10. The observed age composition of Greenland halibut caught by the freezer trawler (Trawl 1), factory trawler (Trawl 2), longline and gillnets during the experiments.

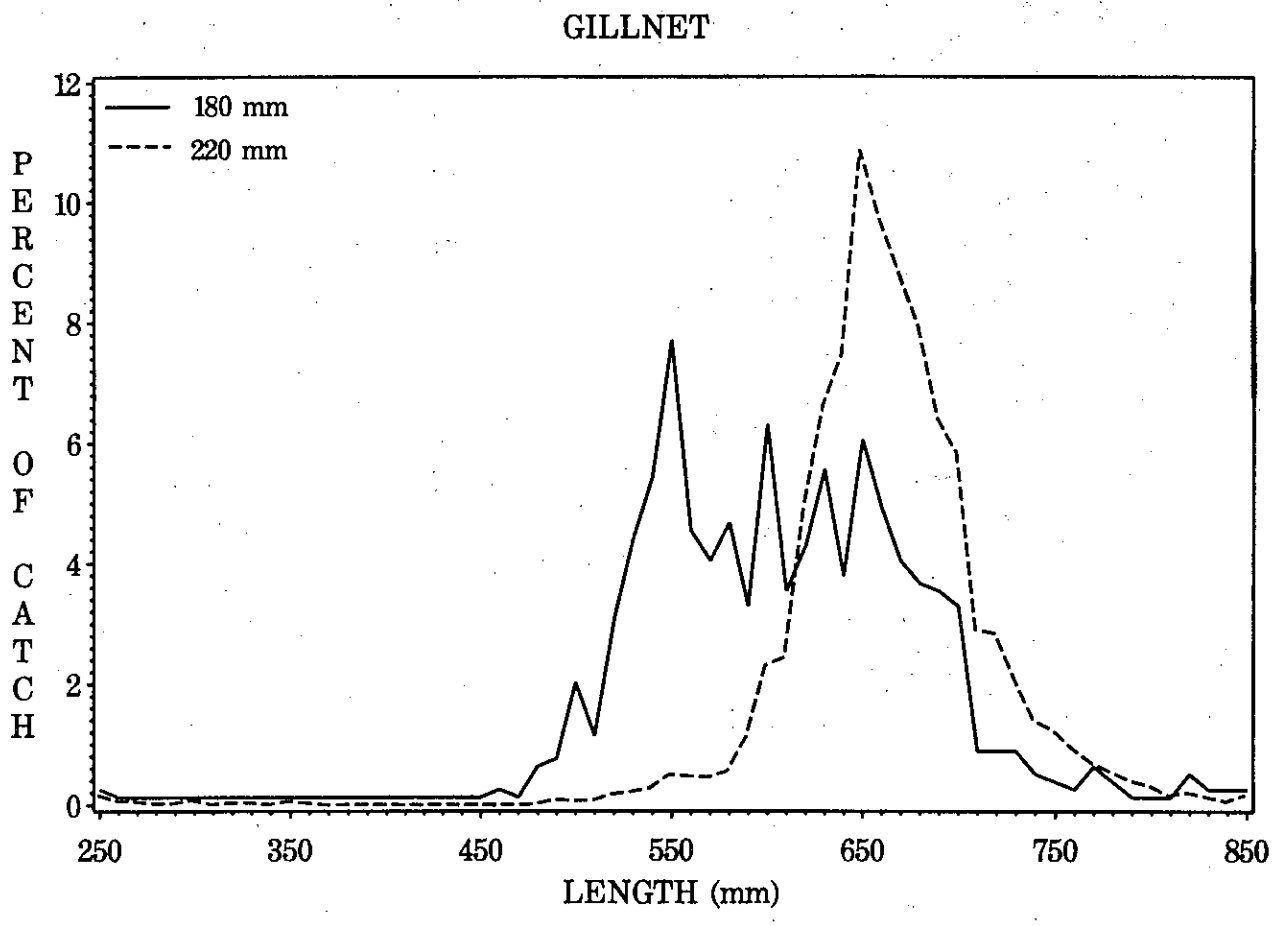

Figure 11. Observed length distribution of Greenland halibut caught by gillnets of 220 mm mesh size and 180 mm mesh size.