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Increasing catches of Pandalus  
borealis in Icelandic waters.

by

Unnur Skúladóttir

Marine Research Institute, Reykjavík

The deep sea prawn is caught mainly in three regions, namely Arnarfjörður, Ísafjarðardjúp and Hrótafjörður. Of those Hrótafjörður has only been fished for the last three winters whereas the other two regions have been fished for years. Elsewhere deep-sea prawn is caught in small quantities, where banks are either recently discovered or production is limited to shelling by hand by a small number of people. The total catch of Pandalus borealis has increased for the last few years not only by the discovery in 1965 of the banks in Hrótafjörður which have yielded between 184-260 tons per year. (These are not used to the full extent yet), but also because of the increasing catches on the old banks in Arnarfjörður and Ísafjarðardjúp. In this contribution an attempt will be made to throw some light upon what has caused this increase.

Methods

The statistics is based on reports written by the captains of every prawn boat. The total catch of the boats is usually slightly lower than what is given by the factories hence these are used in correcting figures for catch and effort. For the assessment of mean size and age composition, samples have been obtained. Moreover

3 years ago daily counts of number per kilo were started on account of prizedifferentiation of the catch. In Ísafjarðardjúp however these counts were only made when it was doubtful that the mean size was large enough and such information was rejected. Last winter the captains started doing such counts themselves in Ísafjarðardjúp, some of them from every haul. In this the contents of one pound can was counted.

The two regions Arnarfjörður and Ísafjarðardjúp will be treated separately assuming no connection between them.

### Ísafjarðardjúp

Information on total catch per season is available since 1955 although not shown here (Sigurðsson and Hallgrímsson). It is known that effort was not considerable till 2 shelling machines were introduced in the winter 1959-60. Effort (see fig 1) increased rapidly and total catch was about 1000 tons in that winter. Already in the winter 1960-61 effort increased far more than the catch, which was about 1210 tons that winter. At the same time catch per trawling hour falls rapidly, see fig 2. Mean weight was rather high in the autumn 1959, or 3.95 g but falls in one year down to 2.8 g. The effort was still great in the autumn 1961. Catch per trawling hour decreased further and was at the lowest in the spring 1962 or 47 kg. The mean weight also decreased and reached a minimum in the spring 1962 or 2.3 g. At the same time meshsize was increased as in Arnarfjörður. By spring 1963 16 boats out of 17 had changed the meshsize. In the spring 1962 the total catch was only 186 tons. A number of boats stopped fishing and boats became 17 instead of 20 in 1961. It was strongly suspected that the prawnstock had been overfished at least in the winter 1960-1961. In the autumn 1962 it was decided that total catch should be limited to 400 tons which was found to be minimal for the factories. In the next 2 winters. Mean weight increased rapidly and was 4.2 g in the autumn 1963 after this, mean weight decreased a little during the winter and was 3.25 g in the spring. The catch per trawling hour was still low or from 64-78 kg/hour. It was doubtful that the prawn stock had recovered fully. The total catch was increased to 655 tons in the winter 1964-65. Catch per trawling hour was up to 138 and 129 kg/hour in

autumn and spring respectively, hence effort was very low (see fig 1). In the winter 1965-1966 catch per trawling hour was as high as 201 kg/hour. Mean weight was higher than ever before. The difference in prize between large and small prawn was introduced in the autumn 1965 as in Arnarfjörður. For the last 3 winters mean effort was 9250 trawling hours and near the value of the winter 1960-61 when the effort was 9730 trawling hours. The mean catch per winter was 1166 tons. At the moment there are no signs of overfishing. Mean weight was in maximum last winter or similar to that of 1965-66.

The total number has been calculated see table 1.

Table 1.

Total number of prawns in the catch per winter.

Winter	Arnarfjörður	Ísafjarðardjúp
	Number in millions	Number in millions
1959-60		287.6
1960-61		414.3
1961-62	43.3	229.9
1962-63	51.8	111.4
1963-64	74.5	102.6
1964-65	95.3	151.1
1965-66	78.0	262.1
1966-67	66.8	254.0
1967-68	83.6	271.1

From the table one can see that the total number of fished prawn the last 3 winters has been near to 2/3 of that of the winter 1960-61, although the total catch is similar.

In order to understand what effect the change in mesh size had, it was calculated how much mean weight would increase by increasing the mesh from 25.4-32.8 mm. It is surprising to see that the immediate gain was only some 9-10% in the years 1960 and 1961. It appears that the prawnstock is not uniform and the very small prawns were not present in the catch. Only occasional samples had a completely different composition consisting of immature and mature males and very few females.

This implies that it is chiefly when mean size has become small e.g. following overfishing and catches of small prawns are larger than that of large prawns, that the increase in mesh size becomes very useful. This may have been the case in the autumn 1962.

On Fig. 3 the mean frequency distributions of prawn before and after meshchange are compared. The increase in mean weight is 22.3% in October and 23.5% in February. Although the comparisons give an idea of what has happened, the part effort plays in increasing and decreasing the mean weight is not shown here. It is also quite certain that there has been an increasing tendency to avoid fishing of undersized prawns, and catches of those have been known to be thrown back into sea. It is impossible to assess the gain in mean weight and total catch which may be due to this. Another important factor which has not been looked into yet is a possible connection between decreasing catches of cod in the last 2 years.

During the winter 1966-67 a Danish prawn captain paid a visit to Ísafjarðardjúp. He was invited to follow the fisheries onboard the prawn-boats. His opinion was that the Icelandic prawn-trawl was like a bag and unlike the Danish trawl completely out of date. At least 5 Danish trawls were bought. In spite of the great disadvantages that could be ascribed to the very long belly and square of the Danish trawl compared to that of the Icelandic trawl, better catches were obtained at times were bottom was even and currents were stronger. On the other hand when small herrings or capelins migrated into Ísafjarðardjúp the Danish trawl fished those unwanted fish and hardly any prawn. The small Icelandic prawntrawls are so shallow that almost all the fish swims out again if caught in the trawl. In the spring 1967 the Icelandic trawl was enlarged from the headline 60 feet to up to 100 feet and other dimensions changed in the same proportion. In Fig. 4. average depth per month is shown and compared to the usage of small and large trawls. By the uptake of those large trawls the average depth during the winter has also increased see Fig. 5. by about 6 fathoms. Schmidt (1966) maintains the meansize increaseswith depth. After the counts (900) made last winter on number per kilo it became evident that in Ísafjarðardjúp mean size decreases with depth. The catch last

winter is divided in the following manner between small and large trawls. In the large trawls catch per trawling hour was 158 kg/hour and catch was about 74% of the total. Catch per trawling hour was 140 kg/hour in the small trawl. Is there a connection between the great effort on the deeper areas and smaller mean size? If this was the case would the prawn population not migrate to another type of bottom?

It is quite certain from the information given in personal communication that the prawn is very much on the move.

### Arnarfjörður

Fig. 1 shows the catch and effort per season since the spring season of 1962. Before this year information on effort and catch per trawling hour is confined to the number of boats fishing and reports from only one boat since 1953, where information on catch per trawling hour per year is given (Sigurðsson and Hallgrímsson). The information on total catch per year dates back to the year 1956. During the last 6 years the number of boats has been constant or 5. Moreover total catch per winter has been limited to about 210 tons from 1962 to 1966. It is therefore not surprising to find so small fluctuations in catch and effort. The reason why total catch was limited was based on the observations of Sigurðsson and Hallgrímsson (1962) of the prawnfishery since 1953. In the year 1953 the boats were 10 and catch per trawling hour fell from 150 kg/hour to 63 kg/hour in 1954. The number of boats was then 8 and the following year the catch per trawling hour decreased still further and was about 48 kg/hour in 1955. After this the number of boats decreased and there were 3-5 boats till 1962 and from then on always 5. Gradually catch per trawling hour increased to 107 kg/hour in 1968. At the same time catch per year increased from 162 tons in 1956 to 248 tons in 1959 and 246 tons in 1960. The catch per trawling hour decreased at the same time to 86 kg/hour. This was suspected of being an indication of overfishing and 246 tons per year as sustained yield was thought to be too high. After the light fishing in 1961 when the total catch was about 122 tons the catch per trawling hour increased a little. Samples of the catch have been taken since the autumn of 1961 (see Fig. 2.). At that time meanweight was about 3.1 g.

In just one year the mean weight was up to 4.1 g. Along with this catch per trawling hour increased to about 164 kg in the spring 1963 (Fig. 2). The following autumn the mean weight was down again to 3 g and later 2.7 g and catch per trawling hour had also fallen down to 113-114 kg/hour. It is rather difficult to understand this drop when the stock seemed to be in such a good condition the previous winter and effort was light compared to that of the years 1959 and 1960. Besides this change in mesh size occurred in 1962 and was over by the autumn of 1962. The mesh increased from 25.4-32.8 mm in wet condition, which is about 30% increase. In spite of this mean weight continued to fall and so did catch per trawling hour. In the spring 1965 mean weight was in minimum or 2.1 g. The following winter 1965-1966 there was introduced a difference in price where higher price was paid for the catch when the mean weight was 2.85 g and more. From now on mean weight increased by every winter and was about 3.1 g in the winter 1966-67. The total catch was increased up to 234 tons. And last winter it was decided to limit the effort in the total number of trawling hours rather than the total catch. In the spring of 1968 mean weight was again at maximum or 4.1 g and catch per trawling hour was 155 kg/hour. The effort was increased by ten days and the total catch over the winter was higher than ever before or 336 tons.

Looking back over the last 5 winters one speculates what caused the decrease during the winters 1963-64 and 1964-65. When there were no longer big catches of large prawn and small prawns were available in larger quantities, was it not likely that these would rather be fished when there was no difference in price? Thus the mean size would decrease further. When the price was different for small and large prawns this would cause preference for the larger prawns and hence the mean weight would increase. The beforementioned tendency of fishermen in Ísafjarðardjúp to avoid undersized prawns was not as apparent here as in Ísafjarðardjúp and may have started later. The total number of prawns has been calculated for every season, see table 1. There are great fluctuations in the total number per winter. As expected the total number is highest when mean size is smallest or 95.2 millions in the winter 1964-1965. Even when the catch was greatest as last winter the total number was only 83.6 millions.

## Migrations

From catch per trawling hour per month one can detect seasonal variations. As there is no fishery during the summer one might expect the highest catch per trawling hour in October or when the fishery is started. This is in fact the case in Ísafjarðardjúp. The catch per trawling hour then decreases and reaches a minimum usually around the darkest time of the year to rise again to a lower maximum often in March. It is very likely that the light intensity plays an important part in this. There was one exception from this rule or last winter when the maximum in spring was far higher than that of autumn. Usually mean weight decreases from autumn to spring see Fig. 2. Here again there are exceptions. Whereas in the winter 1962-1963 the mesh increase may have caused the increase in mean weight over the winter, the increase of mean weight during the winter 1964-65 might have been caused by migrations of larger prawns into the area. In Arnarfjörður the situation is opposite to that of Ísafjarðardjúp and the maximal catch per trawling hour is sometime in the spring season (January to April). Only in one winter is the mean catch per trawling hour of spring lower than that of autumn or in the winter 1966-67, see Fig. 2. The increase was never as marked as in the spring of 1963 and 1968 respectively. On the other hand mean weight is higher in the autumn season except for last winter. It might be mentioned here that seasonal fluctuations are very marked in Hrótafjörður, where catch per trawling hour is nearly doubled in the spring. Mean size however decreases always from autumn to spring. It is of interest to note that the mean weight has increased by every winter since the beginning of the fishery in Autumn 1965 from 3.26 g to 4.28. Here the low mean weight may have been due to overcrowding. This may on the other hand point to that effects of fishing last more than one year. In Húnaflóaáll there was found in March 1966 prawnbank which had a completely different sizecomposition to that of Hrótafjörður. Whereas in Hrótafjörður mean size was small, on that bank catch contained almost no males. But the catch per trawling hour was only 55 kg/hour and only 1/5 of the catch per trawling hour in Hrótafjörður. Late in April the same spring one trip was made to the bank in Húnaflóaáll. The catches were then very small indeed.

It is not clear what part migrations play in the prawnfishery. Arnarfjörður is a thresholdfiord and may therefore have different hydrographic situation to that of Ísafjarðardjúp. The catch per trawling hour and mean weight in the spring of 1963 and 1968 do indeed indicate migrations of prawns into Arnarfjörður. At other times migrations are not so apparent. Last winter there were indications of a migration into Ísafjarðardjúp. If it is the case that migrations occur normally to and from prawnbanks it would be interesting to know at what stages in the life of prawns do migrations occur. It is known that vast numbers of larvae hatch in Arnarfjörður and Ísafjarðardjúp. Occasionally only undersized prawns are caught. At other times all sizes of prawns may be found in the catch from 0-5 years old. The maximum size is around 25-28. mm. There may still be undiscovered prawnbanks from which migrations to the prawnbanks in Ísafjarðardjúp and Arnarfjörður may occur. It is possible that no such banks exist and prawns may be more dispersed offshore than on known banks. The bank in Húnaflóaáall may be an example of this.

#### S u m m a r y

Great fluctuations in catch per trawling hour, (density) are seen both in Arnarfjörður and Ísafjarðardjúp. In Ísafjarðardjúp catch per trawling hour decreases from 145 kg/hour in autumn 1960 to 64 kg/hour in spring 1963. Mean weight decreased at the same time. In 2-3 winters the prawnstock seemed to recover following a very limited total catch and increase in mesh by 30%.

In Arnarfjörður catch per trawling hour fell from the winter 1962-1963 from 150 kg/hour to 89 kg/hour in the winter 1965-66. The increase in mesh did not seem to prevent this. It is possible that some fishermen did fish the small prawns as these were more plentiful at times, when there was no difference in price.

In the last few years there has been a realization of the need to protect the small prawns.

Decreasing number of predators may play a part in increasing catches.



The introduction of more effective trawls may have caused an apparent increase in catch per trawling hour last winter in both Arnarfjörður and Ísafjarðardjúp.

It is not clear what part migrations play. It is unlikely that there are continuous invasions of prawns on to the banks. Migrations may be irregular and occurring seasonally.

R e f e r e n c e s

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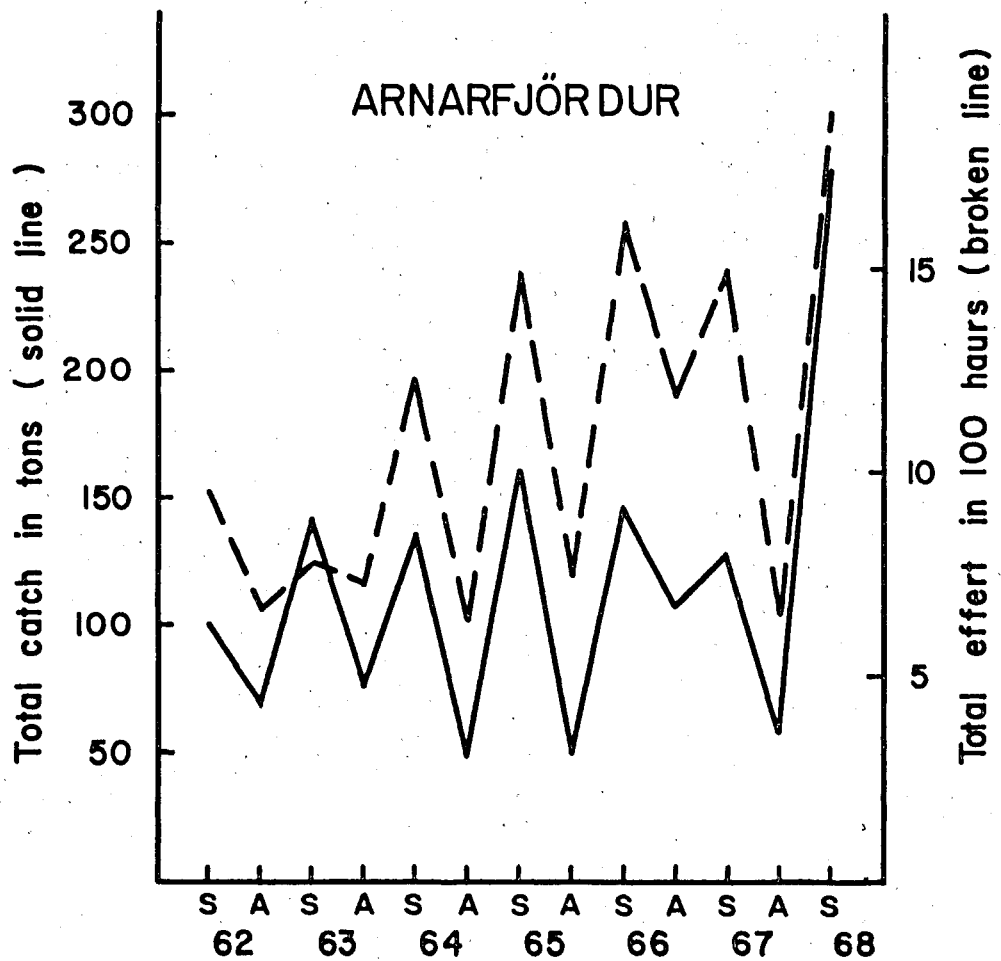
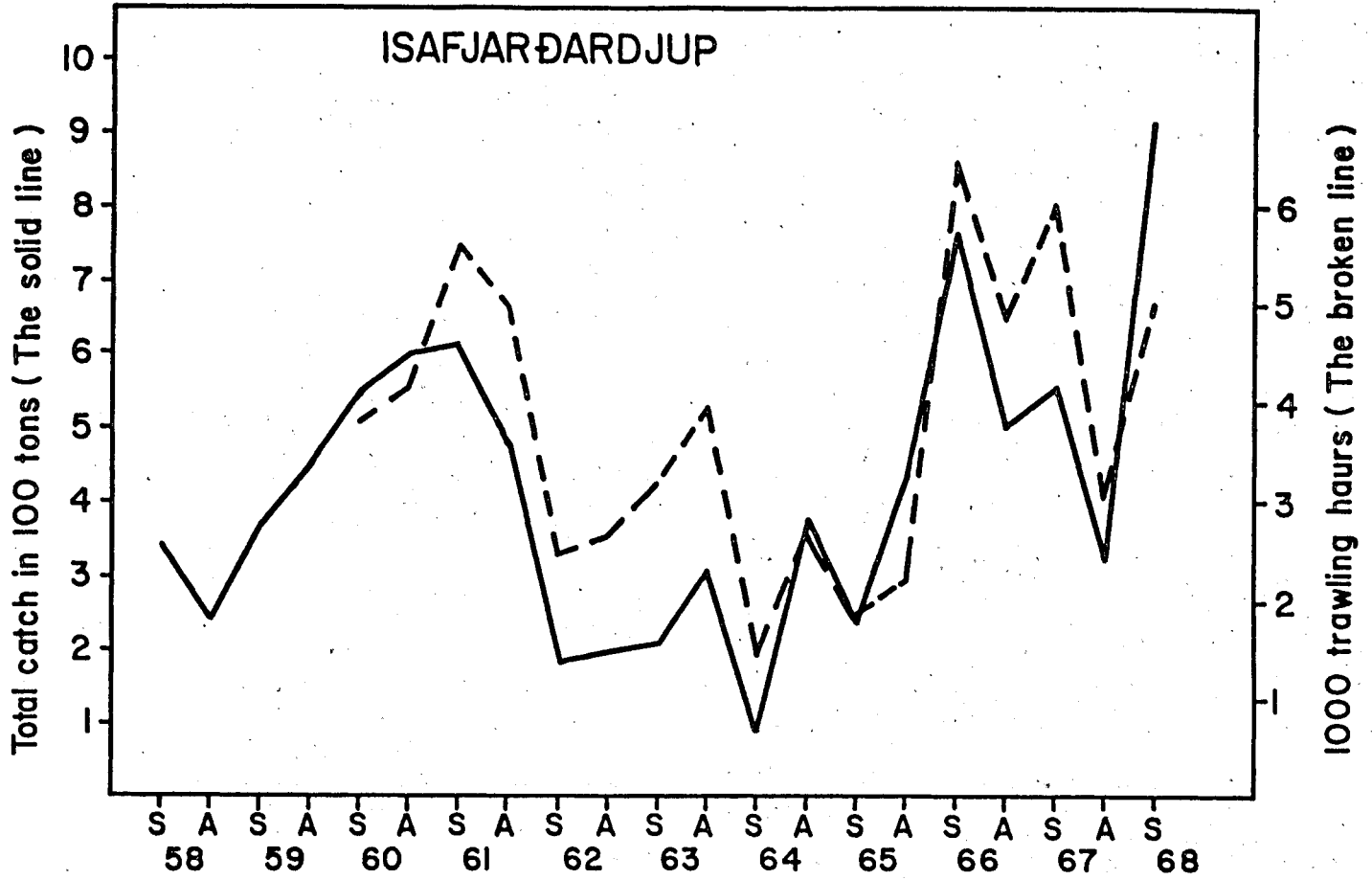


Fig. 1

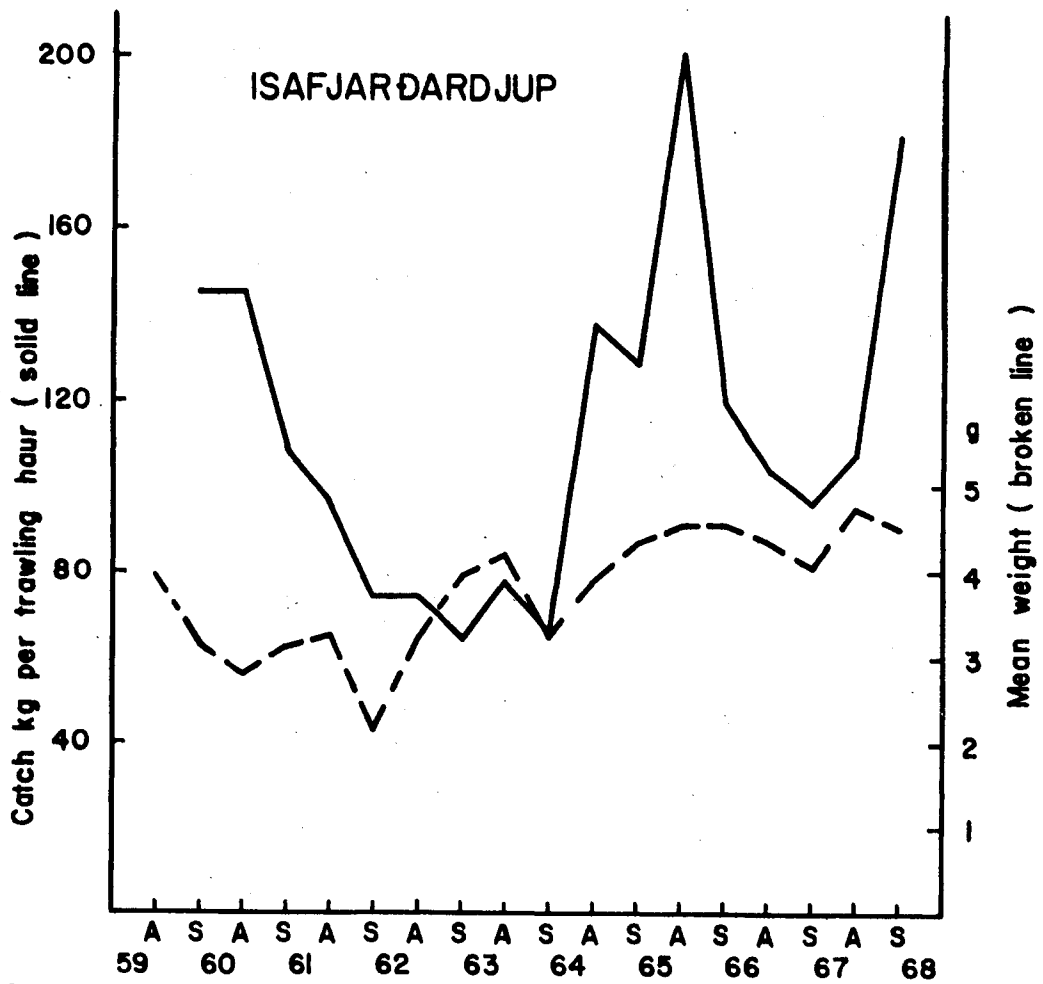
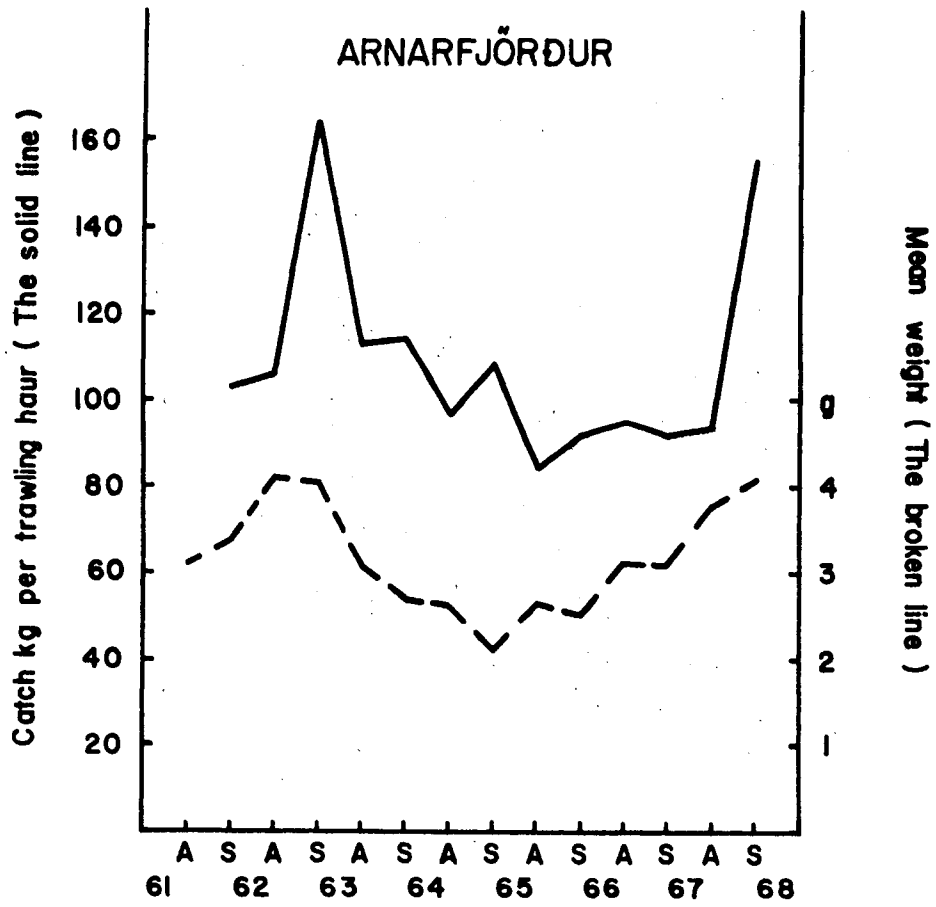


Fig. 2

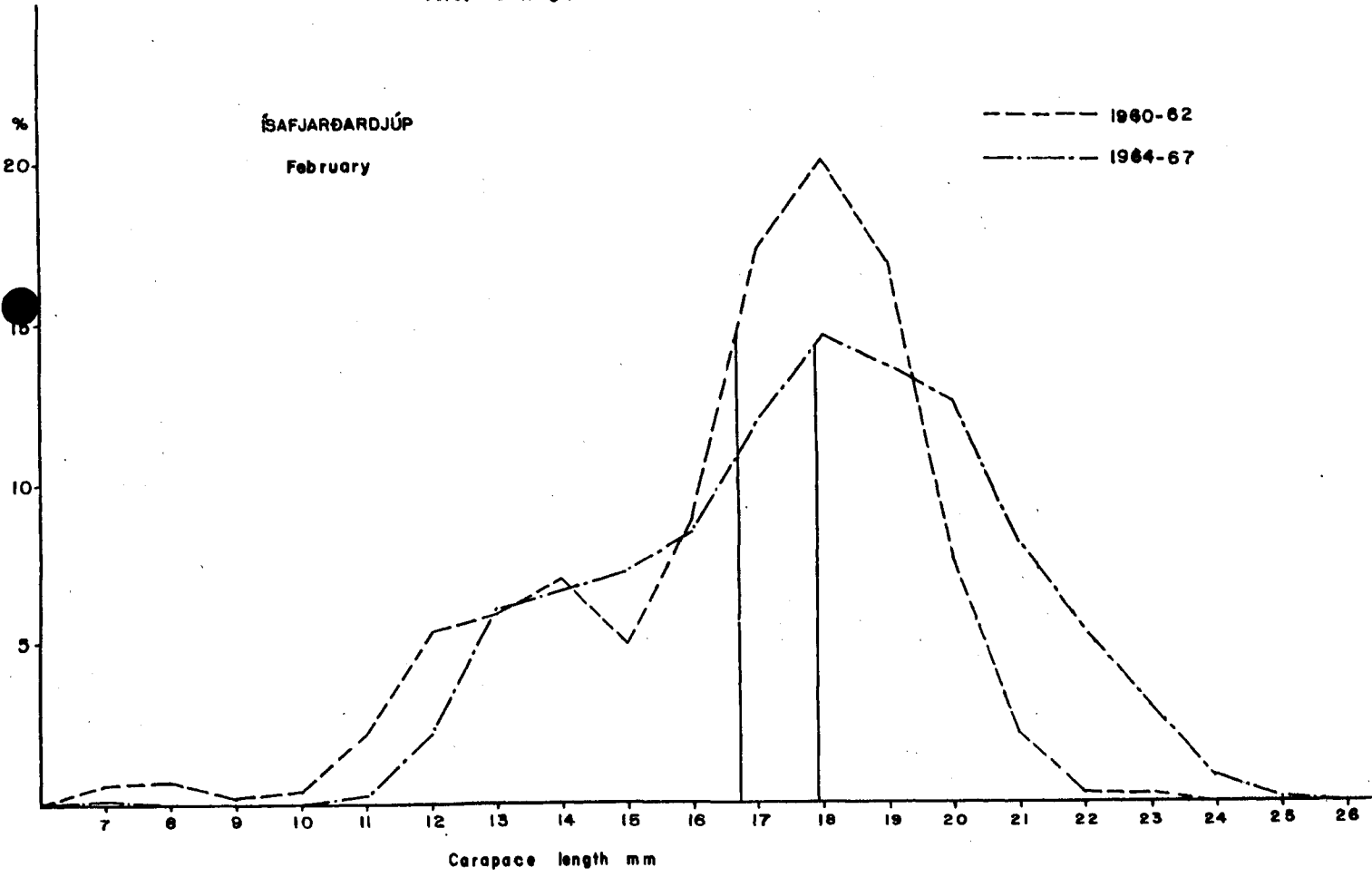
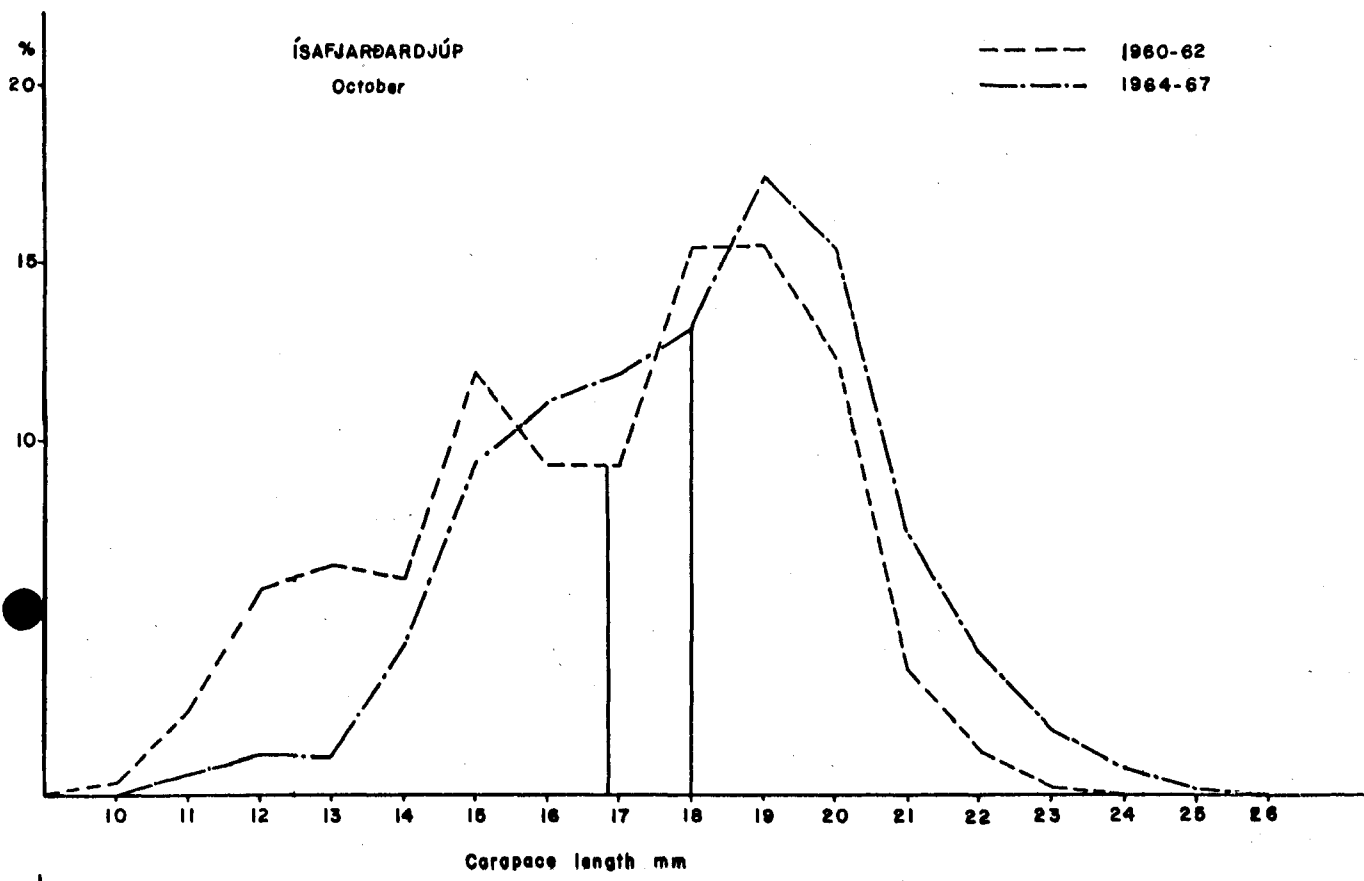


Fig. 3 The mean frequency distribution of prawn before and after change in mesh.

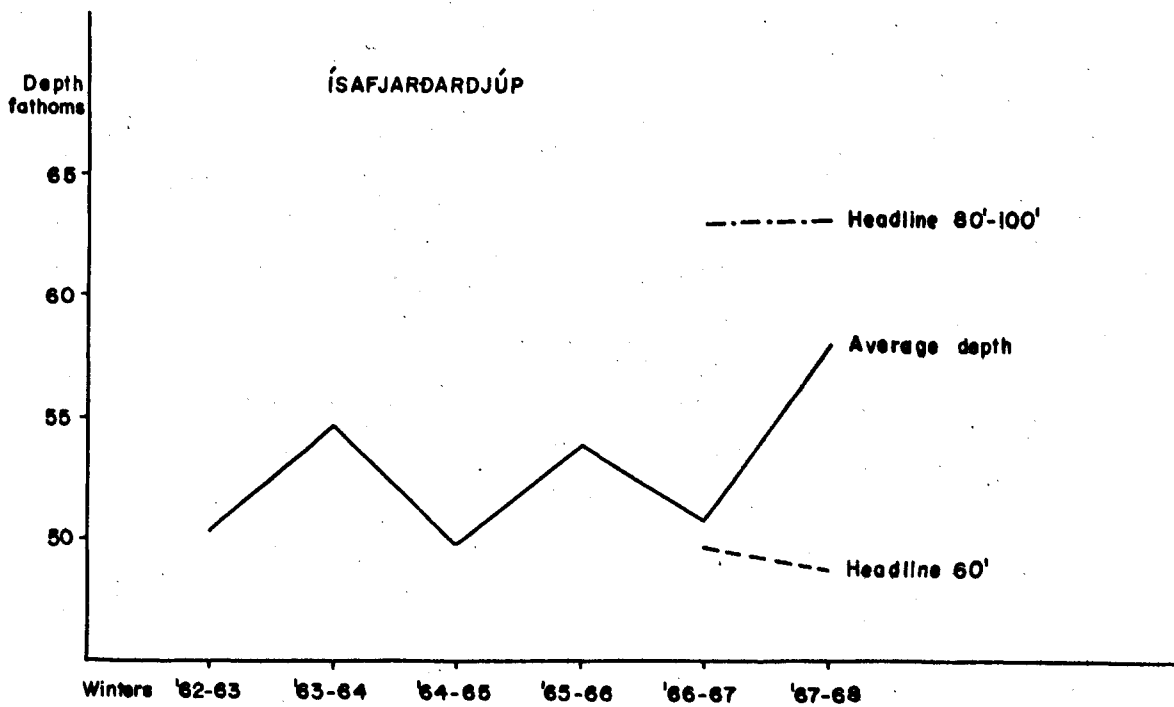
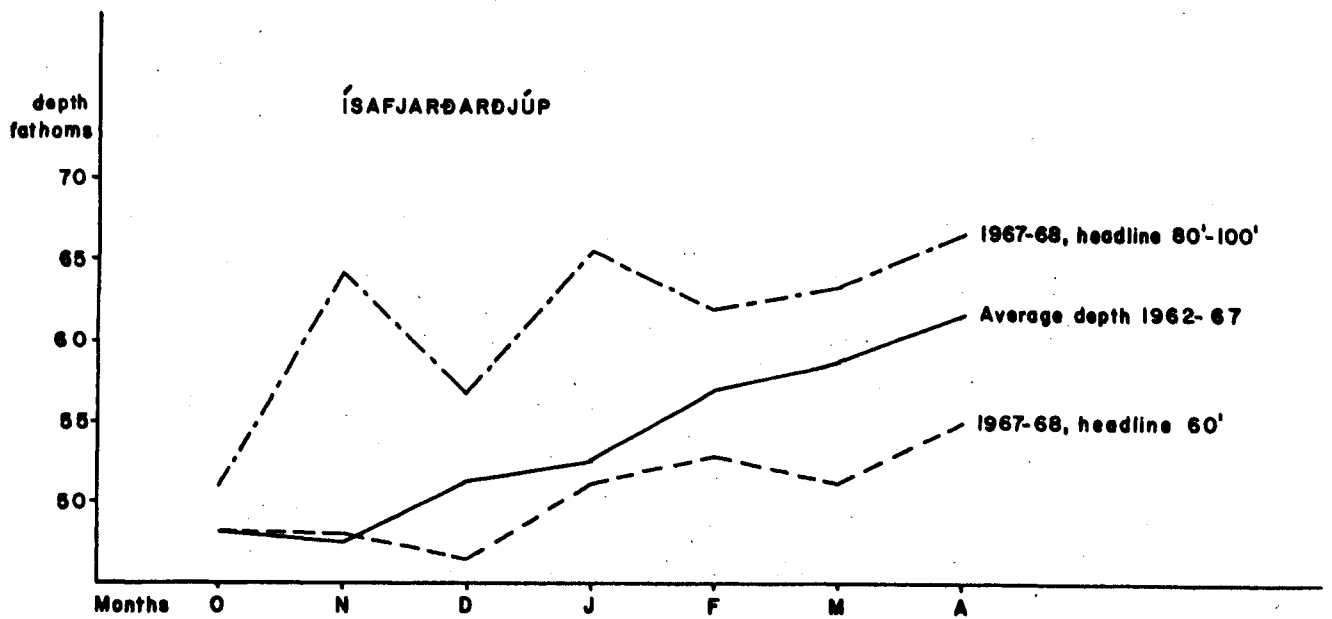


Fig. 4 Average depth by months at which trawling is carried out.