The use of square mesh codends in the Icelandic shrimp (*Pandalus borealis*) fishery

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ABSTRACT


Large quantities of 0-group fish and small undersized shrimp on many inshore shrimp fishing grounds in Iceland have frequently prevented shrimping for extended periods. Many experiments have been carried out to solve this problem, but none of them was successful. The paper describes experiments with square mesh netting in the codend which reduced the by-catch of 0-group fish drastically and the catch of undersized shrimp to a great extent. The reduction of some 10-20% in the shrimp catch was easily accepted by fishermen as it was mainly due to small shrimp that could not be utilized. All boats in the inshore shrimp fishery are now using square mesh netting in the codends in their trawls to reduce the manual work of sorting out the by-catch and to increase the value of their quota by landing larger and more expensive shrimp.

INTRODUCTION

The utilization of one marine stock can influence other stocks in many different ways. One of these problems is the shrimp fishery with small meshed trawls often resulting in the unintended catching of small fish of valuable species. Many attempts have been made to eliminate or at least to reduce this catching of small fish.

In the Icelandic shrimp fishery the first serious by-catch problems arose in 1967 when bigger trawls were taken into use. The shrimp trawls used earlier were small with extremely short bellies (Fig. 1). These small trawls were towed very slowly by small low-powered boats on inshore fishing grounds. The superior swimming speed of the small fish available on the shrimping grounds (mainly 0-group gadoids and II- and III-group herring and capelin) compared to that of the shrimp was sufficient to let them escape from the trawl mouth in most cases.
When new offshore shrimp grounds were discovered in Breidafjördur in west Iceland in 1967, bigger trawls were necessary to obtain reasonable catches. The enlarged trawls were very soon introduced in the inshore shrimp fishery. The bigger trawl designs (see Fig. 2) were observed to catch 2.3 times more shrimp than the small trawls, partly due to faster towing speed made possible by the elongation of the belly (Skúladóttir, 1970). Simultaneously the number of small fish increased considerably. In a comparative fishing experiment in March and April 1967 the smaller trawl design caught 22 fish per trawling hour compared with 314 fish per trawling hour in the bigger trawl (Skúladóttir, 1970).

Some minor attempts were made to reduce the by-catch problem, but they were largely ineffective. Among such efforts was the use of shorter bridles, longer chains between fishing line and footrope, and the hauling of the trawl with the engine disconnected with the propeller. Very soon the conventional
rope-footrope was replaced by bobbins which were originally considered to reduce the by-catch of young fish but actually resulted in shrimping on harder ground where small fish were often more plentiful.

In 1970–1971 and 1974–1975 experiments to reduce the small fish by-catch by using selective trawls were carried out (Thorsteinsson, 1973, 1975). In
spite of rather good results in reducing the by-catch rates, the selective trawls were not accepted by the fishermen due to the inevitable shrimp loss and the inconvenience associated with operating this complicated gear construction. The main problem was the clogging of the selective net panel mainly by flatfish and seaweed resulting in shrimp loss through the escape hole.

In 1970 the shrimp grounds were already closed due to a large concentration of small fish. It was, however, not until 1974 that management guidelines based on economical calculations were adopted. In these calculations the prices of shrimp and fish and natural mortality rates of the fish species were taken into consideration (Pálsson and Thorsteinsson, 1985). The guidelines indicate the number of small gadoids and other fish species allowed per 1000 kg of shrimp.

The codend mesh size was 25 mm prior to 1962 (Skúladóttir, 1970). In 1962 the mesh size was increased to 32 mm. The present minimum mesh size of 36 mm was introduced as a result of mesh size experiments in 1973 (Thorsteinsson, 1974). Often mesh sizes 2–4 mm in excess of the minimum are used. These mesh sizes do not prevent the catch of undersized shrimp especially when the catch rates are high. (The minimum size of shrimp that may be landed is usually 350 individuals kg⁻¹.) Therefore, experiments with extra net slack in the side panels as compared to the upper and lower net panels were conducted in 1980 and as this arrangement improved the selectivity, it has frequently been used on some of the shrimping grounds (Thorsteinsson, 1981).

In 1967 experiments on grading shrimp by machine showed high survival rates of the undersized shrimp in air temperatures above zero. Nevertheless, this method is not used to release small shrimp. Closures of shrimping grounds due to small shrimp have been practised at least since 1974. The main action to solve these problems is the closure of areas, a solution not very convenient for the shrimping industry. Owing to abundance of small fish and shrimp on the shrimping grounds in Ísafjarðardjúp on the NW coast of Iceland and the necessary closure of the shrimping grounds, it was thought to be worthwhile in autumn 1988 to try the square mesh codend as an alternative to solve the problems mentioned above.

MATERIALS AND METHODS

The square mesh codend was tested in comparison with a diamond mesh codend using two boats simultaneously in late October 1988 in Ísafjarðardjúp (Fig. 3). In early December 1988 comparable experiments were carried out on Húnaflói off the north coast using two other shrimp boats. In March 1990 a similar catch comparison was carried out in Ísafjarðardjúp. The boats in both experiments used identical trawl designs and trawl rig, apart from the different codend rig, with the only exception that the boats in Ísafjarðardjúp
did not use the same door size. The square mesh codends were 4 m long and 100 bar wide on each of the two panels. Three rows of diamond mesh net were used at the rear end to simplify its closure by a codline. The heaving bag was made of 120 mm diamond netting, wider than the codend itself. The construction of the trawls is shown in Fig. 2.

The comparative trawling was conducted in a conventional way. The boats were towing nearly side-by-side at the same towing speed at a similar depth. Eleven pairs of valid tows were made in the Ísafjarðardjúp experiment in 1988, nine in 1990 and 18 in Húnaflói in 1988. On all occasions the towing time was 1 h. The same boats used the square mesh codend throughout the experiments. All four boats have been used earlier in shrimp trawl surveys. It was therefore known prior to the experiments that the catching abilities of both boats within both pairs were identical, and therefore it was considered unnecessary to change gear between the boats.

Although both the boats in Ísafjarðardjúp started with the same meshsize in 1988, some difference was found after the experiments were over. The average meshsize in the diamond mesh codend measured 36.8 mm as compared to 39.9 mm in the square mesh codend. In Húnaflói the mesh size of the square mesh was 35.8 mm and 36.3 mm for the diamond mesh codend. In the experiments in Ísafjarðardjúp in 1990 the mesh size of the square mesh was 37.4 mm, but 37.9 mm for the diamond mesh codend. In all cases the mesh size was measured with the ICES mesh gauge with a pressure of 4 kgf.

RESULTS

The results of the 1988 experiments are summarized in Table 1. The 10–20% loss to the shrimp catch is not serious when one considers that the maximum count for landed shrimp is 350 kg⁻¹. As can be seen in Table 1, the

<table>
<thead>
<tr>
<th>TABLE 1</th>
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<tbody>
<tr>
<td>Average catch of shrimp and small fish in square and diamond mesh codend in experiments in Ísafjarðardjúp and Húnaflói in autumn 1988</td>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Shrimp (kg h⁻¹)</td>
</tr>
<tr>
<td>Shrimp count (kg)</td>
</tr>
<tr>
<td>Cod 0-gr. (number h⁻¹)</td>
</tr>
<tr>
<td>Haddock 0-gr. (number h⁻¹)</td>
</tr>
<tr>
<td>Whiting 0-gr. (number h⁻¹)</td>
</tr>
<tr>
<td>Herring I-gr. (number h⁻¹)</td>
</tr>
<tr>
<td>Herring II-gr. (number h⁻¹)</td>
</tr>
<tr>
<td>Capelin (number h⁻¹)</td>
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</table>
shrimp in the diamond mesh codend are on average smaller than those in both localities. Moreover, as the shrimp price increases gradually with size and the fishery is regulated by a daily and weekly quota, which can usually be fished with moderate effort, the catch loss due to escapement of small shrimp has more positive than negative aspects. It is of further importance that repeated landings of undersize shrimp can result in penalties such as a fishing ban lasting for some days. From Figs. 4 and 5 it is obvious that the catch loss mainly affects small shrimp below 14 mm carapace length of no or little commercial value. The loss of 15–17 mm shrimp is noticeably larger in Húnaflói than in Ísafjardardjúp. No explanation can be found for this difference.

In the 11 pairs of tows in Ísafjardardjúp, the shrimp were smaller than 350

![Graph 4](image4.png)

**Fig. 4.** Length distribution of shrimp by number in square and diamond mesh codends in Ísafjardardjúp.

![Graph 5](image5.png)

**Fig. 5.** Length distribution of shrimp by number in square and diamond mesh codends in Húnaflói.
kg\(^{-1}\) (mean weight 2.86 g) in three tows in the square mesh codend, but in the diamond mesh codend this occurred in six tows. Comparable numbers for the 18 pairs of tows in Húnaflói were eight times for the square mesh codend but no less than 16 times for the diamond mesh codend.

Herring is the only fish species represented in significant numbers by more than one year class. As demonstrated in Figs. 6 and 7, the square mesh as compared with the diamond mesh is much superior in releasing small fish. It is worth noting that the 7–11 cm long herring (0-I group) are almost all released by the square mesh netting. This is certainly an important protection for the herring stock and also a welcome help for the shrimp fishermen in sorting the catch.

The size distribution of the gadoids is small as practically all present were 0-group. The size-dependent selectivity is, therefore, not very obvious, especially in the case of cod. For haddock, which are longer and fatter than cod at this age, the size-dependent selectivity can clearly be seen (Fig. 8). Whiting

![Fig. 6. Length distribution of herring by numbers in square and diamond mesh codends in Ísafjarðardjúp.](image)

![Fig. 7. Length distribution of herring by number in square and diamond mesh codends in Húnaflói.](image)
escape better than haddock through the square mesh netting, but the influence of the size-dependent selectivity first becomes apparent at 16 cm length (Fig. 9). The greater escapement through the square mesh netting in the case of capelin seems to be independent of size (Fig. 10).

In the light of these results the use of square mesh codends according to the specification given above was made obligatory in the shrimp fishery in Ísafjardardjúp and Húnaflói shortly after the experiments. Fishermen in Arnarfjörður on the north-west coast and Skagafjörður on the north coast have voluntarily taken up the use of square mesh netting in the codends in order to increase the value of their catches which are limited by quotas.

In March 1990, towards the end of the winter season, the comparative mesh experiments were repeated in Ísafjardardjúp under different fishing conditions. As can be seen in Table 2, only a few small gadoids were present in the
Fig. 10. Length distribution of capelin by number in two pairs of tows in square and diamond mesh codends in Ísafjarðardjúp.

TABLE 2

Average catch of shrimp and small fish in square and diamond mesh codend in experiments in Ísafjarðardjúp in March 1990

<table>
<thead>
<tr>
<th></th>
<th>Square mesh</th>
<th>Diamond mesh</th>
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<tbody>
<tr>
<td>Shrimp (kg h(^{-1}))</td>
<td>341</td>
<td>430</td>
</tr>
<tr>
<td>Shrimp (count kg(^{-1}))</td>
<td>368</td>
<td>427</td>
</tr>
<tr>
<td>I-group cod</td>
<td>2.4</td>
<td>8.6</td>
</tr>
<tr>
<td>I-group haddock</td>
<td>9.2</td>
<td>6.8</td>
</tr>
<tr>
<td>I-group whiting</td>
<td>34</td>
<td>37</td>
</tr>
<tr>
<td>II-group herring</td>
<td>234</td>
<td>2244</td>
</tr>
<tr>
<td>III-group herring</td>
<td>502</td>
<td>298</td>
</tr>
</tbody>
</table>

catch. The 1-year-old cod is smaller than haddock and whiting of the same age and therefore relatively more cod escapes through the square mesh codend. The haddock and whiting have already grown beyond the selectivity range of the square mesh codend which does not release them any more. On the other hand, it is obvious that the 0-I group herring (6–11 cm long) escapes in large numbers through the square mesh codend. The II-group herring, 12–17 cm in length, is, however, too large to get any protection from the square mesh netting. In fact, the total number of II-group herring is higher in the square mesh codend due to one haul with big quantities of this age group. The remaining pairs of hauls brought similar numbers of II-group herring in both codends. The average length of the I-group herring was definitely higher in the square mesh codend, 8.95 cm as compared to 8.15 cm in the diamond mesh codend. Nevertheless, the mesh size of the diamond mesh codend was higher, 37.9 mm as compared with 37.4 mm in the square mesh codend.
Practical experience

The only practical problem in using square mesh netting in the shrimp fishery is some knot slippage when twisted PE 380 den × 48 is used in the codend. Almost no slippage is reported in the case of the more common braided 1.8 mm dia PE netting.

The shrimp fishermen are generally very satisfied with the experience of the square mesh codends. The easier sorting of the catch is certainly important, but the increased value of the quota is, perhaps, more important. For these reasons it has now been decided that square mesh netting should be used in all codends in the inshore fishery.

CONCLUSION

The increased release rate of young stages of commercially important species caused by improved gear technology is certainly something to be desired. It is, however, most difficult to calculate the actual gain in landings in the course of time. This has nevertheless been done, (Pálsson, 1976). For the shrimp season 1974–75 in Ísafjarðardjúp, it was calculated that the shrimp fishery in that season had killed small gadoids which would have yielded a catch of 1600 tons some years later. As the shrimp catch in Ísafjarðardjúp yields some 40% of the total inshore shrimp catch, the figure of 1600 tons gives a good indication of the size of the problem. When evaluating the benefit of the increased release of small fish by the square mesh netting, it must be borne in mind that some of the fish might not survive the procedure. Actually, very little is known about this for small fish. Underwater observations have shown herring scales flow out of the codend but no other damage to small escaping fish or shrimp has been observed on Icelandic shrimping grounds. It is therefore believed that the use of square mesh netting in the codends of shrimp trawls is not only a convenient tool to grade small fish out of the shrimp catch, but also a valuable technique for the conservation of small fish of important species.

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