Reduction of fish by-catch in shrimp trawl using a rigid separator grid in the aft belly

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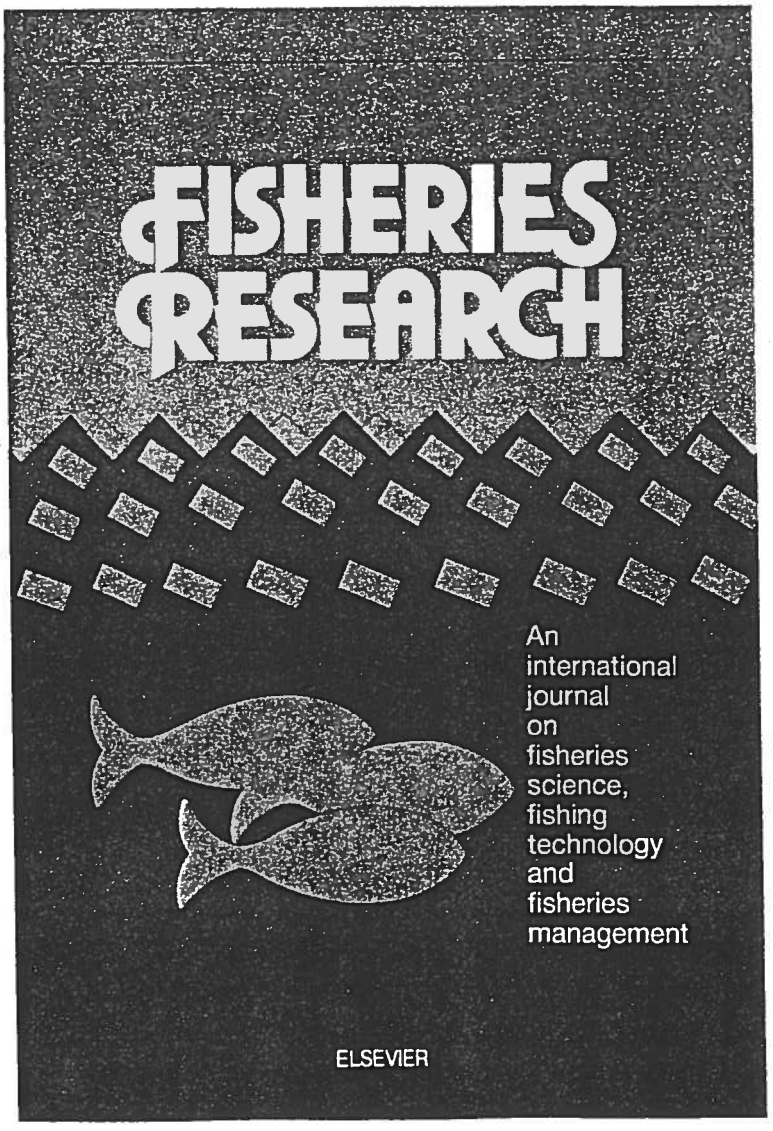

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INTRODUCTION

The by-catch of fish in shrimp trawls has for years been considered undesirable, both in the Barents Sea and along the Norwegian coast. While Norway has regarded the by-catch of small and undersized cod and haddock as the most serious problem, the USSR has long claimed that the large by-catch of small redfish (*Sebastes marinus, Sebastes mentella*) in the offshore fishery is very serious for this species. In addition, on the fishing grounds west and north of Spitsbergen, large quantities of small Greenland halibut are caught during the shrimp fishery, which, of course, is unwise harvesting of an already heavily exploited fish resource.

Since 1984–85, a separator panel of netting (Karlsen, 1976) has been used in the coastal shrimp fishery when the by-catch has exceeded three cod and/or haddock below the minimum landing size per 10 kg of shrimp. This device has helped the fishermen to continue fishing on shrimp grounds that otherwise would have been closed to shrimp trawling. In the offshore shrimp fishery in the Barents Sea, a procedure has recently been introduced to close and open the shrimp grounds based on the number of undersized fish relative to the shrimp catch. Such control has been done by official inspectors who examine the catches on board chartered fishing vessels.

In 1988, the Soviet–Norwegian Fishery Commission approved experiments to solve the problem of the redfish by-catch in shrimp trawls. From the Norwegian side, a grant was allocated in 1989, and a steering group, with participants from research institutions, the fishery administration and fishermens' organisations, was appointed to follow up this project.

During the development of separator panels in shrimp trawls (Karlsen, 1976; Isaksen, 1984), it was found that redfish were rather difficult to separate by means of net panels. Small redfish (8–14 cm) would easily pass through the separator panel, while bigger ones tended to become enmeshed. On some occasions the net burst under the load of meshed redfish. In early 1989, experiments were performed using a rigid separator grid in the aft belly of shrimp trawls. This separator grid, originally developed to avoid jelly fish and now known as the 'Nordmøre'-grid, was able to separate redfish without any meshing problems (L. Karlsen, personal communication, 1989). During 1989–90, much work has been performed to test this device, both in respect of its selectivity and the handling properties.

In addition to the officially controlled experiments, many shrimp fishermen have experience of using the separator grid when fishing on grounds that otherwise would have been closed due to the high by-catch of cod and haddock. Because of the positive advantages, many coastal shrimp trawlers have continued to use the grid on grounds open for normal shrimp trawling. The motivation has been less sorting work on deck and an improved quality of shrimp.

tion curves are drawn by using three-point moving averages (Pope et al., 1975).

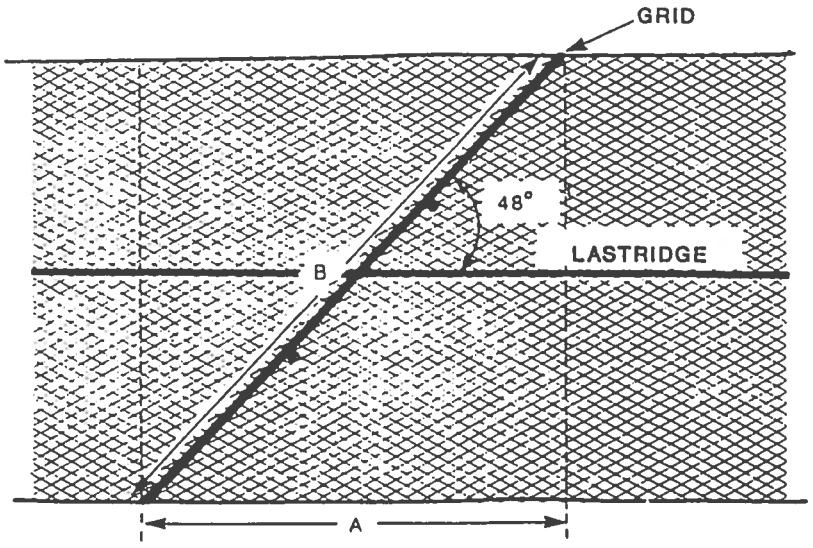
RESULTS

Installation

Evaluation of the results from different experiments has led to both compulsory and recommended specifications for installation of the separator grid. Coastal shrimp trawlers (40–60 feet) are recommended to use an aluminium grid, 0.7–0.8 m wide and 1.35 m long, while bigger boats should use a grid 1.0–1.3 m wide and 1.5 m long (Fig. 2), both with bars spaced by the compulsory 19 mm. With the recommended mounting angle of 48° (Fig. 3), the lower side of a 1.5 m-long grid is mounted along a transverse row of knots in the bottom panel, exactly 1 m ahead of the upper panel knotrow attached to the top of the grid. The mounting should be accurate, with the middle of the top and bottom of the grid mounted at the middle of the top/bottom panel. Two meshes (42 mm) should be taken into each bar space, both on top and bottom, and secured firmly. The excess meshes should be distributed evenly along the sides of the grid and tied quite loosely.

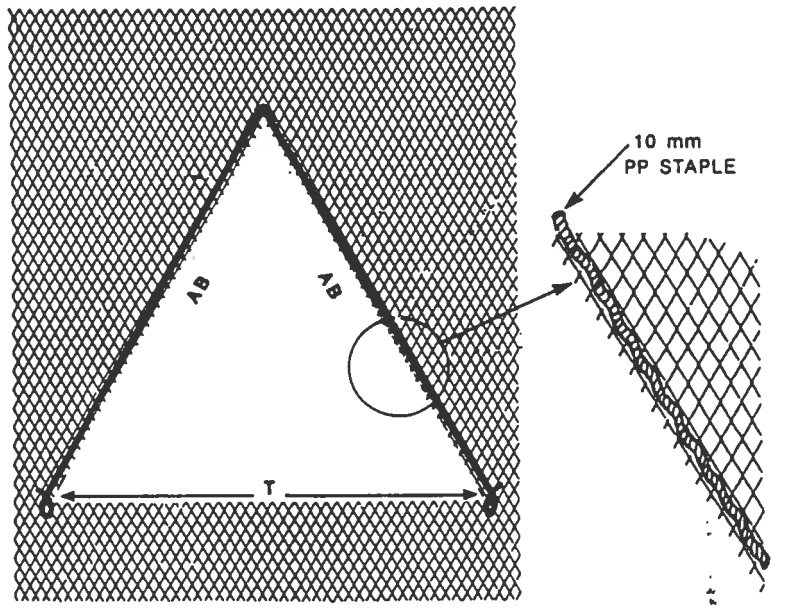
The fish outlet is cut forward on bars from the top corners of the grid, and reinforced by a 10–12 mm rope (Fig. 4). Today, funnels are mostly used as a guiding device in front of the grid, with a front circumference similar to that of the extension piece; i.e. 220–250 meshes for coastal shrimpers, and 330–400 meshes for offshore shrimpers. The recommended material for funnels is polyethylene, and one funnel design is shown in Figs. 5 and 6. The funnel is cut on bars to give an outlet circumference of 80–100 meshes. The distance between the grid and the funnel outlet is 0.5 m, and about half of the outlet meshes should be attached mesh by mesh to the bottom panel. To reduce the size of the funnel outlet, various methods are recommended. One is to use a thin, long twine between the top centre of the funnel and the bottom panel. Such a twine will break when large objects pass through the funnel. Another is to use an elastic rubber band through the last mesh row in the funnel outlet, which also prevents the funnel from opening too much. With big fish, and especially sharks, the rubber band will give way during passage of the fish, and go back to the normal position afterwards. A lead rope through the aft and top meshes of the funnel outlet will give the same effect. The funnel should be mounted with a 5% lengthwise slack relative to the extension piece.

To compensate the weight, or to make the grid a little buoyant, floats are mounted evenly on the upper half of the grid. The float on the topside of the grid should be mounted behind the grid and inside the extension piece. Wear and tear on the webbing surrounding the grid is avoided by lashing a 10–12 mm rope around the frame of the grid after installation (Fig. 7). From time



A = INSTALLATION LENGTH IN EXTENSION PIECE
B = TOTAL LENGTH OF GRID
A/B = 0.67 = 48°

Fig. 3. Sideview of separator grid mounted in extension piece.



T = NUMBER OF TRANVERSE MESHES MOUNTED ON GRID
COASTAL TRAWL: T = 40
OFFSHORE TRAWL: T = 80

Fig. 4. Illustration of fish outlet.

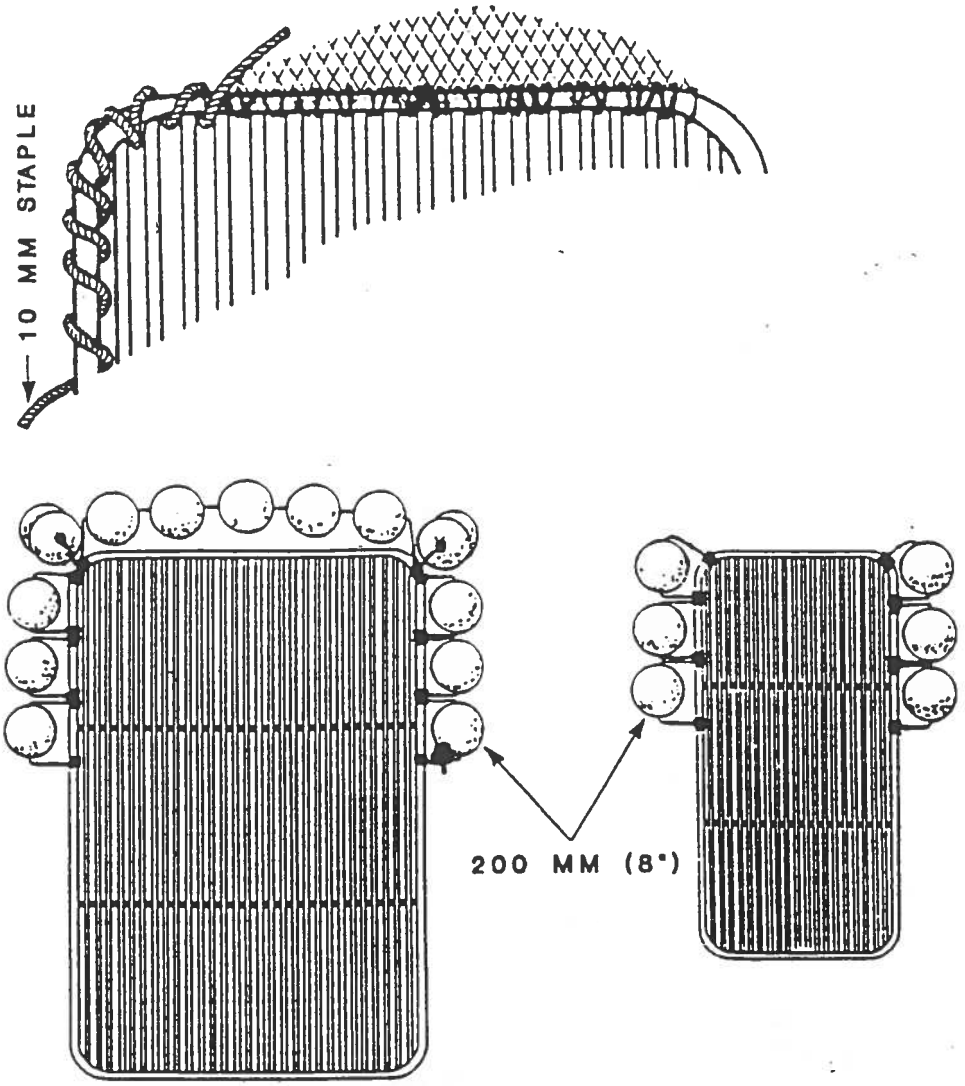


Fig. 7. Illustration of protective rope and floats mounted on the separator grid.

avoided after shooting the separator system, as turns may cause twists in the belly. Another matter of importance is to check that the guiding funnel/preventer twine is undamaged. Aluminium is exclusively used as grid material today. Stainless steel has also been tested, and is no doubt a better material regarding strength and smoothness, but it has the disadvantage of being almost three times as heavy and much more expensive than aluminium. Pipes of stainless steel can be an alternative in this respect.

Speed and angle measurements

During some of the official experiments, a combined speed and angle sensor (Scanmar), mounted on a bracket attached aft of the grid, determined the horizontal speed of water through the bars to be roughly 0.7 of the trawl speed as measured by a headline-mounted sensor. There was no noticeable differ-

marsen, et al., 1990). When shrimps hit the netting in the front part of the trawl, they will normally react with a few tailbeats in random directions. The conical shape of the netting will concentrate the shrimps as they fall back toward the codend and meet the shrimps that fall back in the centre of the trawl. This effect was demonstrated by a much higher density of shrimps close to the netting in the aft part of the belly compared to that further forward.

The funnel guided all shrimps towards the lower part of the grid, and most of them passed through it, in a straight line. In exceptional cases, some shrimps reacted when hitting the grid, and a few of these jumped out of the fish outlet by chance. Some shrimps were guided some distance upwards along the bars before they were carried through the grid. Fish that came back through the trawl normally stayed for some time in front of the guiding funnel before passing through, usually tail first. Evidently, the smaller fish were exhausted and hit the grid after passing through the funnel outlet. Some of the small fish passed through the grid, while others were guided upwards by the bars and out of the trawl. Bigger fish had no problems in swimming in front of the grid, and after some time they would escape through the fish outlet. Flatfish, like long rough dab (*Hippoglossoides platessoides*), were observed to stay on the grid for some time before making a few tailbeats and then sliding up along the grid and out of the trawl. A few skate (*Raja* sp.) were caught, but this species made few attempts to escape.

FISHING EXPERIMENTS

Shrimp

During the experiments, the separator grid has given a low and fairly constant shrimp loss, around 2–5%. With a bar separation distance of 19 mm, there was no evident size-dependent loss of shrimp up to 11 cm commercial length (eye-tail) (Karlsen and Valdemarsen, 1989). However, results from East Greenland in 1991, with very big shrimps, indicated a loss that may be dependent on the shrimp size. Catch rates up to 1 ton h^{-1} have been experienced, and such high catch rates do not indicate increased shrimp loss (Isaksen and Larsen, 1991).

Cod and haddock

The separator grid allowed good escape for small cod and haddock. As can be seen from Figs. 9 and 10, all haddock bigger than 20 cm were released from the trawl, and about the same result was obtained for cod. At a length of 12 cm, about 50% of the haddock were released. Presently, the separating effect on 0-group fish is not as good as we would like.

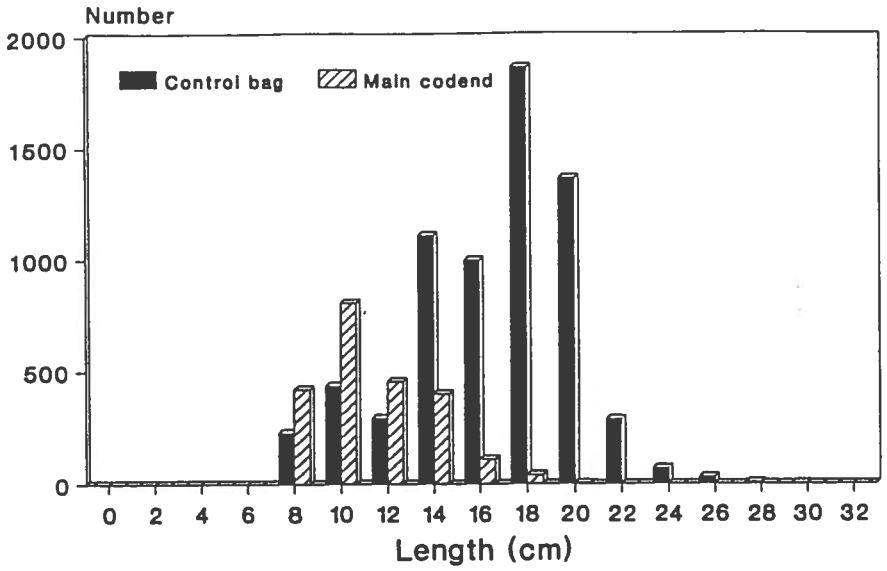


Fig. 11. Length distribution of redfish in the main codend and the control bag.

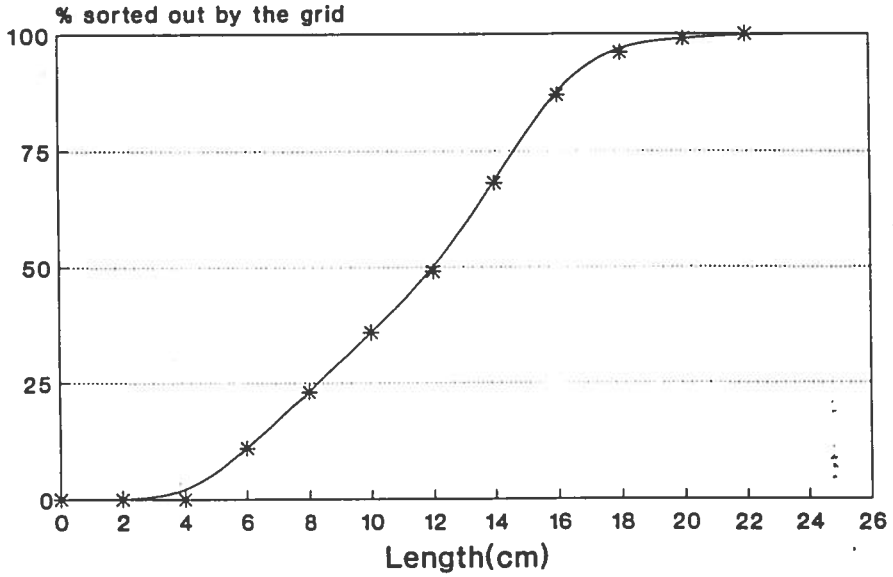


Fig. 12. Selection curve for redfish by using the fish–shrimp separator grid.

Flatfish

The only commercial flatfish caught by shrimp trawl in northern waters is Greenland halibut. For this species the effect of the separator grid was also convincing (Fig. 13). At a length of about 15 cm, 50% escaped from the trawl. The 100% release length, however, was rather high, about 30–32 cm (Fig. 14). Unlike other flatfish in the northern areas, the Greenland halibut was swimming 'on the edge', and was much more likely to be caught between the bars, especially the larger ones which might manage to swim in an 'upright' position in front of the grid. This may be the reason for the sudden change in

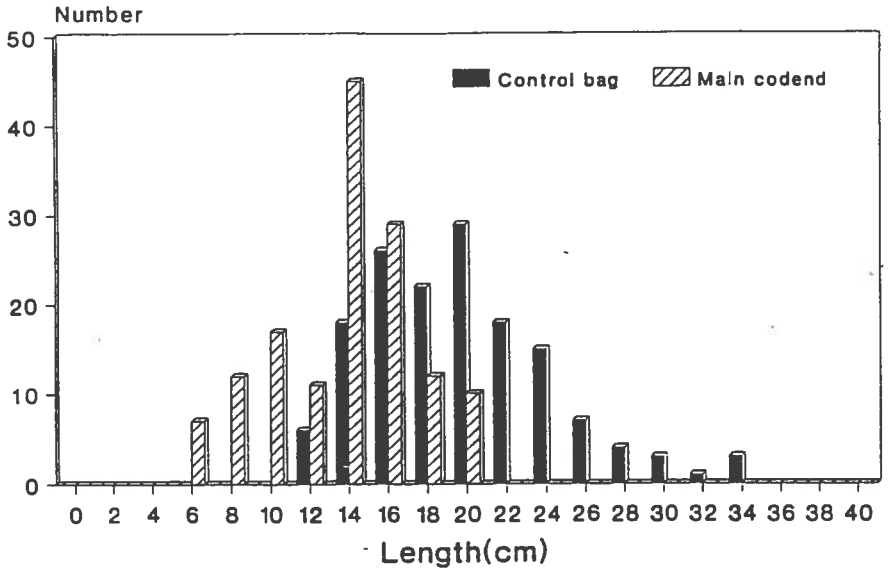


Fig. 15. Length distribution of long rough dab in the main codend and control bag.

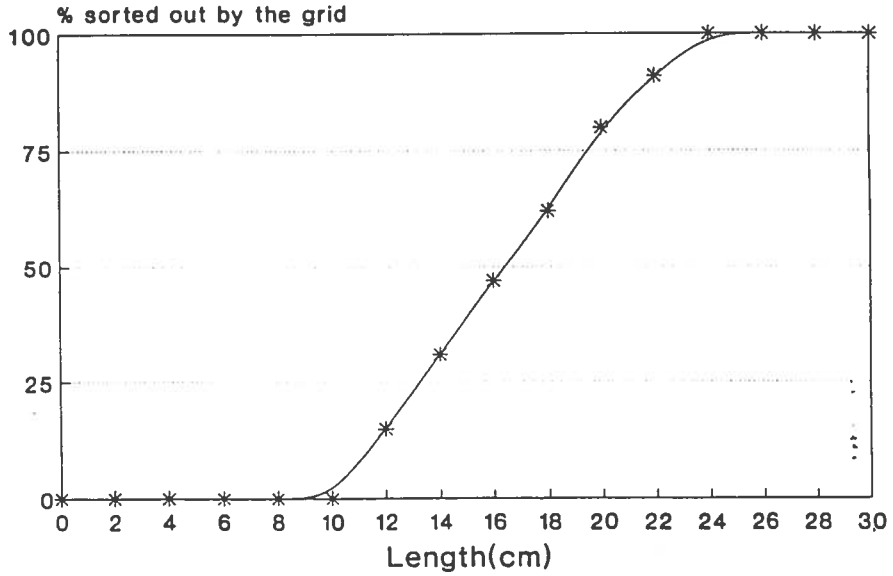


Fig. 16. Selection curve for long rough dab by using the fish–shrimp separator grid.

the crew much work in sorting the catch. As illustrated in Figs. 17 and 18, a separator grid would pre-sort polar cod, removing 50% or more of the polar cod from lengths of about 14 cm.

Shark, stone, sponge, clay

During shrimp trawling at Spitsbergen, Greenland shark (*Somniosus microcephalus*) is frequently caught. Normally the shark land in the codend, resulting in many crushed shrimp. Experiments at Spitsbergen indicated that with a separator grid of size at least 1.0×1.5 m, Greenland shark (up to 4 m)

in the aft belly and angled at 45° (Karlsen, 1976), side-sorting panels (Isaksen, 1984), and radial escape sections (RES) installed as sorting devices in shrimp trawls (Valdemarsen, 1986). In spite of moderately good results, none of these devices has been as good as the separator grid, in terms of separating fish, avoiding shrimp loss and easy handling.

However, to get the best results, the grid must be correctly installed, and the working angle of the grid must be around 45°. If the angle is less than 35°, the shrimps will slide up the bars instead of passing through, and the shrimp loss will be noticeable. At too steep an angle, that is 50° or more, the shrimp loss in the beginning of the haul will be very low, but flatfish and skate will very soon clog the sorting area so that the shrimp loss will increase.

Regarding the sorting area, the shrimp fishermen should use a size of grid appropriate to their boats. The size of the triangular fish outlet is determined by the width (not the length) of the grid and the number of meshes attached to the top side. In areas like Spitsbergen, where Greenland shark are caught frequently, the width of the grid should be 1.2–1.3 m to ensure that the shark can escape. Tests with big rectangular fish outlets have indicated better fish release, but have also given higher shrimp loss.

Aluminium is exclusively used as the grid material today. Stainless steel has also been tested, and is no doubt a better material regarding strength and smoothness, but it has the drawback of being almost three times as heavy and much more expensive than aluminium. Stainless steel may be preferable for stern trawlers with few crew, as this material will last longer and will not corrode.

The chosen bar separation of 19 mm is a compromise between good separation of fish and low shrimp loss which should not exceed 5% to be acceptable. The 19 mm bar separation works well in Norwegian waters where there are few shrimps bigger than 10 cm eye–tail length, but this bar separation may be too small in areas with bigger shrimps. In addition to the importance of having the correct grid angle, it is essential that the guiding device in front of the grid is working properly. Tests without any guiding funnel or flapper have given very good fish separation, but also a very high shrimp loss (40%). Funnels rather than flappers are mostly used today because it is easier to adjust the lengthwise slack relative to the extension piece. If the funnel or flapper is mounted too tight, this will pull on the lower panel and reduce the working angle of the grid. Distances of 50 and 100 cm between the bottom side of the grid and the funnel give much the same results. A distance of 50 cm is recommended, as the funnel outlet is easier to check, looking down the fish outlet.

The results and selection curves presented in this paper are solely based on experiments where the grid system is installed and used as recommended. Any alteration from the recommendations would most probably improve fish escape and worsen shrimp loss or vice versa, at least when fishing in the same area. The shape of the selection curves obtained from these experiments is

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