Behavior analysis of undersize fish escaping through square meshes and separating grids in a simulated trawling experiment

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Abstract:

Understanding fish escaping behavior through any given bycatch reduction device represents the cornerstone for its application as a technical conservation measure. To evaluate the square meshes and sorting grids as successful size-selective bycatch reduction devices in finfish trawl nets, we carried out a simulated trawling experiment to assess the effects of illumination, towing speed, and mesh or grid orientation on undersize fish escaping behavior through the square meshes and rigid grids. Juveniles masou salmon of an average body length of 130 mm were used as the experimental fish. A speed-controllable motor was used to tow the framed net in a circular water tank. Infrared CCD Camera fixed to the towed net, through a rotary connector, was used to observe fish behavior. Results demonstrated that, in contrast to the active escaping under light conditions, there was no active voluntary escaping under dark conditions. As a result, no fish could escape through the parallel and the sloping backward meshes and only 13 % passively escaped through the sloping forward meshes by increasing the towing speed. On the other hand, the probability of encounter and passive fish escaping through the longer openings between the sloping backward grids increased under dark conditions resulting in the highest escaping ratio that more increased from 67 % to 87 % by increasing the towing speed from 1 to 1.5 knot, and also shortened the swimming time before escaping from 5 to 1.5 minutes (the highest escaping ratio and the shortest swimming time before escaping under dark). Frame by frame analysis of some escaping events demonstrated an easy and passive fish escape through the grids without changing the normal swimming direction. Results support the use of the sloping backward grids (at the top panels as in the “Sort-V” grid system or at the bottom panels as in the form of “Evaflex” grid system

of a convenient grid material, area and slot size) as a size-selective bycatch reduction device well ahead of the codend of finfish trawl, especially demersal, working under dark at high towing speeds.

Keywords: escape behavior, square meshes, separating grids, dark conditions, simulated trawling, juveniles masou salmon

Introduction

Recent update of the global bycatch discards in marine fisheries prepared by Kelleher (2005) showed that the average yearly global discards estimated by Alverson et al. (1994) has been reduced from 27 million tons (32 %) to 7.3 million tons (8%) of the global recorded catch (based on recorded data during the period from 1994 to 2003). The increased utilization of bycatch and the use of more selective fishing gears are of the main reasons behind this reduction of the estimated global bycatch discards. Based on this update, the total trawl fisheries account for 82 % of the average global bycatch discards (27 % and 55 % due to shrimp and non-shrimp trawl fisheries, respectively). Demersal finfish trawls account for 36 % of the estimated global discards or 44 % of total trawl fisheries discards.

A worldwide attention has been given to the use of bycatch reduction devices “BRDs” as technical conservation measures for the sustainable development of marine fisheries, and the Square mesh panel and the sorting grid systems have been widely studied and legislated in some countries and are going to be evaluated and legislated in many other countries to be used as BRDs in the majority of shrimp and many finfish trawl fisheries (see ICES, 2005b). The fact that the rigid grids are actually size-selective rather than species-selective has been used by Larsen and Isaksen (1993) to design the “Sort-X” grid system to be used as a size-selective BRD in finfish bottom trawls. Due to the convincing effects of rigid grids as size-selective BRDs in finfish trawling, their use was mandatory in the Barents Sea (Gabriel et al., 2005).

Nowadays, one of the most important issues in fisheries management is the unaccounted mortality due to fish escaping fishing gears and non-considered or unreported discards, which in turn leads to much uncertainty in fish stock assessment relying upon underestimated total mortality coefficients. Therefore, the principle assumption and the only advantage of applying the different kinds of BRDs as technical conservation measures is the survival of fish escaping through them (Isaksen & Valdemarsen 1994; Chopin & Arimoto 1995; Ryer, 2002; Suuronen et al., 1996; Suuronen, 2005).

Since understanding the behavior of fish escaping through square meshes or sorting grids may give a measure for their effectiveness as size-selective BRDs, the main goal of the present study is to observe the behavior of undersized fish escaping through square meshes and longitudinal grids, in a simulated trawling experiment, under light and dark conditions at different towing speeds and orientations of the mesh panel and grids, in order to evaluate the square meshes and the rigid grids as size-selective bycatch reduction devices in finfish trawl fisheries.

Materials and Methods

Experimental fish:

Juveniles of masou salmon (*Oncorhynchus masou)* of an average total body length of 13 cm (range between 12 and 14 cm) were used to carry out this experiment. This species was selected in this study for two main reasons: First, as an experimental fish having high swimming capability and high sensitivity to low illuminations. Second, as a representative of salmonids, of which many species fall as bycatch in the demersal trawling in the North Pacific (Witherell et al., 2002) and the pelagic trawl fisheries in the Northeast Atlantic (ICES, 2005a). Fish were maintained in a rectangular glass fiber tank (L x W x H: 240 x 100 x 70 cm) provided with a continuous fresh water flow. Water temperature was maintained at 14 ^{0}C in both the rectangular tank and the experimental circular tank.

Experimental tank, motor set and the towed net:

A small polyethylene circular water tank of 110 cm diameter and 55 cm height was set centrally inside a larger one of 260 cm diameter and 93cm height, making a circular canal around it of 75 cm width and 50 cm water depth, through which the fish have been obligated to swim inside the framed net close to the square mesh panel or grids. A speed controllable Oriental motor was established over a metallic boards at a central position over the circular tank (for details see figure 1). The towed net consists of aluminum frame and fine mesh panels mounted around all lateral and bottom sides except the area where the square mesh panel or the grids to be fixed. The topside was left exposed, as its margins always emerged just over the water surface in the tank. The frame shape and dimensions, mesh panel and grids, and closing and opening the door for the keeping partition are shown in figure 2.

Towing speed, illumination, and the observation system:

Two towing speeds were predetermined using the speed control: the lower is 50 cm/second (about one knot) and the higher is 80 cm/second (about 1.5 knot). The fish escaping behavior was observed under light and dark conditions at each towing speed and mesh or grid orientation, respectively. The "StowAway LI" light intensity logger was used to measure the light intensity at the water surface in the tank under dark (<0.003 Lx; due to Logger sensitivity threshold) and in light (26 Lx; due to using a cover between the tank and the light source to prevent light reflection at the water surface which may affect fish behavior and its observation quality). An Infrared CCD camera (SK-2124 type) was fixed to the towed net and directed to observe fish behavior at the square mesh panel and grids area, respectively. This camera was connected to a TV monitor and Video recorder through a rotary connector as shown in figure 1. The wavelength of the IR light (from LED illuminators of the Camera) was 850 nm. This wavelength is beyond the visual spectral sensitivity of masou salmon, which ranges between 430 – 666 nm (Nakano et al., 2006).

Experimental protocol and data analysis:

The square mesh panel and longitudinal rigid grids have been fixed to the bottom net frame at three orientations, namely: parallel, sloping forward and sloping backward, respectively (as shown in figure 3). The difference between the sloping forward and sloping backward is the towing direction. Relative to the swimming direction, which will be the same as towing direction, the sloping forward means moving in front of fish while the sloping backward means moving behind fish. Six trials have been carried out for each mesh and grid orientation at each towing speed, respectively: three trials under dark and three trials under light conditions. Five fish were used in each trial and forced to swim up to a maximum of 30 minutes (the maximum duration of towing, after which we stop towing and finish the trial). To avoid the effect of learning on subsequent fish escaping, no fish was used more than once under the same condition: the fish used under light at lower towing speed in their first trial were used under dark at higher towing speed in their second trial, and vice versa, for escaping through the square meshes and grids, respectively, with a maximum of 4 trials for each individual fish (2 trials through square meshes, and 2 trials through grids).

The swimming time, before each fish escaping, and the total number of escaping fish were observed and recorded on videotapes for later retrieve and analyses. The total fish escaping during each three trials for each case as well as the average swimming time of escaping fish was estimated. The two sample Kolmogorov-Smirnov Test (applied in the "STATISTIX 8" software) was used to predict the general effect of illumination (light or dark) and escape opening (square meshes or longitudinal grids) on fish escaping percentage (over mesh or grid orientations) at the different towing speeds. Fisher's exact test was used, by running the two-sample proportion procedure (same statistical software) to evaluate the difference in escaping ratio between each two comparable conditions. Moreover, some fish escaping events has been analyzed and pictured frame by frame to compare between the behavior of fish escaping through the square meshes and that through the longitudinal rigid grids (for this analysis we used the infrared camera position Ca.2 as shown in figure 2.

Results and observations

Results of fish escaping and swimming time are reported in tables 1, 2 and 3, and presented in figures 4, 5, and 6. In general, the two-sample Kolmogorov-Smirnov test revealed that escaping through square meshes, regardless of panel orientation, under light conditions is significantly higher than escaping under dark conditions at both towing speeds, respectively (at lower towing speed: one-tailed Kolmogoro-Smirnov statistic = 0.23, P = 0.0057; at higher towing speed: Kolmogoro-Smirnov statistic = 0.47, P = 0.0017). For escaping through longitudinal grids, the same statistical test failed to predict general significant differences in escaping, regardless of grid orientation, under dark and under light conditions (at lower towing speed: one-tailed Kolmogoro-Smirnov statistic = 0.06, P = 0.415; at higher towing speed: Kolmogoro-Smirnov statistic = 0.09, P = 0.171). Escaping through grids was significantly higher than escaping through square meshes in dark (at lower towing speed: one-tailed Kolmogoro-Smirnov statistic = 0.27, P = 0.0009; at higher towing speed: Kolmogoro-Smirnov statistic = 0.70, P = 0.0000) and in light (at lower towing speed: one-tailed Kolmogoro-Smirnov statistic = 0.24, P = 0.0000; at higher towing speed: Kolmogoro-Smirnov statistic = 0.20, P = 0.0002).

1- Escaping through the parallel square meshes and grids:

Results reported in table 1 and presented in figure 4 show the escaping ratio and the average swimming time before escaping through the parallel square meshes (A) and grids (B) under dark and under light at each towing speed.

From table 1 and figure 4, we can see that no fish could escape through the parallel square meshes in dark at both towing speeds. Under light conditions, increasing the towing speed from 50 to 80 cm/sec reduced the escaping ratio from 40 % (6 fish) to 20 % (3 fish), and at the same time increased the swimming time before escaping from 6.8 (S.D = 4.7 minutes) to 15 minutes (S.D = 14.1 minutes). Escaping through the grids in dark was significantly lower than escaping in light at both towing speeds. Increasing the towing speed slightly increased escaping in dark, and in addition to reducing the escaping in light, the average swimming time before escaping increased from 1 (S.D = 0 minutes) to 8 minutes (S.D = 8.2 minutes). Fisher's exact test revealed that escaping through the parallel grids was significantly higher than escaping through the parallel square meshes in dark and in light at both towing speeds (in dark: $p = 0.0032$ at the lower speed, and $p = 0.0011$ at the higher speed; in light: $p = 0.0003$ at the lower speed, and $p = 0.0003$ at the higher speed).

2- Escaping through the sloping forward square meshes and grids:

As shown in table 2 and figure 5, all fish could escape through the sloping forward square meshes and grids, respectively, in light at both towing speeds. Under dark conditions, there were significant reductions occurred in fish escaping either through the square meshes or the grids at both towing speeds. By increasing the towing speed in dark, escaping through the square meshes decreased, while there was no effect on escaping through the grids. As a result, escaping through the sloping forward grids was significantly higher than escaping through the sloping forward square meshes in dark at the higher towing speed only ($p = 0.0105$).

3- Escaping through the sloping backward square meshes and grids:

In table 3 and figure 6, results show that 27 % of fish escaped in dark at the lower towing speed, while no fish could escape at the higher towing speed. Under light conditions, increasing the towing speed caused an increase in the escaping from 33 % to 67 %. On the other hand, all fish could escape through the grids in light at both towing speeds, respectively. Escaping in dark was significantly lower than escaping in light at the lower speed ($p = 0.0211$). Increasing the towing speed increased the escaping in dark from 67 % to 87 %, so that escaping in dark was not significantly lower than escaping in light ($p = 0.2414$), and also shortened the average swimming time before escaping from 5 minutes (S.D = 8.9 minutes) to 1.5 minutes (S.D = 1.9 minutes). Fisher's exact test could predict that escaping through the sloping backward grids was significantly higher than escaping through the sloping backward square meshes in dark and light at both towing speeds (in dark: $p = 0.0328$ at the lower speed, and $p = 0.000$ at the higher speed; in light: $p = 0.0001$ at the lower speed, and $p = 0.0210$ at the higher speed).

Figure 7-A shows one fish escaping sequence through the sloping forward square meshes under light conditions at the higher towing speed (1.5 knot), we can see how fish dramatically change its body direction, either by its own capability or driven by the moving twines, from parallel into a perpendicular to the towing direction. In dark, at the same mesh orientation and higher towing speed (as shown in figure 7-B), fish being unable to penetrate through the meshes. Figure 8-A shows one fish escaping sequence through the sloping forward grids under light conditions at the higher towing speed (1.5 knot), fish smoothly pass between grids without changing its body direction. In dark, at the same grid orientation and higher towing speed, it is clear that the same escape behavior as under light conditions (figure 8-B). In case of sloping backward grids, escaping was passive and smooth, where fish just find itself out through the grids either under light or under dark conditions (as shown in figure 8-C & D, respectively) under the effect of increased towing speed.

Discussion

Kim and Wardle (2005) indicated that, having a body girth smaller than the mesh circumference, fish could escape from the trawl codend if it can overcome a visual looming effect and swim faster than the net towing speed. Thus, the visual and swimming capabilities are determinants of the fish's voluntary escape from fishing gears. In the absence of vision, fish cannot determine the approaching rate of net components rather than the mesh margins, and consequently cannot decide the swimming speed required to escape and responds only by startle reaction when contact the net components (Glass and Wardle, 1989; Walsh and Hikey, 1993). Therefore, fish may pass passively into the codend without active swimming as the case of walleye pollock in demersal trawling at night or at high depths (Inoue et al., 1993; Xu et al., 1993; Olla et al., 2000), and may have higher probability to strike the net (Ryer and Olla, 2000).

In this study, results showed that vision is essential for fish to do active oriented escape either through square meshes or through longitudinal grids. In the absence of vision in dark conditions, fish could not orient themselves to the escape opening, and only passive escaping occurred when fish found its head or body inside the escape opening of a square mesh or a gap between grids. The probability of this passive escape depended on the size of the escape openings and the probability of encountering these openings, which are affected by the mesh or grid orientation and towing speed. As a result, the percentage escaping through square meshes, regardless of panel orientation, in dark conditions was significantly lower ($p<0.05$) than that in light conditions. Also, escaping through grids in dark conditions was lower, though statistically not quite significant, than escaping in light conditions. Because of the larger longitudinal gaps between grids, though having the same or even smaller width than the length of a mesh bar, escaping through grids was significantly higher ($p<0.05$) than escaping through square meshes in dark and in light conditions, respectively.

The parallel moving square meshes, which is the conventional way of mounting the square mesh panel as a bycatch reduction device in trawl codend, reflected the worst negative impacts on the active escaping in light and on the passive escaping under dark conditions. This may be due to the difficulty with which fish can change its swimming direction by 90^{o} to penetrate through a parallel moving mesh at increased towing speed (Larsen and Isaksen, 1993), and the reduced encounter probability for passive escaping in dark conditions. The parallel grids also showed the worst impact on the active escaping in light conditions at increased towing speed, and on the passive escape in dark conditions compared to other grid orientations.

Even by improving the square mesh panel orientation to be sloping forward (i.e., moving in front of fish), they could benefit it only in light conditions. As shown in figure 7-A, fish escaping through the sloping forward square meshes under light conditions showed a dramatic change in its swimming direction, either under its own will or driven by the moving mesh twines, and though that, all fish could escape after a short swimming time (1.9 minutes). Under dark conditions, only 13 % (2 fish only) passively escaped, and figure 7-B shows fish under dark conditions being unable to take decision of passing through the sloping forward square meshes although opened in front of them.

Under the stress of the fast moving panel of square meshes behind fish, as a result of the increased towing speed, the exhausted fish had higher probability to contact the sloping backward meshes, especially in dark conditions. Though that, no fish could escape in dark at the increased towing speed, while 67 % of fish could benefit from the stress of increased towing speed and actively oriented their heads to escape through the sloping backward meshes in light conditions only. On the other hand, in dark conditions at the lower towing speed, the largest escaping ratio (67 %) in this study was achieved through the sloping backward grids. Increasing the towing speed from 50 to 80 cm/sec further increased this escaping ratio to 87 %, so that there was no significant difference between escaping in dark and in light conditions. Beside that, the swimming time was shortened to 1.5 minutes, which is even shorter than that before escaping in light conditions. This at the time where no fish could escape through the square meshes under the same conditions. The stress of increased towing speed on fish increased their probability of encountering the grids. The longitudinal gaps between sloping backward grids presented convenient openings for juveniles masou salmon to be released out under dark conditions without active swimming or orientation, and hence increased the probability of their passive escape.

Larsen and Isaksen (1993) observed that small fish of cod and haddock escaped rapidly through the grids without changing their normal swimming position in the horizontal plane. The escape behavior analysis in our study showed a similar smooth and easy escaping through the separating grids in light and dark conditions compared to escaping through the square meshes, where fish did not change its swimming direction either during escaping through the sloping forward grids (as shown in figure 8- A&B) or during escaping through the sloping backward grids (as shown in figure 8-C&D).

It is noteworthy that fish in our experiment had higher probability of encountering the square meshes or grids because both towing speeds were within the swimming capability of juveniles masou salmon at the time that the way was closed in front or behind fish. In actual trawling operations, as the towing speed should be higher than or at least equal to the maximum swimming capability of adult target fish, which is known to be higher than that of undersized fish (Wardle and He, 1988; He, 1993; Nikora et. al., 2003), undersized fish may not be able to sustain position or orient themselves to escape volitionally through the square meshes under dark or low illumination due to the absence of vision associated with their poor swimming capability and endurance relative to trawling speed (Breen et al., 2004).

However, recent field experiments showed no significant effect of using square codend or square mesh panel on the selectivity of trawl codends (Bullough et al., 2006; He, 2006). The same conclusion has been shown by Erickson et al. (1996), who found that no significant effect for the square mesh panel on the escapement of undersize walleye pollock as the catch size increases, and they recommended the use of sorting grids to permit escapement of undersized fish before they reach the codend of pelagic trawls, without restricting the catch limits. Therefore, we support the conclusion that the square mesh panel may not be effective as a successive bycatch reduction device when used under dark and high towing speeds, which are the actual trawling conditions of the majority of trawl fisheries (Olla et al., 2000; Ryer and Olla, 2000; Suuronen, 2005), and recommend using sorting grids well ahead of the codend extension of finfish trawl nets, just at the start of the straight passage to the codend.

The reaction behavior of salmonid species towards fishing gears has not been studied before (ICES, 2005 a). However, during the last decade, juveniles of many salmon species have caught as bycatch in demersal trawling in the North Pacific (Witherell et al., 2002) and pelagic trawling in the Northeast Atlantic (ICES, 2005a). Results of our study on juveniles masou salmon, as a representative of salmonids, may be of especial importance. From the results of escape behavior of juveniles masou salmon, we recommend bycatch reduction methodologies that increase the passive and safe escaping of undersized salmon species when trawling under dark conditions (at night or at high depths) at high towing speeds. Any gear modifications that depend on the visual capability of salmon species to be guided out of trawl nets may not be effective under actual trawling conditions.

However, Walsh and Hickey (1993) showed that the natural tendency of demersal fish under dark conditions is to take the bottom side, where many fish including cod, haddock, flatfish and round fish were seen resting on or close to the sea bottom showing collision to the footgear. From the behavior viewpoint, we recommend the use of sorting grids sloping backward at the bottom panels of the codend extension of finfish, especially demersal, trawl nets in a similar way used by Loaec et al. (2006) in the form of “Evaflex” in the Nephrops trawl fishery, but of course, attention should be given to the convenient slot size and modifications required in regard to the target fish species and sizes, and to the handling problems as well. For the handling problem, research is going on to solve these problems by utilizing flexible grids of lightweight material like Condensed Polyethylene or split the structure into smaller sections with hinges between them (Graham et al., 2004; Gabriel et al., 2005; ICES, 2005b, Jørgensen et al., 2006**,** Loaec et al., 2006).

In conclusion, fish escaping from trawl codend under dark conditions will be no longer voluntary. The square mesh panel is not effective as a successful size-selective bycatch reduction device in finfish trawl fisheries under dark conditions at high towing speeds. The passive nature of fish escaping under dark conditions and the natural tendency of demersal fish to be at the sea bottom close to the footgear render the use of the sorting grids sloping backward at the bottom panels (in the form of “Evaflex” used by Loaec et al., 2006) is expected to be most efficient way to increase the escape and survival of undersized fish in demersal finfish trawling under dark conditions and increased towing speeds, compared to the “Sort-X” or “Sort-V” grid systems. Research is needed to clarify the behavioral differences in fish reactions toward the different grid sorts as size sorting bycatch reduction devices in the finfish trawl net.

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Figure Caption:

Figure (1): Schematic drawing of a top view (a), and a side view (b) of the experimental tank used in the simulated trawling experiment: 1-Motor (Model US 590=501C); 2- motor shaft; 3 motor arm; 4-balance weight; 5-metallic boards; 6-metallic stands; 7-polyethylene circular water tank; 8-Infra red CCD Camera (SK-2124 type), position 1; 9- towed framed net; 10-smaller polyethylene circular tank; 11- rotary connector. (Metallic boards and stands are not shown in the top view for clarity)

Figure (2): Pictures showing the towed net shape and dimensions, the square mesh panel and grids specifications, and the way of closing the door and opening it.

Figure (3): Diagram showing the orientation of the square meshes panel and grids used in the experiment (arrows indicate the towing direction).

Figure (4): Percentage escaping ratio and the associated swimming time of masou salmon escaping though the parallel square mesh panel (A) and longitudinal grids.

Figure (5): Percentage escaping ratio and the associated swimming time of masou salmon escaping though sloping forward square mesh panel (A) and longitudinal grids (B) under dark and light conditions at towing speed of 1 knot and 1.5 knot.

Figure (6): Percentage escaping ratio and the associated swimming time of masou salmon escaping though sloping backward square mesh panel (A) and longitudinal grids (B) under dark and light conditions at towing speed of 1 knot and 1.5 knot.

Figure (7): Pictures showing fish escaping through the sloping forward square meshes under light condition (A) and fish unable to take active escape behavior under dark conditions (B).

Figure (8): Pictures showing fish escaping through the sloping forward grids under light (A) and dark (B), and through the sloping backward grids under light (C) and dark (D).

Table 1: Escaping ratios of masou salmon through the parallel square meshes and grids.

- Bold values show insignificant differences between escaping ratios
- Underlined values are the average swimming time and standard deviation between parentheses

Towing speed	Escaping ratio					
	Square meshes		Fisher's test P < or >	Longitudinal grids		Fisher's test P < or >
	Dark	Light		Dark	Light	
1 knot	0/15 -	6/15 6.8 (4.7)	0.0084	7/15 2.1 (2.6)	15/15 1 (0)	0.0011
1.5 knot	0/15 -	3/15 15 (14.1)	**0.112**	8/15 2.8 (4.2)	13/15 8 (8.2)	0.0543
Fisher's test P < or >	**1.000**	**0.2135**	--	**0.500**	**0.241**	--

Table 2: Escaping ratios of masou salmon through the sloping forward square meshes and grids.

- Bold values show insignificant differences between escaping ratios
- Underlined values are the average swimming time and standard deviation between parentheses

Towing speed	Escaping ratio					
	Square meshes		Fisher's test P < or >	Longitudinal grids		Fisher's test P < or >
	Dark	Light		Dark	Light	
1 knot	6/15 23 (5.4)	15/15 4.8 (3.3)	0.0003	9/15 11.2 (8)	15/15 1.3 (0.9)	0.0084
1.5 knot	2/15 13 (5.4)	15/15 1.9 (1)	0.0000	9/15 11.1 (9.6)	15/15 1 (0)	0.0084
Fisher's test P < or >	**0.1074**	**1.000**	--	**1.000**	**1.000**	--

Table 3: Escaping ratios of masou salmon through the sloping backward square meshes and grids

- Bold values show insignificant differences between escaping ratios
- Underlined values are the average swimming time and standard deviation between parentheses

Towing speed	Escaping ratio					
	Square meshes		Fisher's test P < or >	Longitudinal grids		Fisher's test P < or >
	Dark	Light		Dark	Light	
1 knot	4/15 22.2 (4.9)	5/15 10.8 (10.2)	**0.500**	10/15 5 (8.9)	15/15 2.6 (2)	0.0211
1.5 knot	0/15 -	10/15 9.9 (7.6)	0.0001	13/15 1.5 (1.9)	15/15 3.5 (6.3)	**0.2414**
Fisher's test P < or >	0.0498	**0.0716**	--	**0.1949**	**1.000**	--

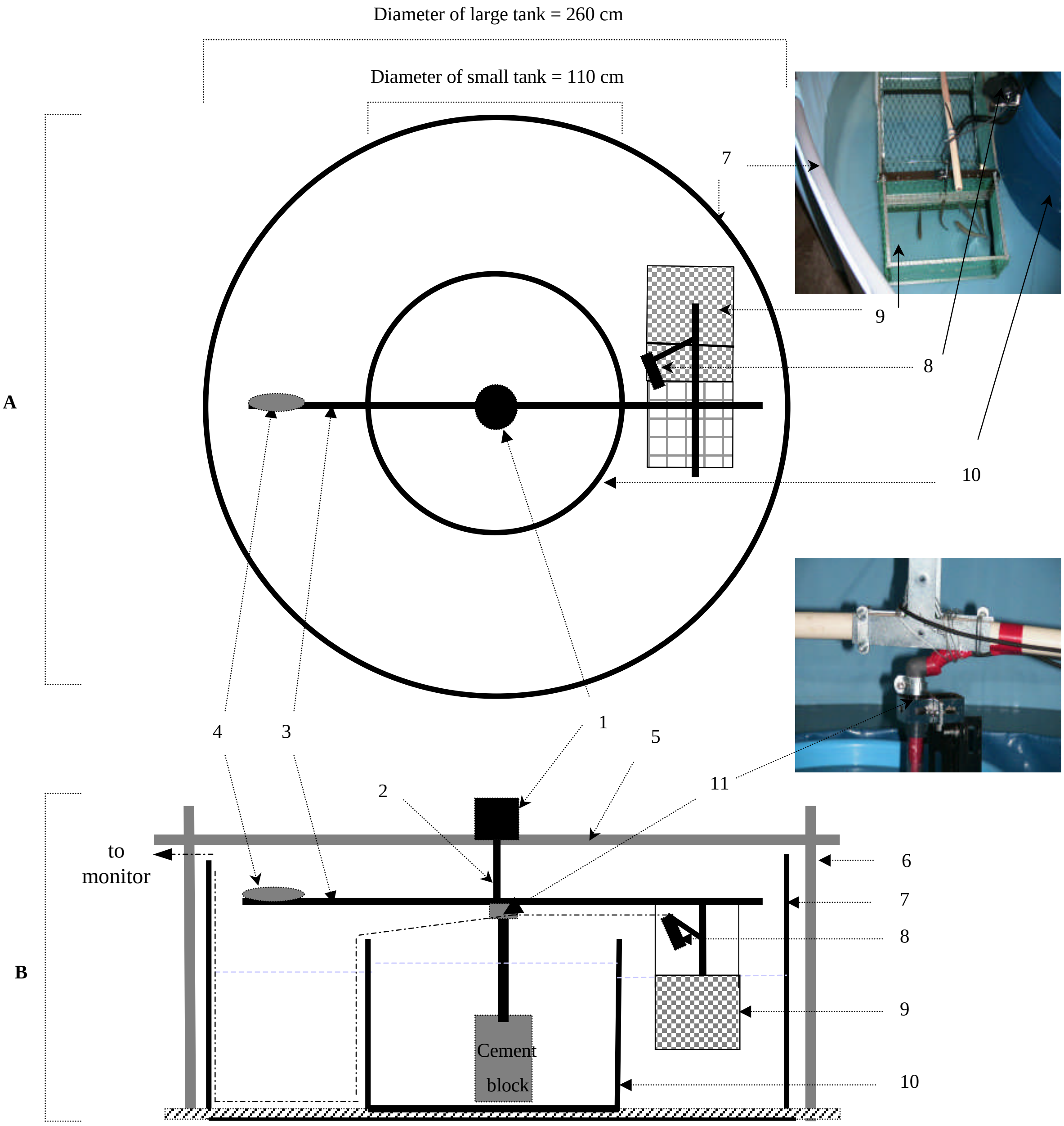
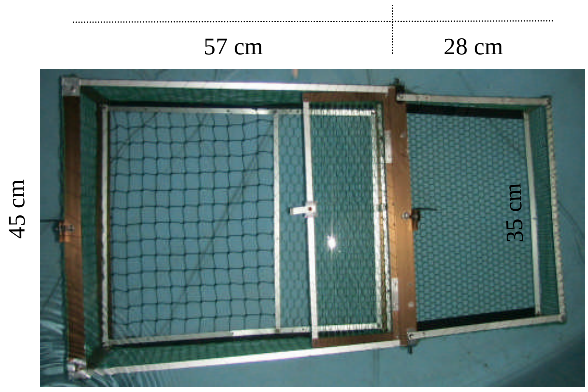
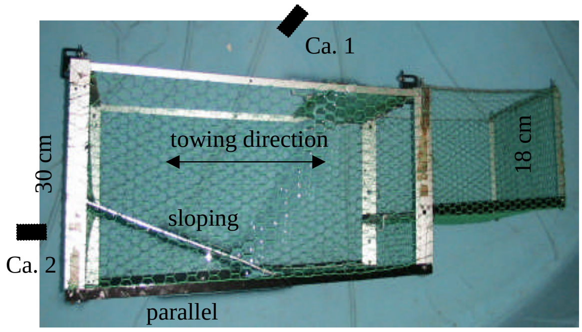

Diameter of large tank = 260 cm
Diameter of small tank = 110 cm
A
B
1
2
3
4
5
6
7
8
9
10
11
to monitor
Cement block

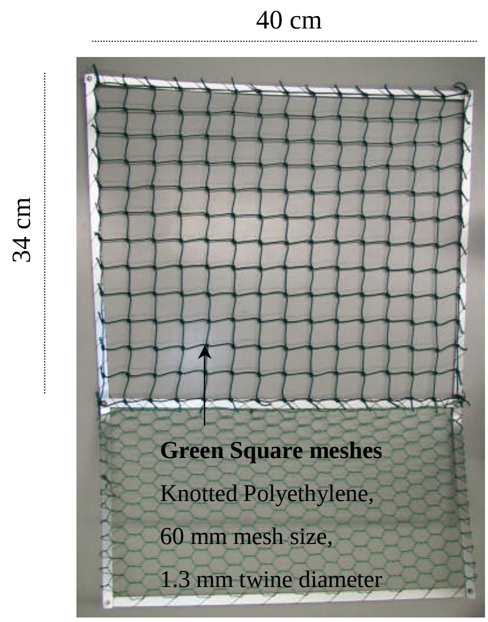
Figure (1)

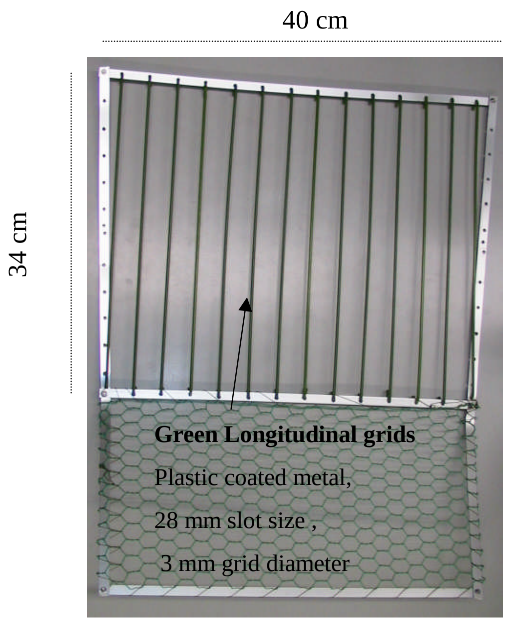


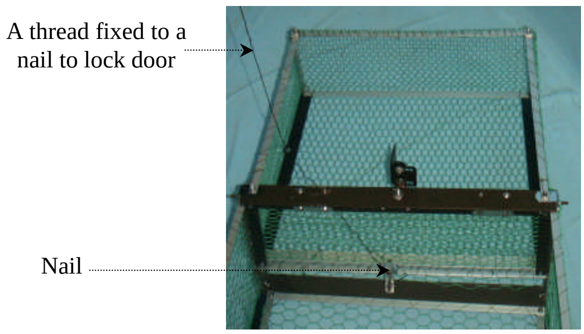
Top view showing net frame dimensions and the square mesh panel in the parallel orientation



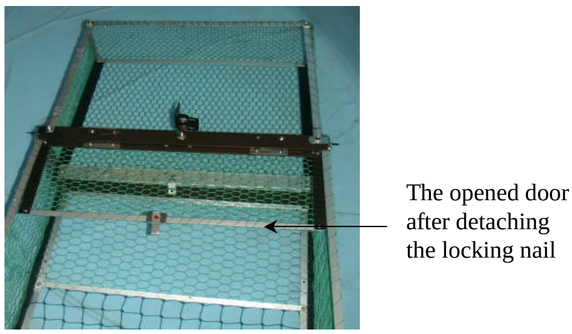
Side view showing the panel or grid orientation, net depth dimensions and the camera positions; Ca. 1 and Ca. 2







Picture shows closing the door



Picture shows opening the door

Figure (2)

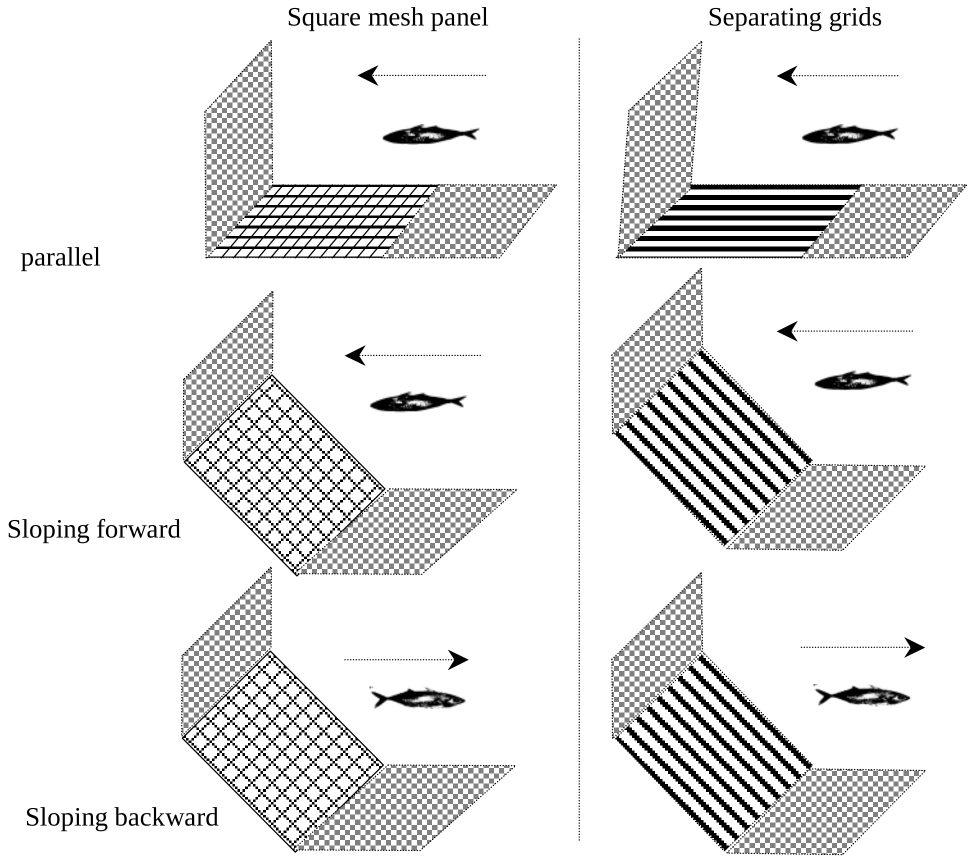

Square mesh panel
Separating grids
parallel
Sloping forward
Sloping backward

Figure (3)

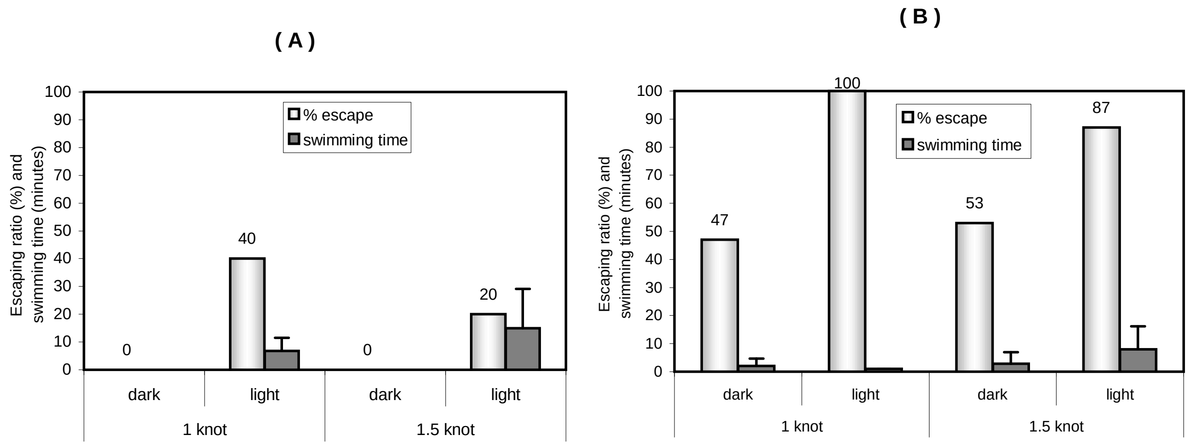


Figure (4)

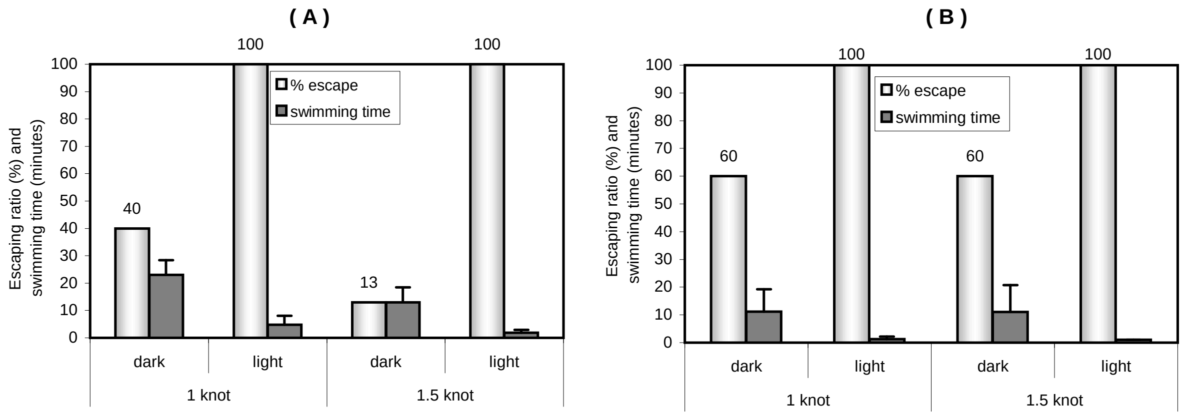


Figure (5)

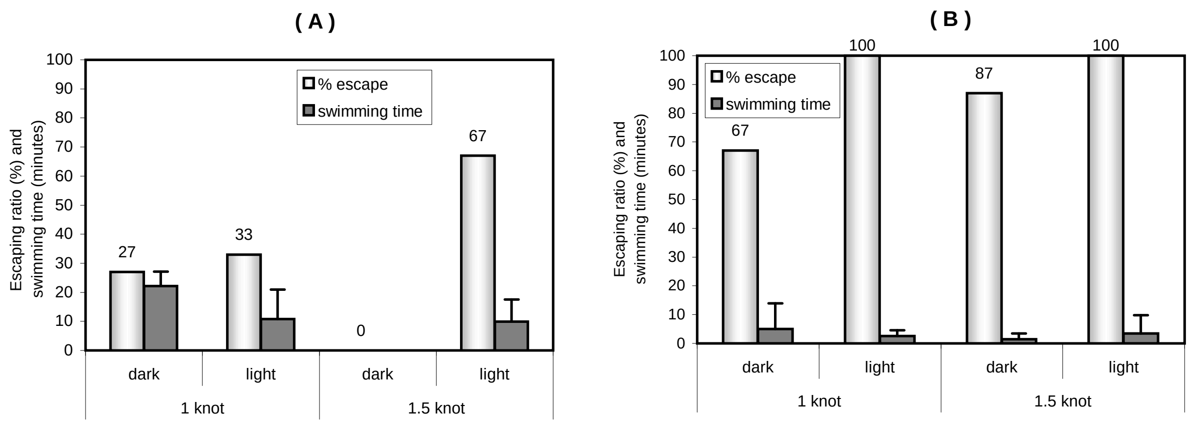


Figure (6)

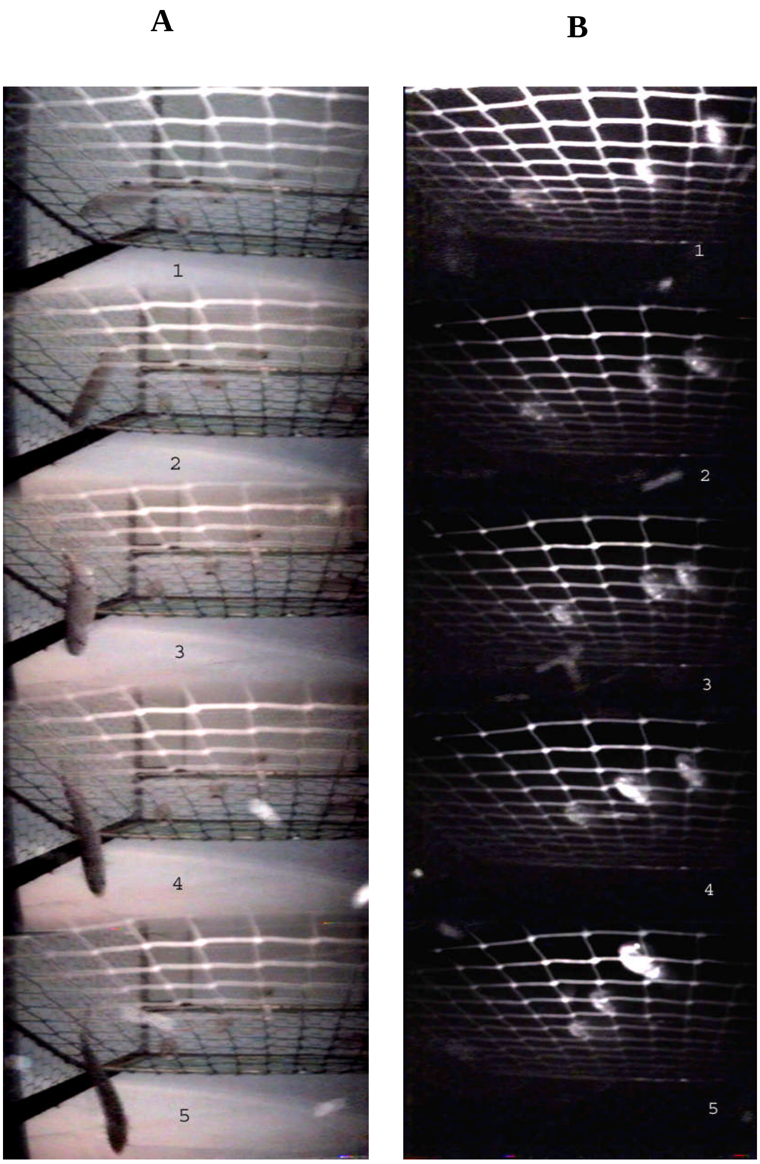


Figure (7)

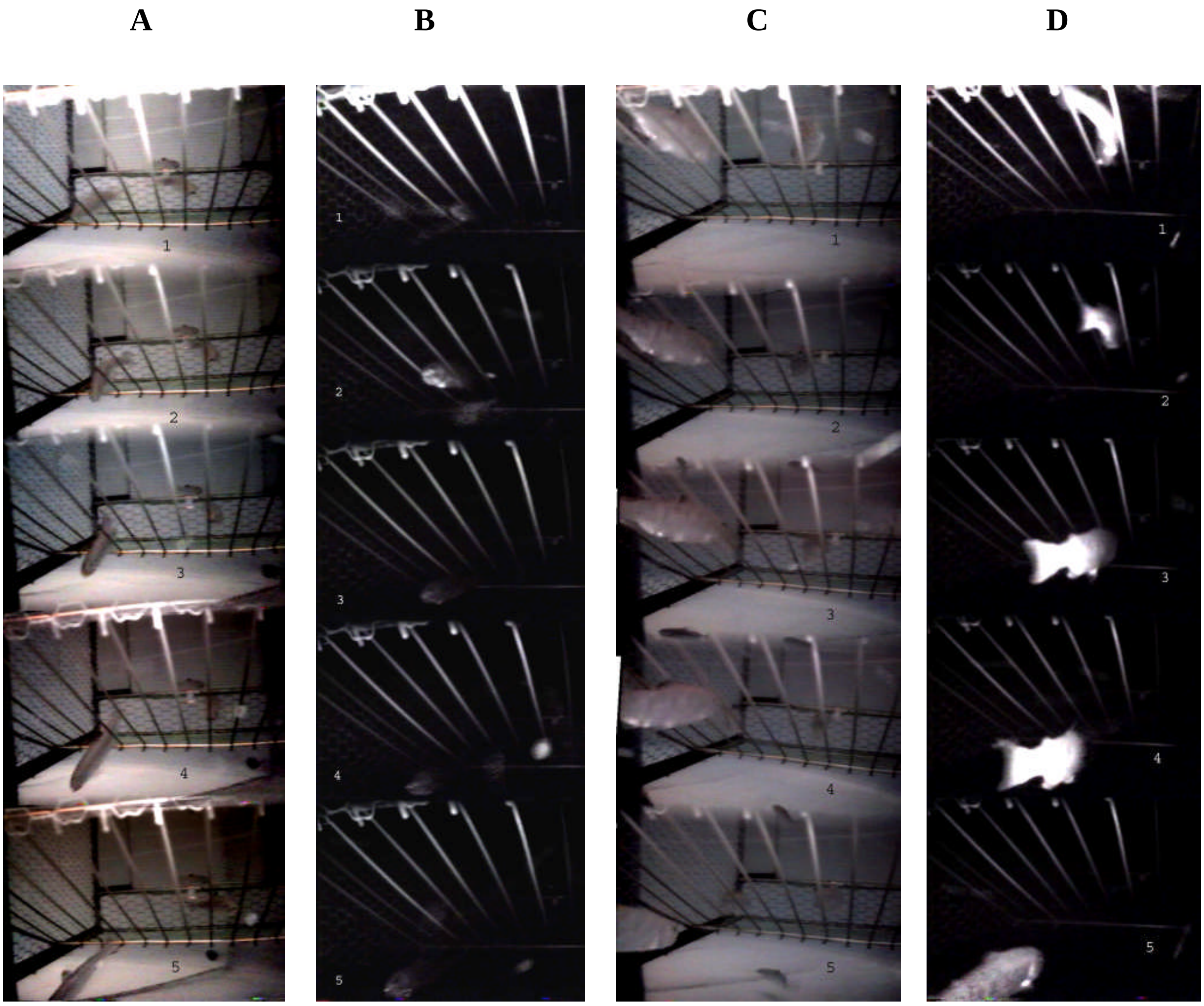


Figure (8)