International Council for
the Exploration of the Sea

Fish Capture Committee
C.M. 1995/B:15 Ref. G

Vulnerability to predation of small cod (*Gadus morhua*) that escape from a trawl

by

Svein Løkkeborg and Aud Vold Soldal
Institute of Marine Research
Department of Marine Resources, Fish Capture Division
P.O. Box 1870, N-5024 Bergen, Norway

Abstract

Studies of the vulnerability to gear damage of fish that have been caught in a trawl but have escaped through the codend meshes have focussed on determining survival rates. This study examines the risk of predation in small cod (*Gadus morhua*) (18.2 cm mean total length) escaping a small-scale trawl. Trawling was simulated in a circular tank by towing a small mock-up of a trawl (70 mm codend meshes) for 30 minutes. Escaped fish were retained in a small-meshed net (16 mm) covering the codend. After each towing period, three or four of these fish and the same number of fish from a control group were immediately transferred to a tank holding five large cod (56.3 cm mean total length). Predation by the large cod was recorded for 30 min or until 50% of the small cod had been taken. In a total of nine experiments, equal numbers of escaping fish and fish from the control group were eaten by the large cod. This indicates that small cod escaping from a trawl do not have increased risk of predation under these experimental conditions. However, the stressed fish were not physically exhausted and the predation experiment was conducted under conditions where the predator could easily capture both stressed and control fish.

Introduction

Attempts to improve fishing gear selectivity are based on the assumption that fish escaping from fishing gears survive and recover completely after escapement. Fish escaping from towed fishing gears have been subjected to several stressors including severe exercise when swimming in front of and inside the gear, injuries due to contact with the gear and other fish, stress associated with confinement and overcrowding, and injuries when escaping through the meshes. Most studies on the fate of fish escaping from towed gears have focussed on determining short term mortality rates caused by these stressors. The mortality rates reported for different species show large variations (see review by Chopin and Arimoto, 1995), but those recorded for cod indicate low mortality (Main and Sangster, 1991; DeAlteris and Reifsteck, 1993; Soldal et al., 1993).

Damage and stress suffered by escaping and surviving fish may, however, cause increased vulnerability to predation, decreased food consumption and reduced capacity to resist disease. Fish escaping from fishing gear may therefore suffer delayed mortality as an indirect result of their exposure to the gear. Cannibalism is common in cod, and small fish that escape through codend meshes may be subjected to increased predation risk from large cod or other species occupying the same fishing ground. This situation was simulated in the laboratory, and the predation rate on stressed fish was compared with that of fish from a control group.

Material and Methods

Trawling was simulated in a large circular tank (10 m inner diameter, 14 m outer diameter, 2.5 m deep, water temperature approximately 8°C) that had a motorized carriage running on rails on the top of the walls of the tank. A steel frame to which the trawl was mounted was suspended from the carriage into the tank. The trawl was 2.1 m long, with a mesh size of 70 mm. The trawl opening, 2 m wide and 1 m high, was held open by the frame, and the trawl was towed just above the bottom of the tank. The cover that was used to retain escaping fish had a length of 5 m and was made of knotless netting with a mesh size of 16 mm. The aft 1 m of the cover was made of canvas to keep retained fish in water when tranferring them

to the tank holding the predators. Two tanks (1.0 m x 2.5 m, 1.0 m deep, water temperature approximately 8°C), each holding five large cod (56.3 cm mean total length), were used for the predation risk experiments.

One day before each trial, 18-30 small cod (18.2 cm mean total length) were taken from a holding tank and transferred to the circular tank and 4 small cod were transferred to a 12-litre bucket suspended in the tank holding the large cod. The fish in the bucket constituted the control group. In each trial, the experimental trawl was towed for 30 min. A current was set up in the tank by the towed trawl, and at intervals the ground speed of the trawl was increased to counteract the decreasing relative speed through the water. This gave a towing speed between 0.19 - 0.31 m s^{-1} (0.36 - 0.61 knot). At this towing speed, most of the fish were cruising in the mouth of the trawl and easily maintained their position. Few fish were exhausted and dropped back into the codend during the 30-min haul. After 30 min towing, the speed of the carriage was therefore increased to its maximum capacity for 5 min. During this period, the towing speed dropped from 0.57 to 0.41 m s^{-1} (1.1 to 0.8 knot) due to the induced current. The carriage was then stopped, and the fish caught in the cover were released into a bucket. Immediately, four of these fish were length measured, transferred to the bucket holding the four fish in the control group, and all eight fish released into the tank with the large cod. In three out of the nine trials, only three fish were caught in the codend cover, and three stressed and three control fish were therefore used in these trials. To be able to tell the two groups apart, the aft back fin of the stressed fish was cut by a scissor either before they were released into the circular tank or when they were caught and length measured.

The small cod were exposed to predation for 30 min or until half (i.e 3 or 4) of them were had been eaten. A maximum duration of 30 min. of the predation exposure period was set to prevent the stressed fish from recovering. As far as possible, the time of capture and the identification of each fish taken were recorded in the course of the experiment. At the end of the experiment, the fish left in the tank were identified.

Result

Stressed fish and fish from the control group were eaten by the large cod in equal proportion (Table 1). In most of the trials, the fish were taken within the first 1-2 min of exposure to predation. Few fish could be identified at the moment of capture because several fish were simultaneously chased and taken within this short period.

Discussion

This result indicated that trawling-induced stressors do not cause increased risk of predation in small cod. However, the finding can not be generalized, and drawing the same conclusion for fish escaped during actual trawling has to be based on a few assumptions. The stressors to which the experimental fish were subjected and the conditions when the fish were subjected to predation do not ideally represent the conditions under actual fishing.

The fish in the stressed group were subjected to several types of physical and traumatic stressors before they were subjected to predation; swimming in front of the trawl at about 0.25 m s^{-1} for 30 min and then at about 0.5 m s^{-1} for 5 min, going through the meshes into the cover, being transferred from the cover to a bucket, and being length measured and in some cases finclipped. In addition, the fish had been tranferred between several tanks; the holding tank, the circular tank, the bucket and the tank holding the predators. Most of the fish easily maintained their position in front of the trawl, and the maximum sustained swimming speed for a 18-cm cod has been shown to be much higher than the present towing speed (2.6 body length s^{-1} for small cod; see Wardle, 1977; He, 1993). Even during the five minutes of increased towing speed several fish were able to maintain their position in front of the trawl. Therefore, the stressed fish were probably not physically exhausted when subjected to predation. This will, however, represent the situation for fish that drop back into the codend shortly after they encounter a trawl, i.e. small fish that are not capable of swimming at the towing speed or fish being "caught by surprise" (see Godø et al., 1990). The experiences of the stressed group are therefore comparable to those of fish that have been caught and escape immediately after encounter, but not the fate of fish that have been caught after exhaustion.

The conditions under which a fish escape from a trawl and is subsequently exposed to predation are difficult to simulate in the laboratory. The tank used in the predation experiment was relativly small compared to the size of the fish, and the large cod could easily take both stressed fish and fish from the control group. Potential differences between the two groups in escaping the predators might therefore have been masked by the narrow confinement. In addition, releasing the fish into the tank holding the predators might also have caused stress in the control group.

Furthermore, under commercial trawling the gear herd fish from a relatively wide area and release escapees into the narrow width of the codend. This may increase the catching success of a predator swimming in the path of a trawl, and thereby cause increased vulnerability to predation in escaping fish.

Conclusion

The results indicated that under the present experimental situation, small cod did not experience increased risk of predation when subjected to different types of stressors associated with trawling. However, the fish were not subjected to severe physical exercise, and their predation risk was tested under laboratory conditions where both stressed and control fish were easily taken by the predator. The predation risk in exhausted fish should therefore be tested under conditions that are more representative of actual fishing operations.

Acknowledgement

We are grateful to Kent Olav Mikkelsen and Anne Britt Skar Tysseland for their assistance during the laboratory experiment. We would also like to thank Bill West for improving the Engish text.

References

Chopin, F.S., and Arimoto, T. 1995. The condition of fish escaping from fishing gears - a review. Fish. Res., 21: 315-327.

DeAlteris, J.T., and Reifsteck, D.M. 1993. Escapement and survival of fish from codend of a demersal trawl. ICES mar. Sci. Symp., 196: 128-131.

Godø, O.R., Pennington, M., and Vølstad, J.H. 1990. Effect of tow duration on length composition of trawl catches. Fis. Res., 9: 165-179.

He, P. 1993. Swimming speeds of marine fish in relation to fishing gears. ICES mar. Sci. Symp., 196: 183-189.

Main, J., and Sangster, G.I. 1991. Do fish escaping from codends survive? Scot. Fish. Work. Paper No. 18/91, 8 pp.

Soldal, A.V., Engås, A., and Isaksen, B. 1993. Survival of gadoids that escape from a demersal trawl. ICES mar. Sci. Symp., 196: 122-127.

Wardle, C.S. 1977. Effects of swimming speeds in fish. In Scale effects of size on swimming speeds in fish, pp. 299-313. Ed. by T.J. Pedley. Academic Press, New York.

Table 1. Number of control fish and stressed fish eaten by a predator. The time at capture indicates at what time after introduction to the tank the control fish (C) and the stressed fish (S) were eaten.

	Number of fish eaten		
Trial no.	Control	Stressed	Time of capture
1	2	1	12-14 min: 2C and 1S
2	3	1	0-1 min: 3C and 1S
3	2	2	0-1 min: 1C and 2S 10 min 45 sec: 1C
4	2	2	20-27 min: 2C and 2S
5	1	2	0-1 min 30 sec: 1C and 2S
6	0	3	0-1 min: 3S
7	2	2	0-2 min 40 sec: 1C and 2S 18 min: 1C
8	2	2	0-1 min: 2C and 2S
All trials	14	15	