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Short Communication

Selection efficiency of encircling grids in a herring pontoon trap

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ABSTRACT

High bycatches of undersized herring constitute a major problem in the Baltic Sea herring trap fishery. In an attempt to reduce these bycatches, this field study evaluates the efficiency of rigid selection grids encircling a herring pontoon trap. The results show that 54–72% of the undersized herring were removed from the catch. The introduction of such grids would therefore represent a significant step towards a more efficient and sustainable herring fishery in the Baltic Sea.

1. Introduction

Bycatches, whether of undersized fish or of non-target species, are not only a threat to the sustainability of fisheries world-wide, they are also a very time consuming problem for fishermen to deal with (Hall et al., 2000). Hence, one of the main points which should be focused on in the development of new types of fishing gear is to look for methods which reduce the bycatch of undersized fish.

Several studies have been conducted on size selection of fish in trawls (Suuronen et al., 1996a,b; Armstrong et al., 1998; Madsen and Stær, 2004; Herrman and O'Neill, 2006; Bahamon et al., 2007). Various modifications such as the fitting of square mesh panels are commonly used to improve the selectivity of trawl codends. There has also been a substantial amount of research into using rigid sorting grids to improve the selectivity (Graham et al., 2004; Madsen, 2007). In a trawl, the fish are often sieved out more or less involuntarily through the selection device. The effectiveness of the selection depends not only on the shape and size of the fish, but also on many other factors, including the placement and design of the device (Armstrong et al., 1998; Madsen, 2007) towing duration and towing speed, and the amount of fish held in the codend (Dahm et al., 2002).

Only a few studies of selective release have been conducted for fixed gear such as larger traps and pound-nets (Laarman and Ryckman, 1982; Brothers and Hollet, 1991; Tschernij et al., 1993; He and Inoue, 2010; Lundin et al., 2011). With fixed gear, both capture and possible escape require active behaviour on the part of the fish (Hubert, 1996). According to previous studies, size-selection efficiency is highly dependent on ambient factors such as the amount of fish in the trap, what other species are present in the trap, light conditions, currents and water temperature (Ryer and Olla, 2000; Lundin et al., 2011). Moreover, the design of the gear and the selection device can be expected to affect the selection efficiency. Hence, there is a need for a better understanding of the behaviour of the fish during the selection process to be able to optimize the efficiency of the selection device.

The spring spawning herring (*Clupea harengus membras*) fishery in the Bothnian Sea is an important regional fishery, in which a common fishing method is the use of large traps (Parmanne, 1989; Tschernij et al., 1993). By using the recently developed pontoon trap, also known as the push-up trap, damage to gear and catch losses caused by grey seals (*Halichoerus grypus*) have significantly decreased (Lunneryd et al., 2003; Suuronen et al., 2006; Hemmingsson et al., 2008; Lehtonen and Suuronen, 2010).

An abiding problem with all herring traps, including the pontoon trap, is that they catch herring indiscriminately (Tschernij et al., 1993). However, Lundin et al. (2011) demonstrated that effective

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selection of small herring through a selection grid installed in a herring pontoon trap was achievable. Up to 27% selection efficiency was reached with a prototype grid covering only about 0.1% of the chamber's total wall area. It was considered probable that a significantly better efficiency could be attained with a larger grid and a more advanced design.

The aim of this study was to evaluate the selection efficiency of rigid, encircling grids covering 10% of the chamber's total area in a herring pontoon trap.

2. Materials and methods

2.1. Sea trials and gear

The study was conducted in the Swedish inshore waters of the Bothnian Sea (61°57′N, 17°22′E). Nine separate trials were performed between the 24th May and the 7th July 2010. Soak-times for each trial (starting with the trap entering the water and ending with the trap being emptied) varied from 16.5 h to 120 h (Table 1).

The herring trap used was of the same type used by Lundin et al. (2011). A single-walled cylindrical fish chamber, 6 m long and 3 m in diameter, with netting of 24 mm stretched mesh length was attached to the trap (Fig. 1). The resulting small mesh is assumed to retain herring of all sizes encountered.

2.2. Selection grids and placement

The cylindrical fish chamber was modified with the addition at each end of a 300 mm wide selection ring, of the same hoop-shaped tubular aluminium construction as the framework of the fish chamber itself. Within these rings, 2 mm diameter stainless steel rods were fitted vertically (and reinforced with horizontal cross-ties every 200 mm) to form the selection grids (Fig. 1). The grids, 7 m in length, reached around the entire chamber, apart from 2 m at the bottom which was covered with a solid stainless steel plate, to prevent herring from getting caught in the bottom net when emptying the trap. The fish chamber netting behind the grids could not be completely removed without compromising the strength of the whole construction. Instead the original 24 mm stretched mesh was replaced with a square meshed net with 100 mm mesh sides, in order to make as little impact on the selection process as possible.

The grids were made in two sets, one with 14 mm bar spacing and one with 15 mm bar spacing. Estimated mean selection lengths achieved by each bar spacing were based on the results from Lundin et al. (2011). Results from this study showed that a herring with a dorsal width of 1 mm wider than the bar spacing of a rigid grid could pass through the grid. In the case of 14 mm and 15 mm grids, this corresponds to herring with a mean length of about 17.5 cm and 18.5 cm, respectively. Grids with a bar spacing of 14 mm were used during trials one to four and grids with a bar spacing of 15 mm were used during trials five to nine (Table 1).

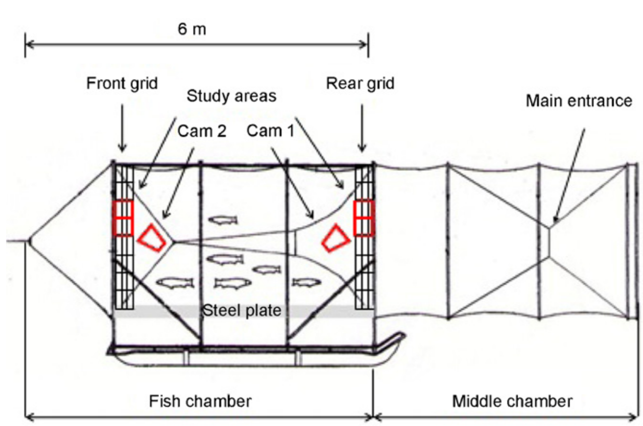

Fig. 1. Pontoon fish chamber, showing placement of selection grids, areas monitored and positioning of cameras. Study area number 3 and camera number 3 on the opposite side of the chamber are not shown in the figure.

2.3. Data collection

The numbers of herring escaping through the selection grids were recorded with three underwater cameras, using the same system setup as described in detail in Lundin et al. (2011). Camera no. 1 was facing the west side of the rear grid, camera no. 2 the west side of the front grid and camera no. 3 the east side of the rear grid (Fig. 1). To get a good overview, and to avoid overestimating the numbers of herring escaping through the grids, only escapees passing through a clearly demarcated 400 mm × 300 mm section of the grids were counted when the film was later analysed. The demarcated areas were horizontally located just above the centre of the fish chamber. Camera 1 was used in all nine trials while cameras 2 and 3 were only operational during the last two trials. The numbers of escapees passing through each of the demarcated areas were counted during 5-min sequences (representing a total of 10–13% of the total soak-time) randomly distributed over the total soak-time for each trial, whether day or night. On a few occasions it was observed that escapees swam back into the trap through the grids. A similar behaviour was also seen by Lundin et al. (2011). Fish returning were subtracted from the total number of escapees during the 5-min sequence in question. At the end of each trial the total catch remaining in the trap was weighed in kilogram, and a subsample of 89–163 fish were measured in length to the nearest 0.5 cm and weighed to the nearest gram.

2.4. Selection efficiency

The selection efficiency of the grids (*SE*) was determined for each trial from the estimated total number of escapees passing through the grids and the estimated total number of potential escapees remaining in the trap when the trial ended. Such that:

$$SE = 100 \cdot \left(\frac{N_E N_{5\ \min} A}{(N_E N_{5\ \min} A) + N_{PE}} \right) \quad (1)$$

where N_E is the mean number of escapees per 5 min in one demarcated area, $N_{5\,\min}$ is the total number of 5 min periods, A is the extrapolation factor to the total effective area of the two grids and N_{PE} is the total number of potential escapees remaining in the trap when the trial ended. Confidence intervals (CI) of 95% around the mean number of escapees per demarcated area and 5 min period were calculated by using the normal bootstrapping method (Efron and Tibshirani, 1986) with 1000 repetitions. In the two cases where more than one camera was used (trials eight and nine), a combined mean and CI were weighted by the number of cameras on each grid. Under the assumption that all parts of the grids, with the exception of the uppermost 1 m, had equal selection potential, the extrapolation factor A was based on the total area of the two grids minus the areas represented by the top 1 m on both sides of each grid. The deduction of these sections was based on camera observations showing very little activity in the top of the chamber. Total numbers of potential escapees remaining in the trap when the trials ended were estimated from the numbers and mean weights of potential escapees in the subsamples, under the assumption that these samples were representative of the length distributions and length–weight ratios in the entire catches. Due to a weighing scale malfunction, mean weights of escapees in trials three and four were based on the same values as in trial two. Trials one, five and six had insufficient recording periods due to bad weather conditions and were excluded from all analyses.

Table 1
Grid size, trial time period, total catch and estimates of number of escapees for each trial. Pot. escapees (%): number of potential escapees in subsample, Pot. escapees (kg): estimated weight of potential escapees in total catch, Pot. escapees (No): estimated number of potential escapees in total catch, No. Cameras: number of cameras used in each trial, No. Per: number of 5 min sequences. Escapees per 5 min: estimated number of selected escapees per 5 min in one demarcated area, SE (%): estimated selection efficiency for the total area of the grid. Lower 95% and upper 95% represent 95% CI for estimated number of escapees per 5 min and the SE.

Trial	Grid (mm)	Start	End	Total catch (kg)	Pot. escapees (%)	Pot. escapees (kg)	W Pot. escapees (g)	Pot. escapees (No)	No. cameras	No. 5 min periods	Escapees per 5 min	Lower 95%	Upper 95%	SE (%)	Lower 95% (%)	Upper 95% (%)
2	14	06-01 09:50	06-03 07:25	1070	25	262	28	9329	1	62	0.66	0.34	1.21	54	37	68
3	14	06-03 08:34	06-07 13:39	1200	26	310	28	11,018	1	126	0.40	0.27	0.56	57	47	65
4	14	06-07 14:18	06-09 08:25	400	17	68	28	2420	1	64	0.25	0.13	0.42	61	44	73
7	15	06-22 13:01	06-23 05:32	800	59	474	36	13,033	1	22	3.77	1.73	6.64	63	44	75
8	15	06-23 10:10	06-28 10:15	700	68	476	38	12,559	3	150	0.74	0.51	1.02	72	64	78
9	15	06-30 09:47	07-01 07:52	743	76	565	33	17,008	3	30	5.58	2.53	10.01	72	54	82

3. Results

The selection efficiency of the grids was between 54 and 72% in the six trials analysed, regardless of bar spacings in the grids, soak-times and numbers of demarcated areas and cameras used (Table 1).

4. Discussion

Two large sorting grids covering 10% of the total netting area of a herring pontoon trap produced a selection efficiency (*SE*) of 50–70% for undersized herring. This is a considerably better *SE* than previously shown by a smaller square sorting grid (Lundin et al., 2011), and fully comparable with the *SE*s derived for active gear (Bahamon et al., 2006).

Although there were several extrapolation steps and the confidence intervals of the *SE*s were quite large, mainly due to high diurnal variability in escapes between daytime and night time (Lundin et al., 2011), the results were similar regardless of bar spacings in the grids, soak-times and the number of demarcated areas observed. Hence, this strengthens the reliability of the results.

The only variations in the *SEs* were in the two final trials as compared to the previous four trials. This might be an effect of better recording coverage of the grid, since all three cameras were operational, or it might be due to a larger amount of potential escapees later in the season. A higher *SE* later in the season was also found by Lundin et al. (2011). Whatever the reason, in addition to the fact that the top sections of the selection grids were deducted from the area used for calculation in the analyses, it suggests that the *SE* of the encircling grid might be better than estimated, as a smaller area was used in the calculations than the actual area.

The extrapolation from the number of observed escapees to the total number of escapees was based on the assumption that all parts of the grids, with the exception of the uppermost meter, have equal selection potential. This will, however, depend on how the fish are distributed in the vertical plane, which in turn might depend on the light intensity at different depths (Peltonen et al., 2004).

Occasionally, herring got stuck in the narrow space between the square mesh of the fish chamber and the grids. Some of them died and may have hindered other herring from escaping. Hence, a possible way to further increase the *SE* of the grids would be to remove the square mesh altogether and strengthen the construction of the chamber by using other measures.

No loss of scales was observed as the herring squeezed through the bars. Nor were any scales seen floating in the water. It seems that young herring escaping through a sorting grid installed in a trap-net have substantially higher survival probabilities than herring escaping from active gear such as a trawl (Suuronen et al., 1996a,b). However, further studies are needed.

In conclusion, this study demonstrated that selection grids fitted around the fish chamber are indeed a very effective method for releasing small herring from the catch in a pontoon trap. The improved *SE* has both environmental and economic advantages; it reduces the discard rate of undersized fish and decreases the workload for the fishermen.

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