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The efficiency of selection grids in perch pontoon traps

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ABSTRACT

In commercial fishing, minimizing the bycatch of undersized fish or non-target species is highly beneficial, to avoid unnecessary fish mortality and to save time for the fishers. Two pontoon traps developed for perch fishing were equipped with size selection grids, and the efficiency with which under-sized fish could escape was tested. Average size of perch, roach, and whitefish was larger in traps with selection grids compared to in control traps without grids. Selection efficiencies using these comparisons were 82–86% for perch, 33% for whitefish and 100% for roach. The selection grids were filmed with an underwater video camera over the daily cycle, to estimate timing, and total number of exits from the traps. Selection efficiencies, calculated by extrapolating number of escapes observed to the total time of trap submergence, were 94–100% for perch and 100% for roach. The discrepancy in the selection efficiency estimates for perch probably depends on an uncertainty in the extrapolation, because of the variation in escape rate across time periods. Perch and roach differed in time of day for escapes. For perch most escapees was seen in the evening, and for roach most fish escaped at night, probably reflecting the general activity cycles of the two species. Over a fishing season, several thousands of fish would be able to escape from each trap, and an increase in the use of size selection grids could potentially be an efficient tool for fish population management.

1. Introduction

The stocks of many commercial fish species in our seas are decreasing at an increasing rate due to changes in the environment and to overfishing (Pauly et al., 2002; Worm et al., 2006; Costello et al., 2012). It is very important to develop methods of managing the fish resources in order to keep populations at sustainable levels (Alverson et al., 1994; Hall et al., 2000; Pitcher and Cheung, 2013). A big problem with commercial fishing is the bycatch of undersized fish or non-target species that, even if sorted out, experience a huge mortality rate when returned to the water (Alverson et al., 1994; Hall et al., 2000; Davis, 2002).

The Eurasian perch (*Perca fluviatilis* L.) is a common freshwater species, also occurring in the brackish waters of the Baltic Sea and the Gulf of Bothnia. The species is a popular target for both commercial and recreational fishing. There is no reliable information on the status of the perch populations along the coasts of Sweden (Swedish Board of Fisheries, 2011). Trends of both increases and decreases of perch abundance can be seen at the local level (Ljunggren et al., 2010). However, at the international level, commercial catches has decreased to half the size compared to those in mid 1990s, and questionnaire studies indicate that there is also a decrease in catch per unit effort (Olsson et al., 2012). This decrease may be explained by a combination of factors such as changes in the ecosystem (Casini et al., 2008; Ljunggren et al., 2010), increased populations of cormorants (Östman et al., 2012, 2013) and an increase in recreational fishing (Olsson et al., 2012). The annual landing of perch in the Swedish commercial fisheries is currently approximately 85 t (Swedish Agency for Marine and Water Management (SwAM), 2013), but catches from recreational fishing is many times higher (Persson, 2010).

Suuronen et al. (2012) included traps in a compilation of LIFE fishing gear (low impact and fuel efficient) as a fishing gear that possess several attractive characteristics compared to many other fishing gears: low energy use, minimal habitat impact and high

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quality of the fish. In line with this, a new pontoon trap was recently developed for the commercial small-scale perch fishery, with the aim to be catch-effective while at the same time protect the caught fish from seal predation (Harmångers Maskin & Marin AB in collaboration with Programme Seals & Fisheries). The function and properties of the pontoon trap for perch is similar to the pontoon traps developed for the salmonid fishery (Suuronen et al., 2006; Hemmingsson et al., 2008) and the herring fishery (Lundin et al., 2011a) but is approximately half the size of the aforementioned. One drawback is that traps sometimes get large bycatches of undersized fish and non-target species. With a mesh size of 20 mm, also small, unwanted perch remain in the trap and have to be sorted out and returned to the water, a procedure that is time consuming for the fishers and may lead to mortality of the discarded fish. Even small individual roach (*Rutilus rutilus*) and whitefish (*Coregonus maraena*) are caught in this trap. It is desirable to decrease the catch of small fish, in order to lower the ecological impact of fishing, by improving the possibility for escape and survival of these non-commercial sizes. This would be positive both from an ethical perspective and for a long-term prospect of the populations.

The use of selection panels have been tested and evaluated in other types of pontoon traps, with good results (Lundin et al., 2011a,b, 2015). In these tests non-commercial fish have been able to escape from the trap. There are also indications of a good survival rate after escape through a selection grid (Lundin et al., 2012). The captured fish have to find the escape route and manage to pass through the grid, by making active choices. It is therefore important to place the selection grid where most of the fish are located and where they can easily detect and escape through the grid. Here we describe a development of a pontoon trap for perch, aimed at allowing small fish to escape and survive after a trapping event.

The use of selection grids in smaller perch traps has so far not been evaluated. The aim of this study was to test and estimate the escape efficiency of a selection grid in perch traps by comparing size distribution in traps with and without grids and by looking at fish behaviour in the traps by continuous video recordings.

2. Material and methods

2.1. The traps

In this study two different types of traps were used (A and B) (Fig. 1). Trap A was manufactured by Ab Scandi Net Oy and consisted of a leading net and adapter combined with wings. Trap B was manufactured by Harmångers Maskin & Marin AB and consisted of a leading net, wings and adapter. Both traps were made of Polyethylene netting with 40 mm mesh size. The wings and adapter in trap B were separated by an additional entrance. Both traps were equipped with pontoon fish chambers of Dyneema® netting with 20 mm mesh size. The fish chambers were produced by Harmångers Maskin & Marin AB. The location for trap A was near Sundsvall, Sweden (62°23′N, 17°32′E), trap B was placed near Forsmark, Sweden (60°28′N, 18°04′E) and was used in collaboration with a commercial fisher. Both traps were placed at a final depth of 6 m.

2.2. Selection grids

The selection grids used were made of vertical 2 mm stainless steel bars covering an area of 300 × 400 mm, with 30 mm wide gaps between the steel bars. The grid was attached with cable ties in the far end of the fish chamber near the final entrance where the selection efficiency has been high in other types of traps targeting other species (Lundin et al., 2011b, 2013, in prep) (Fig. 2).

2.3. Data collection and analyses

Trap A was used between 12 June and 21 August, and trap B between 27 June and 27 July. The number of fishing periods (from submersion until harvesting of the trap) were 18 for trap A and 9 for trap B. To be able to measure the effect of the selection grids on size distribution of caught fish, the grids were covered with fine-meshed netting during certain fishing periods. For trap A, the grid was covered during the first four fishing periods and at two additional periods in the end of the season. For trap B, the grid was covered during the first three fishing periods. The aim was to measure at least 100 perch from each trap caught without the grids, to get reliable background data. All fish caught in the traps were measured (total length to the nearest lower 0.5 cm length class), and the length distributions with and without grid, were compared for each trap separately, using independent sample *t*-tests. The difference in the proportions of small fish caught with and without selection grid was tested using χ^2 tests comparing number of small and large fish, respectively, caught in each of the traps with the grid present and absent. The definitions of small fish were <24.5 cm for perch, <25.5 cm for whitefish and <30 cm for roach (see below).

The grids were video-recorded from a distance of 50 cm with an underwater camera connected to a recorder in a water-proof case

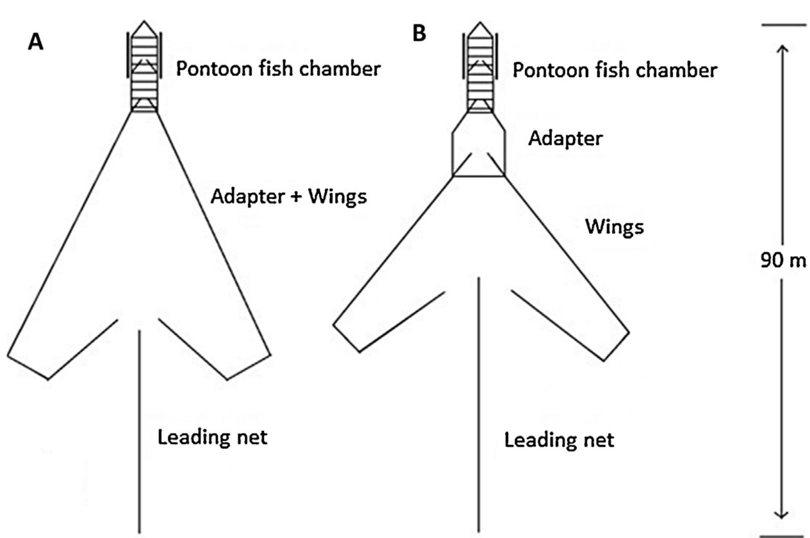

Fig. 1. Perch traps used in the experiment.

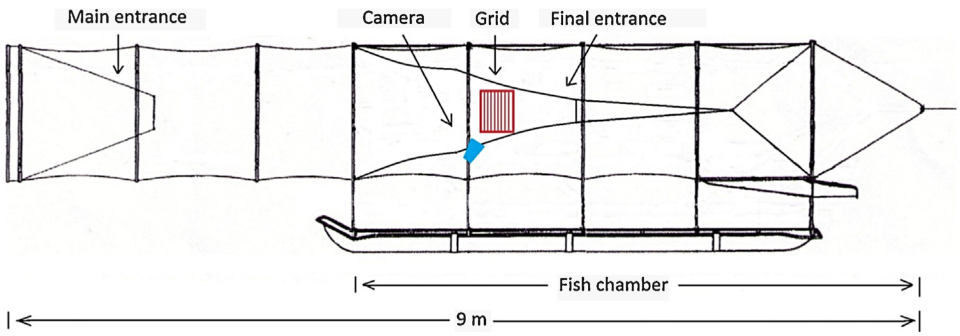

Fig. 2. Pontoon fish chamber including placement of the selection grid and camera.

Table 1
Total number of individuals of the most common species caught in perch pontoon traps, with and without selection grid. Where relevant, percentages of the total catch consisting of small fish (perch: <24.5 cm; whitefish: <29.9 cm; roach: <25.5 cm) are shown within parentheses.

Trap	Grid	Perch (%small)	Whitefish (%small)	Roach (%small)	Herring
A	No	199 (56%)	97 (82%)	0	
	Yes	50 (8%)	29 (55%)	0	
B	No	97 (77%)	7	79 (90%)	205
	Yes	37 (14%)	3	17 (0%)	

that was attached to the trap (Fig. 2). During the study period, the natural light was enough for filming even at night, and no extra light was used. The camera was started in connection with the submersion of the fish chamber after harvesting, and the recorded time varied between 5 and 25 h. All recordings were analysed and every escape was registered with species, date, and time of day. The number of escapees during the recorded time was extrapolated to the total time between trap submersion and the following fish harvesting. This number was then compared with the remaining number of fish in the trap small enough to be able to pass through the grid (selectable size). Selectable size was defined as smaller than the species-specific length that corresponded to a width of 30 mm (i.e. the distance between bars in the grid). The length/width relationships were calculated from trapped fish caught and measured at 6 locations along the Swedish coast in 2011. The length at a width of 30 mm was 24.5 cm for perch (commercial minimum size 20–24 cm), 25.5 cm for roach and 29.9 cm for whitefish (commercial minimum size 30 cm) (n = 97, 12, 102, respectively). Thus the selection efficiency could be estimated for each species and for each trapping period.

Four time periods were compared over the 24 h cycle: morning 03:00–09:00 h; day 09:00–15.00 h; evening 15:00–21:00 h; night 21:00–03:00 h. Number of hours filmed during the four periods were similar, except for the evening period that had more hours recorded (morning: 22 h, day: 27 h, evening: 34 h, night: 25 h). The differences between time periods in number of escapees of different species were tested with a χ^2-test comparing observed escapes with the expected number if the escape rate was the same during all time periods, adjusting for number of hours recorded during the different periods.

3. Results

3.1. Species caught

At both fishing locations the harvest consisted mainly of perch, whitefish, herring, and roach (Table 1). No roach, and very few herring were caught in trap A, and only a few whitefish were caught in trap B. Other species caught occasionally were ide (*Leuciscus idus*), bream.

(*Abramis brama*), vimba bream (*Abramis vimba*), Crucian carp (*Carassius carassius*), rudd (*Scardinius erythrophthalmus*), salmon smolt (*Salmo salar*), trout (*Salmo trutta*), three-spined stickleback (*Gasterosteus aculeatus*), pike (*Esox lucius*), pike-perch (*Sander lucioperca*), and flounder (*Platichthys flesus*).

3.2. The effect of selection grid

The number of small, non-commercial fish caught in the traps was clearly reduced when the selection grids were in function, compared to when they were not in use (Fig. 3). The reduction, with a significantly lower proportion of small fish caught with the grid present, could in trap A be seen most clearly among perch ($\chi^2 = 36.7$, df = 1, $p < 0.001$) and whitefish ($\chi^2 = 8.3$, $p < 0.004$, df = 1; Table 1). In trap B, the reduction was most apparent for perch ($\chi^2 = 42.9$, $p < 0.001$, df = 1) and roach ($\chi^2 = 52.0$, $p < 0.001$, df = 1; Table 1, Fig. 3). These reductions are equivalent to selection efficiencies of 86% and 82% for perch in trap A and B, respectively, 33% for whitefish, and 100% for roach.

Table 2
Average body length (cm; mean ± sd) of fish caught in the traps, with and without selection grid. Differences between treatments, tested with independent samples t-test, are also presented where relevant. N/A—not applicable due to lack of catch data.

Trap	Grid	Body length		
	Roach		Perch	Whitefish
A	No	23.9 ± 3.2	23.2 ± 6.4	N/A
	Yes	27.8 ± 2.8	28.3 ± 6.4	N/A
		$t = 8.0$, $p < 0.05$, df = 247	$t = 3.8$, $p < 0.05$, df = 124	
B	No	21.8 ± 4.1	30.7 ± 9.0	22.0 ± 3.3
	Yes	28.1 ± 3.3	37.2 ± 1.5	28.4 ± 1.3
		$t = 8.4$, $p < 0.05$, df = 132		$t = 7.8$, $p < 0.05$, df = 94

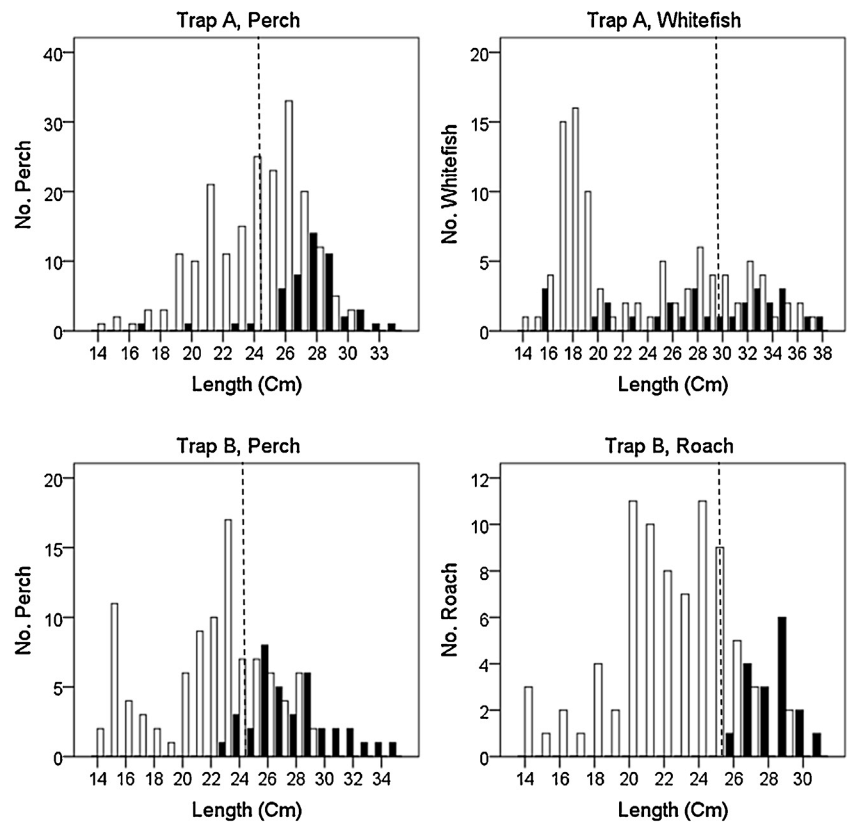

Fig. 3. Size distribution of fish in the traps with (black bars) and without (white bars) selection grid. The data from all catch periods are used here. (Dashed line indicates the length at which the width of the fish is equal to the distance between the bars in the grid.)

The fish of all three species were on average longer when the grid was used compared to when it was not (independent sample *t*-tests; Table 2).

3.3. Video recordings

The total recorded time was 108 h divided into six fishing periods. The last period lacked catch data and was therefore not used in the efficiency calculations. The film from the 6th period was, however, examined and used in the time-of-day analysis. The time recorded at the separate time periods correspond to 12%–79% of the total time (Table 3). Number of recorded hours per time-of-day period varied between 22 and 34.

In the video recordings a total of 418 fish were seen escaping from the traps of which 286 were perch and 121 roach. Even during the darkest hours the natural light was enough to clearly detect and distinguish the escapees.

When comparing the number of perch escaping during a fishing period, estimated as an extrapolation of escapees filmed, to the full fishing time, with number of remaining fish of a selectable size, the selection efficiency varied between 94% and 100% (Table 4). The same calculations for roach gave consistent selection efficiencies of 100% (Table 4).

For perch and roach, there was a significant difference in number of escapees during the different time periods (Perch: $\chi^2 = 91.0$, $p < 0.001$, df = 3, Roach: $\chi^2 = 287.1$, $p < 0.001$, df = 3; Fig. 4). For perch, there were significantly more fish escaping during the evening, in connection with dusk, compared to the other time periods (Fig. 4). For roach, most escapes occurred during night time (Fig. 4).

Table 3
Catch periods when video recordings were made. Number of recorded hours, total time of each catch period and percentage of time recorded of the total time of trap submersion are shown. N/A—not applicable due to lack of catch data.

Date	Trap	Hours recorded	Total time	% time recorded
22 Jun	A	5	42	12
25 Jun	A	19	24	79
10 Jul	B	13	72	18
13 Jul	B	23	75	31
16 Jul	B	25	69	36
19 Jul	B	23	N/A	N/A

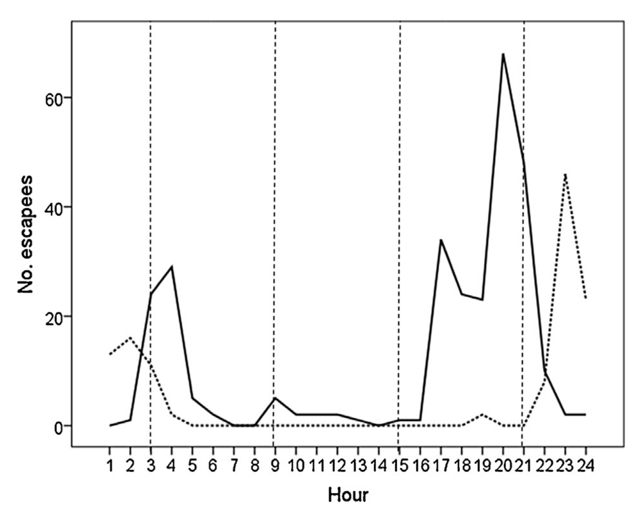

Fig. 4. Total number of escapes of perch (black line) and roach (dotted line) over the daily cycle observed on video recordings. Vertical broken lines show the divisions of time periods (morning, day, evening, night).

Table 4
Number of observed fish escaping per recorded event, and number of escapes for the whole catch period estimated by extrapolation. Number of observed escapes, estimated total number of escapes, number of remaining fish in the trap of selectable size, and selection efficiency for perch and roach for the separate traps and catch periods are shown.

Trap/period	Perch				Roach			
	Obs. escapes	Estimate total	Remain total	Eff. %	Obs. escapes	Estimate total	Remain total	Eff. %
A 1	0	0	0	–	0	0	0	–
A 2	13	16	0	100	1	1	0	100
B 1	32	178	1	99	6	33	0	100
B 2	62	200	13	94	110	359	0	100
B 3	28	78	1	99	6	17	0	100

4. Discussion

The use of selection grids on the perch pontoon traps is an efficient way to sort out small-sized fish. The frequency of the total catch of perch that was smaller than 24.5 cm decreased from 56% to 8% in trap A and from 77% to 14% in trap B when the grid was used, compared to when it was not. No roach smaller that the grid dimension was caught when the grid was in use, while 90% of the roach caught without the grid were of the smaller size class (i.e. <25.5 cm). This shows that all roach which could escape through the grids did so. In trap A, the selection of under-sized whitefish seemed less efficient than for perch. Without the grid, 82% of the whitefish were of non-commercial size, but with the grid, the frequency of these smaller individuals was still as high as 55%. Thus, the whitefish seems to be the species less likely to escape the trap. More than 200 herring were caught in trap B, but since they were all caught on one occasion, when there was no selection grid, no conclusions can be made on herring selectivity.

The selection efficiency was calculated in two ways for perch and roach. Comparisons were made of the proportions of small fish in the trap, with and without the grid, including the total catch over the season. These estimates showed an efficiency of 82–86% for perch, and 100% for roach. The video recordings showed a higher selection efficiency for perch, varying between 94% and 100%, but still with a 100% escape rate for the roach smaller that the grid width. The different estimates for perch may depend on an uncertainty in the extrapolation, because of the variation in escape rate across time periods. Filming time was distributed among all the time periods, but with a higher number of hours filmed in the evening, when the perch had the highest number of escapes. The total escape rate could thus be exaggerated, explaining the discrepancy between the two different ways to estimate selection efficiency of perch. Still, both estimates show a higher selection efficiency than earlier found for similar grids for herring (28%, Lundin et al., 2011a) and whitefish (78%, Lundin, unpublished data). The reason for this is unknown, but may depend on differences in behaviour between species. There is also a difference in the location of the traps. The fish chamber in a perch trap is usually placed on the bottom, while those traps aimed at catching herring and whitefish are placed near the surface. In herring traps there is a higher selection efficiency during the dark hours (Lundin et al., 2011a,b). On the bottom where the perch traps are placed there is less light. Accordingly, these results may suggest that fish in general tend to explore the surrounding more in low light conditions when less conspicuous. Also, the smaller size of the perch trap compared to the herring and whitefish traps may lead to a higher probability of detection of the grid, as the volume of water the fish may swim in, is considerably smaller.

Another important feature for selection efficiency is the design of the selection grid. The location, size, and shape of the grids are important factors. Pilot studies have shown that the optimal opening size was around 30 mm as a compromise of a practical selection of commercial sizes of perch and whitefish in Sweden fishery, allowing fish smaller than the required size of each particular species to escape.

The timing of the escape differed between perch and roach. Perch had the highest escape rate in the evening at dusk compared to other time periods, but some also escaped in early morning. In contrast, most roach escaped during the night. This may depend on differences between the species in activity pattern. Perch is a diurnal forager, and shows activity peaks at dawn and dusk (Eriksson, 1978; Jamet and Lair, 1991). Roach in the river Spree were found to stay in structured areas in the daytime but entered open areas at night (Baade and Fredrich, 1998). In a laboratory study, swimming speed was highest during the night, in connection with a shift of habitat, and it was hypothesised that roach migration occurred mainly during the dark hours (Hammer et al., 1994). Further, with perch being an important predator on roach (Persson, 1988), the activity of roach in the presence of perch in the trap may have been concentrated to the time of day when the perch is not foraging. There is probably a correlation between the timing of the fish entering the trap and escaping, however, we do not have any data on when the fish of different species enter the trap.

In conclusion, the use of selection grids for commercial fishing with pontoon traps is recommendable for several reasons. It saves time for the fishers who will spend less time size sorting when emptying the trap. When using our results to estimate number of fish managing to escape across a fishing season of two months, 3–4000 small perch would be spared by the escape from one trap only. The potential increase in improved recruitment and higher fisheries yields due to selection is however difficult to estimate. Compensatory mechanisms, for example, in terms of reduced survival and body growth at a higher population density may reduce the positive effects. An estimation of the competition for perch between humans and cormorants in the Baltic area shows that the predation of small perch was more important than the direct consumption of commercial size, using available figures of perch life parameters (Östman et al., 2013). This is reasonable as perch abundance has declined during the last decades in many parts of the Baltic Sea (Ljunggren et al., 2010), probably resulting in low density dependent effects.

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References

Alverson, D.L., Freeberg, M.H., Murawski, S.A., Pope, J.G., 1994. A global assessment of fisheries by-catch and discard, FAO, Fish. Tech. P. NO. 339. FAO, 92-5-103555-5.

Baade, U., Fredrich, F., 1998. Movement and pattern of activity of the roach in the River Spree, Germany. J. Fish. Biol. 52, 1165–1174.
Casini, M., Lövgren, J., Hjelm, J., Cardinale, M., Molinero, J.C., Kornilovs, G., 2008. Multi-level trophic cascades in a heavily exploited open marine ecosystem. Proc. R. Soc. B 275, 1793–1801.
Costello, C., Ovando, D., Hilborn, R., Gaines, S.D., Deschenes, O., Lester, S.E., 2012. Status and solutions for the world's unassessed fisheries. Science 338, 517–520.
Davis, M.W., 2002. Key principles for understanding fish bycatch discard mortality. Can. J. Fish. Aquat. Sci. 59, 1834–1843.
Eriksson, L.O., 1978. A laboratory study of diel and annual activity rhythms and vertical distribution in the perch, *Perca fluviatilis*, at the Arctic circle. Environ. Biol. Fishes 3, 301–307.
Hall, M.A., Alverson, D.L., Metuzals, K.I., 2000. By-catch: problems and solutions. Mar. Pollut. Bull. 41, 204–219.
Hammer, C., Temming, A., Schubert, H.J., 1994. Diurnal variations in swimming activity of *Rutilus rutilus* (Cyprinidae) in a group under tank conditions. Int. Rev. Gesamten Hydrobiol. 79, 385–396.
Hemmingsson, M., Fjälling, A., Lunneryd, S.G., 2008. The pontoon trap: description and function of a seal-safe trap-net. Fish. Res. 93, 357–359.
Jamet, J.L., Lair, N., 1991. An example of diel feeding cycle of 2 percids, perch (*Perca fluviatilis*) and ruffe (*Gymnocephalus cernuus*) in eutrophic lake Aydat (France). Ann. Sci. Nat. Zool. Biol. Anim. 12, 99–105.
Ljunggren, L., Sandström, A., Bergström, U., Mattila, J., Lappalainen, A., Johansson, G., Sundblad, G., Casini, M., Kaljuste, O., Eriksson, B.K., 2010. Recruitment failure of coastal predatory fish in the Baltic Sea coincident with an offshore ecosystem regime shift. ICES J. Mar. Sci. 67, 1587–1595.
Lundin, M., Calamnius, L., Hillström, L., Lunneryd, S.G., 2011a. Size-selection of herring in a pontoon trap equipped with a rigid grid. Fish. Res. 108, 81–87.
Lundin, M., Ovegård, M., Calamnius, L., Lunneryd, S.G., Hillström, L., 2011b. Selection efficiency of encircling grids in a herring pontoon trap. Fish. Res. 111, 127–130.
Lundin, M., Calamnius, L., Lunneryd, S.G., 2012. Survival of juvenile herring after passing through a selection grid in a herring pontoon trap. Fish. Res. 127–128, 83–87.
Lundin, M., Calamnius, L., Fjälling, A., 2015. Size selection of whitefish (Coregonus maraena) in a pontoon trap equipped with an encircling square mesh selection panel. Fish. Res. 161, 330–335.
Olsson, J., Beier, U., Bergek, S., Karlsson, M., Hentati-Sundberg, J., 2012. Beståndsstatus hos abborre, gädda, sik och gös i de stora sjöarna och längs kusten. In: Report in Swedish. Dept. of Aquatic Resources, Swedish University of Agricultural Sciences, pp. 37.
Pauly, D., Christensen, V., Guénette, S., Pitcher, T.J., Sumaila, U.R., Walters, C.J., Watson, R., Zeller, D., 2002. Towards sustainability in world fisheries. Nature 418, 689–695.
Persson, L., 1988. Asymmetries in competitive and predatory interactions in fish populations. In: Ebenmann, B., Persson, L. (Eds.), Size-structured Populations: Ecology and Evolution. Springer, Berlin, Heidelberg, pp. 203–218.
Persson, L., 2010. Sweden's fisheries catches in the Baltic Sea (1950–2007). In: Rossing, P., Booth, S., Zeller, D. (Eds.), Total Marine Fisheries Extractions by Country in the Baltic Sea: 1950—Present Fisheries Centre Research Report 18 1. Fisheries Centre, University of British Columbia, Vancouver.
Pitcher, T.J., Cheung, W.W.L., 2013. Fisheries: hope or despair? Mar. Pollut. Bull., http://dx.doi.org/10.1016/j.marpolbul.2013.05.045.
Suuronen, P., Siira, A., Kauppinen, T., Riikonen, R., Lehtonen, E., Harjunnpää, H., 2006. Reduction of seal-induced catch and gear damage by modification of trap-net design: design principles for a seal-safe trap-net. Fish. Res. 79, 129–138.
Suuronen, P., Chopin, F., Glass, C., Løkkeborg, S., Matsushita, Y., Queirolo, D., Rihan, D., 2012. Low impact and fuel efficient fishing—looking beyond the horizon. Fish. Res. 119–120, 135–146.
Swedish Agency for Marine and Water Management (SwAM), 2013. Catch Statistics, ⟨https://www.havochvatten.se/en/start/permits-and-enforcement/commercial-fishing/catch-statistics.html⟩.
Swedish Board of Fisheries, 2011. Fish Stocks and the Environment in Marine and Inland Waters—A resource and Environment Overview, Available on internet: ⟨https://www.havochvatten.se/download/18.472732f513318aaf1af800075/1348912838598/ROM+2011.pdf⟩ (in Swedish).
Worm, B., Barbier, E.B., Beaumont, N., Duffy, J.E., Folke, C., Halpern, B.S., Jackson, J.B.C., Lotze, H.K., Micheli, F., Palumbi, S.R., Sala, E., Selkoe, K.A., Stachowicz, J.J., Watson, R., 2006. Impacts of biodiversity loss on ocean ecosystem services. Science 314, 787–790.
Östman, Ö., Bergenius, M., Boström, M.K., Lunneryd, S.G., 2012. Do cormorant colonies affect local fish communities in the Baltic Sea? Can. J. Fish. Aquat. Sci. 69, 1047–1055.
Östman, Ö., Boström, M.K., Bergström, U., Andersson, J., Lunneryd, S.G., 2013. Estimating competition between wildlife and humans—a case of cormorants and coastal fisheries in the Baltic Sea. PLoS One 8 (12), e83763, 10.1371/journal.pone.0083763.