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Letter to the Editor

Overestimated effect of cormorant predation on fisheries catches

Comment to the article by Salmi, J.A. et al., 2015: Perch (*Perca fluviatilis*) and pikeperch (*Sander lucioperca*) in the diet of the great cormorant (*Phalacrocorax carbo*) and effects on catches in the Archipelago Sea, Southwest coast of Finland. Fisheries Research 164, 26–34

1. Introduction

The article by Salmi et al. (2015), recently published in *Fisheries Research*, presents valuable novel information on the diet of the great cormorant (*Phalacrocorax carbo sinensis*) in the Archipelago Sea in two years, and on the size and age distribution of the commercially important percid species, pikeperch (*Sander lucioperca*) and perch (*Perca fluviatilis*), in the diet. However, the calculation of potential catch losses of pikeperch and perch ignores some essential data and knowledge on the population dynamics and fishery of the stocks, and fails to demonstrate the real uncertainty of the results. To understand the role and potential effects of the cormorants vs. fishing, it is necessary to more thoroughly consider the growth, natural and fishing mortalities in the pikeperch and perch stocks, and the state of fisheries in the study area. There is extensive data starting from the 1980s available for this purpose, and also published articles on the pikeperch (Heikinheimo et al., 2006, 2014; Pekcan-Hekim et al., 2011; Kokkonen et al., 2015). Here we present background information on the commercial and recreational catches, CPUEs (catches per unit of effort) in the commercial fishing, and growth and mortality of the species. We repeated the calculation of the potential catch losses of pikeperch correcting some inconsistencies in the parameter values, and performed sensitivity analysis to cover the whole range of uncertainty in the results. For perch we did not recalculate the catch losses but we present data that was ignored by Salmi et al. (2015) and show that their estimates were apparently biased.

2. Fisheries catches and CPUE

Salmi et al. (2015) present the commercial pikeperch and perch catches in the Archipelago Sea in 1998–2011 with the number of cormorant nests in the same figure, and there seems to be a negative correlation since the early 2000s when the cormorant population started a rapid growth. In pikeperch this is largely a consequence of the catch peak in 2003, due to the strong year class 1997 (Heikinheimo et al., 2014), which by chance occurred at the same time as the start of the increase in the abundance of cormorants. Moreover, the recreational catches should be included to see the real development of the catches (Fig. 1). Further, the catches depend on the fishing effort, and therefore the CPUEs should be considered as well (Figs. 2 and 3). Total catch estimates are currently available until 2013 for commercial fisheries, and until 2012 for recreational fisheries (Official fisheries statistics, Natural Resources Institute Finland).

Salmi et al. (2015) say that the recreational pikeperch and perch catches reached their lowest level since 1986 in 2010. This is partly misleading because in 2010 the sampling scheme in the recreational fisheries survey was different from that in earlier years, and in 2012 the recreational pikeperch catch rose again to the same level as in most years in the latter half of the 2000s (Fig. 1). Thus, it seems not plausible that the recreational pikeperch catches decreased in the 2000s; on the contrary, in relation to the commercial catches they have increased. The recreational perch catch was on a rather constant level in the period 2008–2012, only the year 2010 was an exception.

Salmi et al. (2015) point out a downward trend in the commercial perch catch in the period 1998–2011. However, the development of the catch (Fig. 2) looks different when we consider the whole time series available from 1980 to 2013; there is rather natural fluctuation than an effect of a new external factor in the recent decade. The share of recreational fishing in the perch catch is even larger than in the pikeperch catch, and thus there is still more uncertainty in the magnitude and fluctuation patterns of the total perch catches.

If there was an effect of the increasing cormorant population on the pikeperch and perch stocks, it should come out rather in the catches per unit of effort than in the total catch. The commercial fishing effort with gillnets, which is the main gear used in the pikeperch and perch fishery, was high in the 2000s in the rectangles 47 and 52, compared to the two earlier decades (Fig. 3). There was a peak in 2003 in all rectangles. In the rectangle 51 the fishing effort went down after that peak, mainly due to the disturbance caused by grey seals (*Halichoerus grypus*) (Lehtonen and Suuronen, 2004), and the fishing largely concentrated to more sheltered inner archipelago and bay areas in the rectangles 47 and 52.

In the CPUE of pikeperch there was a peak in 1997 in other rectangles than 47, and after that relatively constant level, except a slight decrease in the rectangle 52 (Fig. 3). In the CPUES the peak observed in the total catch in 2002 is only slightly distinguishable, which is most probably due to the exceptionally high fishing effort in that period, reducing the density of catchable-sized fish, with the instantaneous fishing mortality rate reaching even 1.8 per year (Heikinheimo et al., 2014).

In perch, there has been mainly downward trend in the CPUEs since 1998–2002, but less so in the rectangle 51. On the contrary, an abrupt increase in the CPUE occurred there in 2009–2013. Comparison to the fishing effort indicates that the lower CPUEs since 2002 in the rectangles 47 and 52 coincide with high fishing effort (Fig. 4).

The number of cormorants was highest in the rectangle 51 (1446 breeding pairs in 2010), compared to the numbers in the rectangles 47 and 52 (1067 and 425 breeding pairs in 2010, respectively,

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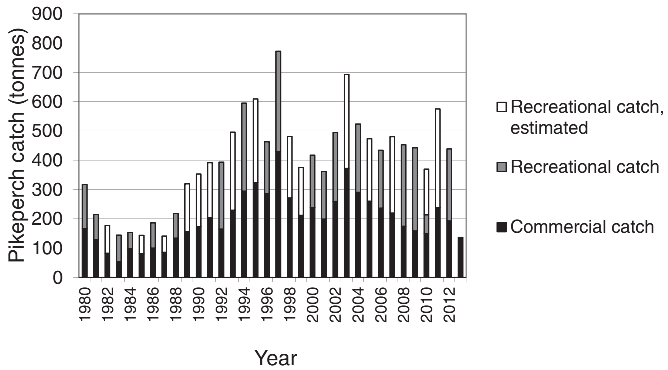

Fig. 1. Pikeperch catches in the Archipelago Sea (ICES rectangles 47, 51 and 52) from 1980 to 2013 according to the official fisheries statistics (Natural Resources Institute Finland). Estimates of recreational catches in the years between the recreational fishery surveys were produced by interpolation, using the recreational catch/commercial catch relationship. In 2010 both the survey result and the estimate are shown because of different sampling schedule and low number of responses in the survey (Heikinheimo et al., 2014). The recreational catch in 2013 was not estimated.

source: P. Rusanen, Finnish Environment Institute). Thus the presence of cormorants seems not to explain the drastic difference in the perch CPUE patterns between rectangles 51 and 52.

3. Sex differences in growth and mortality of perch

The perch females form the majority of catches in gillnets, about half of the catch in trap nets, and minority in wire trap nets (unpublished data, Natural Resources Institute Finland). The reasons to this are mainly the size-selectivity of gillnets, most of the big perch being females, and maybe partly the behavior of the fish. Trap nets are less size selective than most other gear types, and the catches can be assumed to roughly represent the size and sex composition in the population in the size classes recruited to trap nets. When we consider the length distribution by sex in the trap net catch, it is obvious that at least half of the perch in the size classes mainly taken by cormorants are males, whereas females dominate in the catches of commercial fisheries. The most common length classes of perch in the food of cormorants (13–14 cm, Salmi et al., 2015) are predominantly males (Fig. 5). Therefore it is erroneous to assume, as Salmi et al. (2015) did, that all the small perch taken by cormorants would have grown to the sizes taken by fisheries. The mean length of male perch is 22–24 cm even in age groups >10 years, and the mean length in the total trap net catch is 18 cm for males and 22 cm for females. Moreover, the perch below 100–150 g in weight, corresponding to the lengths of about 20–22 cm, have no commercial value and are mostly discarded from the trap net catch.

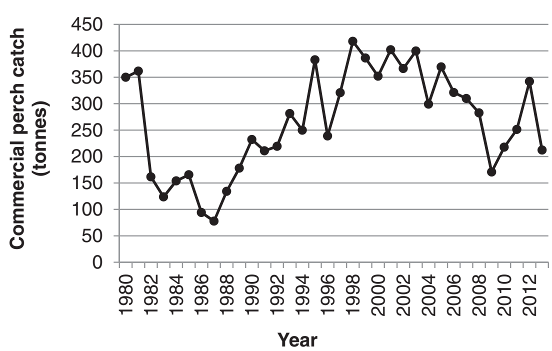

Fig. 2. Commercial perch catch in the ICES rectangles 47, 51 and 52 in the Archipelago Sea in 1980–2013 (Official fisheries statistics, Natural Resources Institute Finland, P. Söderkultalahti).

Table 1
Instantaneous mortality per year of perch males and females in the Archipelago Sea, calculated from the average age composition in the trap net catches using the catch curve method (Hilborn and Walters, 1992). The age groups completely recruited to the trap net fishing were used in the calculation. In the periods less than 10 years the year class fluctuations may affect the mortality estimates.

Period	Males		Females	
	Mortality	Age groups	Mortality	Age groups
1978–1989	0.71	6–15	0.73 (0.76)	6–15 (7–15)
1990–1999	0.61	6–15	0.82	6–13
2000–2012	0.63	7–16	0.66	7–16
2000–2005	0.48	7–14	0.63	7–16
2000–2006	0.51	7–14	0.65	7–16
2005–2012	0.54 (0.61)	7–16 (7–14)	0.68 (0.71)	7–12 (6–12)

The size-selectivity of recreational fisheries is not well-known, but at least gillnets take predominantly females, and so does rod fishing with lures such as jigs. Ordinary angling or ice fishing with rods is most probably less size selective because small lures or natural baits are mostly used. As 82% of the recreational perch catch is taken with gill nets in the Archipelago Sea (P. Moilanen, Natural Resources Institute Finland), we can deduce that about 90% of the recreational catches consist of females.

If the effect of cormorant predation on the perch stocks would be large, the mortality of at least male perch should be higher since the mid-2000s compared to earlier decades. However, there is no change in the mortality in males, nor in the mortality of females (Table 1).

4. Calculation of potential loss of pikeperch catches

According to Salmi et al. (2015), the uncertainty in the calculation of potential loss of fisheries catches was due to the estimated food consumption of cormorants, and only minor uncertainty (14%) would be caused by the assumed rate of natural mortality. However, there are several other sources of uncertainty, and in our opinion the assumptions by Salmi et al. (2015) are partly

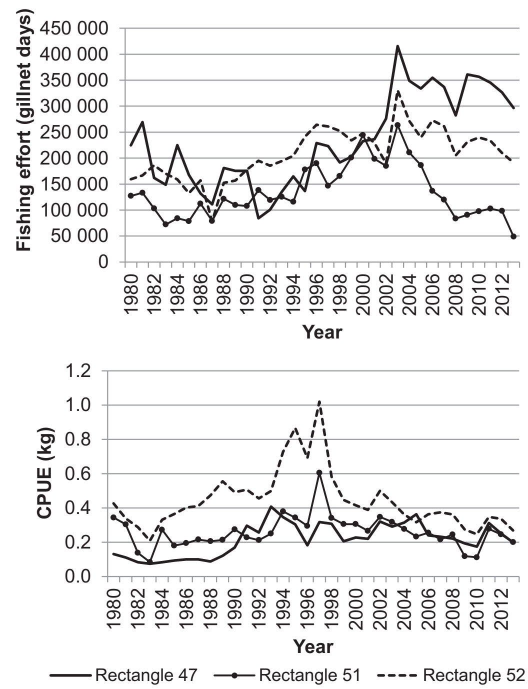

Fig. 3. Fishing effort with gillnets of mesh size 36–60 mm (bar length) and the pikeperch catch per unit of effort (CPUE) in the ICES rectangles 47, 51 and 52 in the Archipelago Sea.

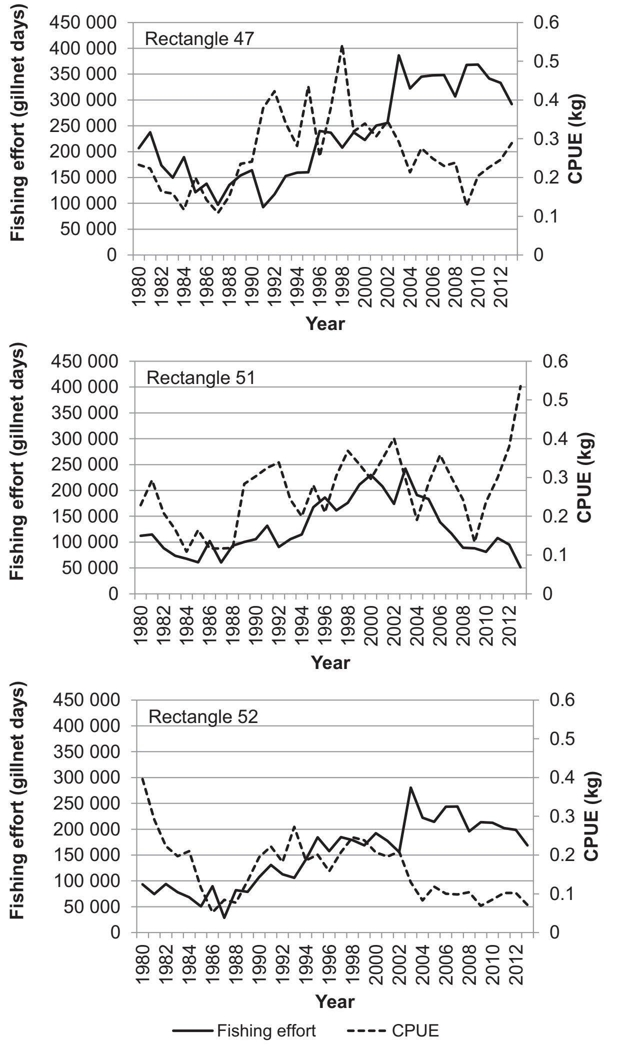

Fig. 4. Fishing effort with gillnets of mesh size 36–60 mm (bar length) and the perch catch per unit of effort (CPUE) in the ICES rectangles 47, 51 and 52 in the Archipelago Sea.

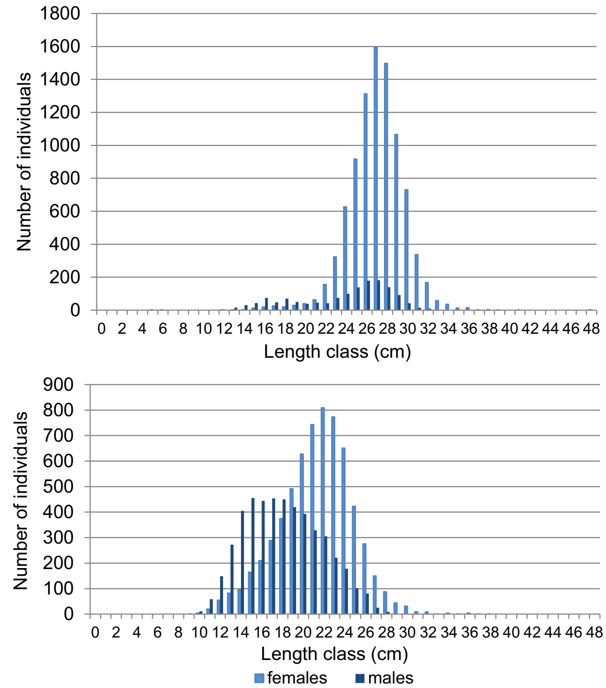

Fig. 5. Length distributions of female and male perch in gillnet catches (upper panel) and in trap nets (lower panel) in the Archipelago Sea. Data from 1978 to 2009. Cormorants mainly take perch of the length classes 9–22 cm, mode 13–14 cm (Salmi et al., 2015).

unrealistic. We repeated the calculation for pikeperch using alternative assumptions or values for instance for natural mortality, growth rate and proportions of discarded pikeperch in the fishery (Table 2). We used the same numbers of pikeperch individuals by age preyed upon by cormorants as Salmi et al. (2015). We made the following corrections to the parameter values or assumptions used in the calculation.

Salmi et al. (2015) assumed that the landings from trap net and rod fishing consist of legal-sized pikeperch only, and all fish under the legal catchable size (37 cm) are released, and 95% of these survive. This assumption is quite optimistic because majority of the pikeperch taken by trap nets and most probably also rods are below 37 cm in length, and even if the fish released from the trap nets may largely survive, those taken with rods and lures are often severely injured. Moreover, unfortunately, not all recreational fishermen obey the rules. Therefore we assumed that the catch includes individuals below 37 cm, and the mean weight of the pikeperch caught by trap nets and rods equals to that in the random samples from the trap net catches.

Salmi et al. (2015) took into account the proportion of undersized (<37 cm) pikeperch that will be discarded from gillnets using the data from 2010 to 2013, in which period the young pikeperch were mainly from weak year classes and thus there were relatively

Table 2
Results of the calculation of pikeperch catch losses caused by cormorants (Salmi et al., 2015), repeated using partly corrected parameter values and including sensitivity analysis with different assumptions on natural mortality.

Estimated catch loss (tonnes)		
Estimated number of pikeperch consumed by cormorants (Salmi et al., 2015)	461 000	570 000
Parameter values as in Salmi et al. (2015)	111	137
Proportion of fish below catchable size (37 cm) in gillnet catch from the data 2000–2010 (Table S1)	98	121
In addition: mean weight of pikeperch in trap nets and rod fishing in 2000–2010 (Table S1)	88	109
In addition: growth and mortality in age groups ≥5 corresponding to the initial length of 28 cm	77	95
In addition: different options of natural mortality:		
(a) Salmi et al. (2015) (sensitivity analysis, 0.8–0.1)	64	79
(b) Higher optional values (1–0.1)	59	73
(c) Vainikka and Hyvärinen (2012) (1.3–0.1)[a]	37	46

[a] Mortalities in age groups 1 and 2 were based on Vainikka and Hyvärinen (2012), but here the mortality was assumed to be lower for naturally born juveniles compared to the stocked fingerlings in Lake Oulujärvi. See Table S2 for age-specific values used in the sensitivity analysis.

few undersized individuals. We used the average proportion in 2000–2010, to cover different year class strengths (Table S1).

Salmi et al. (2015) assumed that the pikeperch taken by cormorants at ages ≥4 would grow to catchable size in one year. This is not possible because the majority of the pikeperch in the cormorants' diet in 2010 did not exceed the length of 28 cm, thus the older fish were slow-growing individuals and would need 2–3 years to reach the length of 37 cm. The length also affects the mortality rates. We combined the age groups ≥4 and used the same mean weights and mortality rates in successive years for all these age groups.

In addition, the natural mortality of young pikeperch most probably varies depending on the density of the stock and other factors, and in general the uncertainty in the estimates of natural mortality is large. Vainikka and Hyvärinen (2012) estimated the rate of natural mortality of pikeperch on the basis of stocking rates and stock assessment in Lake Oulujärvi, and the estimates for young age groups (1.5 at age 1, 1.0 at age 2) were essentially larger than those used by Salmi et al. (2015). Here we used slightly lower values for age 1 because the mortality of stocked fingerlings in Lake Oulujärvi may have been higher (Table S2).

Our results based on the first alternative of food consumption by Salmi et al. (2015) (461 000 pikeperch individuals) varied from 37 to 111 tonnes (Table 2), and for the larger estimated food consumption from 47 to 137 tonnes. The upper limits of these ranges are identical to the result by Salmi et al. (2015).

Our results show that the estimated catch loss largely depends on the assumptions and parameter values used in the calculation, the lowest results being only 34% of those by Salmi et al. (2015) (Table 2). Moreover, the calculation does not take into account any compensative processes in the fish assemblage (Rose et al., 2001), or the fact that the cormorant-induced mortality might not be additive to other sources of mortality (Hilborn and Walters, 1992). Consequently, the real effect of cormorants on the natural fish stocks may be at least in this case even negligible. This is supported by the fact that the stock-recruitment model for pikeperch, presented by Heikinheimo et al. (2014) fitted equally to the year classes preyed upon by cormorants, indicating that the summer temperature and spawning stock biomass still mainly determined the recruitment of pikeperch.

5. Implications for fisheries management

The overestimation of the cormorant effect on the fish stocks may significantly affect the attempts to sustainably manage the fisheries. The willingness of the fishermen to cooperate is low if they believe that the cormorants will take a considerable part of the pikeperch and perch before recruitment to the fishery, and they will prefer using small gill net mesh sizes to effectively compete with the predators. As the maturing size in the pikeperch stock in the Archipelago Sea has probably decreased as a consequence of high and size-selective fishing pressure (Kokkonen et al., 2015), the biased information on the effect of cormorants may lead to further negative development in the productivity of the stock and lower catches for the fishermen in the future.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.fishres.2016.01.020.

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