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Comments on the criticism in 'Overestimated effect of cormorant predation on fisheries catches' presented by Heikinheimo and Lehtonen, 2015

Heikinheimo and Lehtonen, 2015 assert in their paper that we had overestimated the effect of cormorant predation on fisheries catch in our article (Salmi et al., 2015). We do not agree. In their comment, they only show that the choice of parameter values and assumptions have a great influence on the results. They present alternative choices of parameter values and assumptions for the model. Their choices cumulatively reduce the effect of cormorants on fish catches.

In our paper (Salmi et al., 2015) we aimed at studying whether cormorant predation on perch and pikeperch in the Archipelago Sea could affect fishery catches. In the calculations we aimed at using parameter values and assumptions that could be supported by previous research. However, as we state in article, many parameters in the calculation are still poorly known and therefore concluded that the model gives only a rough estimate of the real situation.

Choices of assumptions and parameters for the pikeperch model

The largest difference in the results of these papers is due to the choice of natural mortality parameters. We applied the mortality rates from earlier studies in the Archipelago Sea (Setälä et al., 2003; Heikinheimo et al., 2006). Heikinheimo and Lehtonen (2015) chose to use higher values for the natural mortality. In their paper they did not express a preference for any of these values, but merely showed how a high natural mortality rate has an effect on the estimated catch loss of pikeperch. The adoption of a higher natural mortality rate from Lake Oulujärvi, situated about 500 km northeast of the Archipelago Sea, may be problematic because the abiotic and biotic conditions differ. In Lake Oulujärvi, the pikeperch lives at the northern border of its distribution area. There are many factors that affect the natural mortality rate and some of them differ from those in the Archipelago Sea when compared to Lake Oulujärvi, as presented in Vainikka and Hyvärinen (2012). Namely, (i) the pikeperch in Lake Oulujärvi were stocked as one-summer-old fingerlings and originated from natural food ponds and had no exposure to fish predators prior to stocking, (ii) the length of the growing season is shorter in Lake Oulujärvi, (iii) the ice-covered period is longer in Lake Oulujärvi, (iv) the fish assemblage in Lake Oulujärvi differs from that in the Archipelago Sea and v) in Oulujärvi there is an active commercial fishery with trawls catching vendace (*Coregonus albula*) and smelt (*Osmerus eperlanus*), with young pike-perch caught as by-catch (Korhonen et al., 2004). All these factors tend to increase the mortality of young pikeperch when compared to the Archipelago Sea.

The other parameter values that are presented in Table 2 (Heikinheimo and Lehtonen, 2015) had a smaller effect on the catch loss of pikeperch than the natural mortality rate. In our calculations we used the time period 2010–2013 when estimating the proportion of pikeperch below legal size (37 cm) in gill net catches. We selected this period because the growth rate of pikeperch has increased in recent years (data of Natural Resources Institute Finland), possibly because of multiple warm summers. Heikinheimo and Lehtonen (2015) used another time period, but in our opinion it is not appropriate for the present circumstances because of the changed growth rate.

Heikinheimo and Lehtonen (2015) criticize the assumption that fishermen using trap nets or rod fishing take mainly pikeperch of legal size (37 cm). However, they fail to give any estimate of the ratio of undersized fish in the reported catch. They also criticize our assumption that 95% of undersized pikeperch would survive after being released from trap-net or rod fishing. They do not give an alternative parameter value for this survival, but instead use the mean weight of trap-net samples in each age group and thus assume that all undersized fish in this gear are taken as catch. In our opinion, this assumption is unrealistic as the trap net catches are taken by commercial fishers and they cannot market undersized fish. In the few existing field experiments, the mortality of walleyes (*Stizostedion vitreum*) released after being caught using artificial baits in rod fishing has been around five percent (0–10%) (Payer et al., 1989; Parks and Kraai, 1991; Cano et al., 2001).

Heikinheimo and Lehtonen (2015) maintain that the share of undersized pikeperch in the gill net samples would be low in 2010–2013 because of previous weak year classes. However, the year-class strength does not influence the discard percentage, because the calculations were made on the basis of year class and age for the samples in 2010–2013.

In our paper we assumed that pikeperch under 35 cm in 2010 would not reach a legal size in the same year. During the following years they were assumed to be caught in the fisheries along with other fish in the same year class. The pikeperch exhibits a great plasticity in growth rate. The annual increment of fish size ranges from *ca.* 2 to 10 cm (data of Natural Resources Institute Finland). Warm summers are favorable to the growth of pikeperch (Pekcan-Hekim et al., 2011). In 2010 the mean annual increment in the back-calculated length of four- five- and six-year-old pikeperch was 58 mm, 52 mm and 43 mm, respectively. In the growth season 2011 the annual mean increments in length were 59 mm, 48 mm and 38 mm for the same year classes. Heikinheimo and Lehtonen (2015) maintain that it would not be possible for a pikeperch of 28–35 cm in length to reach the legal size (37 cm) in one or two growing seasons. As the growth increments in 2010 and 2011 have been as high as stated above, their assumption is not fully valid.

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Choices of assumptions affecting perch

The sexes of fishes eaten by cormorants were not determined. However, Heikinheimo and Lehtonen (2015) maintain that in the diet of cormorants males predominate in the most common length classes of perch. They base this assumption on trap net samples. It is commonly known that male perch are overrepresented during the spawning season in trap net samples (Le Cren, 2001). In gill net test fishing samples in the Archipelago Sea (Brunskär), the share of females has been over 50% in all length groups between 12 and 34 cm (data of Natural Resources Institute Finland). Gill net test fishing should reflect the actual sex ratio in the population as a whole. Therefore we conclude that at least half of the perch eaten by cormorants are females.

PIT- tag studies have shown that in the size classes from 12 to 25 cm the larger specimens of perch, roach (*Rutilus rutilus*) and bream (*Abramis brama*) have a greater risk of being eaten by a cormorant than their smaller specimens of the same species (Skov et al., 2014). This could imply that within a year class at least in a certain period of life, fish with a higher growth rate have a higher risk of being eaten, *e.g.* female perch may be under a greater risk than males.

Heikinheimo and Lehtonen (2015) further claim that some of the perch males would never have reached a catchable size. Although we agree that some of the males may not have reached the size being caught by commercial gill net fishing, they have had a possibility to grow to the sizes valued by recreational fishermen and commercial trap net fishers, who can sell even small sized perch to the European market.

Heikinheimo and Lehtonen (2015) have estimated the total mortality of perch in several time periods on the basis of the age distribution in trap net samples, and, because they did not notice changes in the total mortality rate, conclude that cormorants have not affected the perch stock. The total mortality may reflect the changes in the year-class strength, environment, fish assemblage, fisheries and predation by fish, birds and mammals. Therefore it is questionable to come to any conclusion about the role of cormorants based on these mortality values. The various mortality factors may have a wide variety of simultaneous effects.

Comments on other comments

In the introduction of our paper we presented the development of pikeperch and perch commercial catches in the Archipelago Sea and the number of cormorant nests during the period that cormorants have nested in the area. These developments led to us becoming interested in the subject and studying the cormorant's role in it. The increase of the perch and pikeperch catches since the mid 1980's until the turn of the millennium was mainly due to changes in the biotic and abiotic conditions, to the disappearance of cod (*Gadus morhua*) from the northern Baltic, to increased eutrophication and to the warmer climate. In our paper we did not deal with the fishing effort and the catch per unit of effort (CPUE) of pikeperch and perch fisheries in the Archipelago Sea. However, in their comment Heikinheimo and Lehtonen (2015) present their own opinions about the development of the fishing effort and the CPUE for pikeperch and perch fisheries in the Archipelago Sea, and about the role of cormorants in this development. In our opinion it is not relevant to speculate in this comment on something that we had not dealt with in our paper. The use of CPUE has its own uncertainties, especially as the types of the fishing gear, the fishing locations, and the attractiveness of fish species have changed during the time period presented by Heikinheimo and Lehtonen (2015). Furthermore, though the recreational fishing effort is poorly known its influence on the total fishing effort is decisive in perch fishing and has a significant effect in the pikeperch fishing.

In our paper, we used the official catch statistics on recreational fishing. Heikinheimo and Lehtonen (2015) suggest that values presented by Heikinheimo et al. (2014) should have been used instead. However, we consider those values at least partly misleading for the following reasons. The ratio between the pikeperch catch in the recreational fishery and the commercial fishery was rather stable during 2000–2006, *e.g.* between 0.8 and 0.96. In 2008 the ratio jumped to 1.6 and dropped to 0.5 in 2010. The coefficient of variation of the estimate was high in 2008 and 2010 (37 and 43, respectively), *e.g.* the reliability of both estimates was on the same level. However, Heikinheimo et al. (2014) have accepted the higher estimate for 2008 as such, but changed the lower estimate, 2010, to a much higher value outside 95% confidence interval. This largely hypothetic interpretation has influenced their virtual population analysis (VPA) results and the stock-recruitment model based on the VPA (Heikinheimo et al., 2014). Their stock-recruitment model also include statistical mistakes (Hansson, 2016).

Heikinheimo and Lehtonen (2015) stated that cormorants' presence does not explain differences in the perch CPUE between the statistical rectangles. This is obviously true, but they probably did not understand that the cormorants' feeding grounds and rectangles are not spatially equal, because cormorants do not respect man-made lines in their search for food. Therefore the comparison between the CPUE of perch and the cormorant breeding pairs is not relevant.

The number of fish eaten by cormorants probably has the greatest influence on fishery. The annual changes can be big, *e.g.* in 2009 cormorants consumed over 1 million pikeperch in the Archipelago Sea (Heikinheimo et al., 2015) whereas the number in 2010 was 460 000–570 000.

In contrast to our article, Heikinheimo and Lehtonen (2015) only use values in their sensitivity analysis that result in lower estimates of the effect of cormorants. They do not suggest any of their presented results as the most likely outcome and they cannot prove that the values they have chosen would be more reliable or better than those in our article.

Their main concern as to the alleged overestimation of cormorant effects seems to be the willingness of fishermen to accept fisheries management regulations. This does not justify the allegation that our results are overestimated. In order to make fishery management acceptable among the interest groups, the reasoning behind the suggestions should equally cover all the possible factors affecting the fish community and fishery. It is nevertheless the responsibility of the governmental officials to create such regulations that can be accepted by all participants.

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