



## Reply

### Response to comments by Heikinheimo *et al.* (in press) on Hansson *et al.* (2018): competition for the fish—fish extraction from the Baltic Sea by humans, aquatic mammals, and birds

Hansson, S., Kautsky, L., Bergström, U., Bonsdorff, E., Jepsen, N., Lundström, K., Lunneryd, S.-G., Ovegård, M., Salmi, J., Sendek, D., and Vetemaa, M. Response to comments by Heikinheimo *et al.* (in press) on Hansson *et al.* (2018): competition for the fish—fish extraction from the Baltic Sea by humans, aquatic mammals, and birds. – ICES Journal of Marine Science, 75: 1837–1839; advance access publication 10 July 2018.

As discussions and debates are crucial to science, we appreciate the comments by Heikinheimo *et al.* (in press) on our article on competition for Baltic Sea fish resources between fishery and wildlife. We cannot see that the comments by Heikinheimo *et al.* changes the general conclusion derived in our original article—that there are cases of competition between wildlife and fisheries in the Baltic Sea, although not for all species and not to the same extent everywhere. Our responses are structured in the same order as the comments by Heikinheimo *et al.*

**Keywords:** Baltic Sea, bird, catch, competition, fisheries, food consumption, seal.

#### Comparison of fisheries catches and predation

The objective of our article was to compare fish consumption by aquatic mammals and birds with fishery landings (both commercial and recreational) over the entire Baltic Sea and with the finest possible spatial resolution, given the biology of different species and the data available. We applied the ICES subdivision (SD) grid system when analysing data, as most fishery catches are reported using that system. This spatial division of the Baltic is reasonably consistent with the natural system of sub-basins (Bothnian Bay, Bothnian Sea, Gulf of Finland, and different parts of the Baltic Proper). Bird and seal abundances could also be derived for these areas. The ICES subdivisions simply constituted the least common denominator for a spatial analysis that integrates data from both fishery and the different species of wildlife. Our purpose was thus to present an overview of sources of fish removal, and not to focus on local-scale assessments of resource competition and predator–prey dynamics.

Heikinheimo *et al.* (in press) focus their comments on only one of the species of fish predators included in our analyses—the great cormorant (*Phalacrocorax carbo sinensis*) and on two coastal fishes, perch (*Perca fluviatilis*) and pikeperch (*Sander lucioperca*). Their main point is that ICES subdivisions constitute too large areas for drawing general conclusions regarding competition, as conditions vary within subdivisions. This is an aspect that we actually stress in our paper. For pikeperch we conclude that *With the patchy distribution of pikeperch, possible competition among seals, cormorants, and fisheries cannot be captured by our large-scale study.* For perch, we have an entire supplement in which we

discuss published studies on the possible impact by cormorants and conclude that conditions vary among areas, depending on e.g. the abundance of cormorants and the extent of habitat suitable for perch production.

In this context, when Heikinheimo *et al.* more specifically discuss local catches in coastal areas along the Finnish coast and deny effects of cormorant predation, we find it notable that they ignore the findings by Gagnon *et al.* (2015). That study was conducted at 18 stations along the Finnish coast, and is to our knowledge the only study designed specifically to investigate effects of cormorant predation on fish in the Baltic Sea. With its standardized approach, that study is likely to have a substantially better chance to detect effects of cormorant predation than *ad hoc* studies that use data that has been collected for other purposes (e.g. catch reports from a commercial fishery that targets several species and consequently exploits various habitats, have no specified fishing sites and uses gill nets with different mesh sizes). Gagnon *et al.* (2015) reported strong local effects of cormorant colonies on perch abundance. Östman *et al.* (2012) also found a negative correlation between cormorant abundance and perch catches, based long-term catches in a standardized fishery. Neither Östman *et al.* (2012) nor Gagnon *et al.* (2015) present information on the geographical extent of the area where perch had been impacted by cormorant predation. Their study sites were however substantially smaller than the ~3000 km<sup>2</sup> large ICES statistical rectangles from which Heikinheimo *et al.* (in press) and Lehikoinen *et al.* (2017) reported that there were no correlations between cormorant abundances and commercial catches. With the patchy geographical

distribution of both cormorants and perch, and the natural variation in perch year-class strength, we find it reasonable to assume that the likelihood of detecting negative impacts by the birds on catches decreases with increasing size of the study area, in particular if catch data are derived from a commercial fishery.

Heikinheimo *et al.* are critical to the cormorant diet compositions that we have applied to different subdivision, with 33% perch in SD29 based on a large study in the Finnish archipelago. There are however data from 4 other sites located close to SD29 and in these the proportion of perch in the diets were 30, 21, 17–41, and 3% (F, G, M, N in Supplement 2 of Hansson *et al.* 2018). The applied proportion of perch in the cormorant's diet in SD29 is thus not extreme, and even if this figure would result in an overestimation by 100%, the perch consumption by cormorants would still exceed fishery catches. For pikeperch, we concluded that *Pikeperch constitute a small fraction in cormorants' diet and predation estimates are uncertain*. Given this direct quote from our original text, and the citation above on the patchy distribution of pikeperch, we do not find any disagreement between the conclusions brought forward in Hansson *et al.* and the comments by Heikinheimo *et al.*

### Year-class fluctuations of perch and pikeperch

In this section, Heikinheimo *et al.* imply that we consider dynamics in fish abundance as resulting only from variation in predation and/or fishing, and that we consequently view population decreases as signs of competition. It is difficult to see how they can have misinterpreted us in this respect, as we were very explicit in our wording *Field observations of decreased abundance of a fish species in response to fisheries and/or predation by wildlife imply exploitative competition* (the underlining added here). Heikinheimo *et al.* then write that Hansson *et al.* (2017) stated that the commercial perch catch in the Finnish Archipelago Sea decreased by about 50% from 1998 to 2011, and Salmi *et al.* (2015) proposed that this was caused by predation by cormorants. This refers to a section in Supplement 4, and immediately after the cited section we write *Using data from all Finnish coastal areas during 2002–2014, when cormorants were well established and abundant, Lehikoinen et al. (2017) reported generally increased perch catch. They analysed changes in catch rates in commercial fisheries vs. dynamics in cormorant numbers and found no significant relationship.* By not also citing these two sentences, Heikinheimo *et al.* give a biased representation of our study, which may give readers the impression that Hansson *et al.* are “cherry picking”, presenting primarily data that support the notion that wildlife are competing with the fishery.

Fish population abundances are naturally very variable, with year-class strength and catches being influenced by e.g. temperature variation. Because of this, Heikinheimo *et al.* stress that when exploring population dynamics in response to predation, *the effect of temperature and other potential factors* should be accounted for in the analyses. It thus becomes paradoxical when Heikinheimo *et al.* criticize our use of Östman *et al.* (2012) as a reference for documented effects of cormorants on perch abundance. In that study, Östman *et al.* included not only cormorant abundance as an explanatory variable, but also temperature, water transparency (Secchi depth) and different study sites. When reanalysing data from the same area as Östman *et al.* (2012), Heikinheimo *et al.* apply the approach that they just criticized, namely simple regression analyses with cormorant abundance as the only explanatory variable to catch changes.

### Are fishing and natural predation comparable?

It is well known that different fishing methods and predators can impact targeted fish species differently, but these differences do

not necessarily prevent competition from developing. One of the reasons why multi-species models are needed in fisheries management is that significant mortalities can be inflicted by predators, not only by the fishery. Even if cormorants generally target smaller perch than the fishery, there is an overlap in the size distributions of perch caught by cormorant and humans. Furthermore, cormorant's consumption of small fish can also have the potential to negatively impact catches. The consumption of 10 perch with a weight of 30 g may be more damaging to the commercial fishery than the consumption of a single 300 g perch, all depending on the natural mortality rate inflicted on perch by other factors than cormorant predation (c.f. Östman *et al.* 2013).

### Food consumption of piscivorous fish

There are several reasons why we excluded predation by piscivorous fish from the analyses. The primary reason is an important difference between consumption by fish and birds/mammals. Even if piscivorous fish would decrease the total quantity of fish available to the fishery, the consumption results in the production of fish that can be harvested by the fishery. Consumption by birds and seals results in a complete loss to the fishery.

The piscivorous fish included in our study, do consume some of the fish species targeted by the fishery, but to compete with the fishery these prey fish must constitute a substantial fraction of the piscivorous' diets. If not, the consumption of fish species that are of no interest to the fishery will increase the production of the targeted piscivorous fish. This will increase the quantity of fish available to the fishery.

Another reason why we excluded piscivorous fish from the analyses was that reliable data on abundances and diets were not available for all subdivisions. Furthermore, estimating the consumptions by piscivorous fish, without the possibility to split these data into quantities of different prey species, would not provide particularly useful information (c.f. mergansers in our article).

In conclusion, we cannot see that the comments by Heikinheimo *et al.* changes the general conclusion derived in our original article: *our results show that there are cases of competition between wildlife and fisheries in the Baltic Sea, although not for all species and not to the same extent everywhere. There are many uncertainties, e.g. how far from cormorant colonies perch abundances are adversely impacted and how much of marginal diet components (e.g. salmon, sea trout, eel, and pikeperch) are actually consumed. There are also uncertainties regarding the potential for compensatory mechanisms in the fish populations, in particular if wildlife feed on smaller sizes than exploited by the fishery.* Future efforts for improving our understanding of the potential competition between top predators and human fisheries are thus clearly needed. This kind of information is central for the ongoing transition towards an ecosystem-based management, and will aid in striving for a balance between providing opportunities for fisheries and conservation of top predators, as well as conservation of fish populations.

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