# Comment to Hansson, S. *et al*. (2017): "Competition for the fish – fish extraction from the Baltic Sea by humans, aquatic mammals, and birds", with special reference to cormorants, perch and pikeperch

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## Abstract

Hansson *et al*. (2017) concluded that competition between fisheries and piscivorous mammals and birds exists in the Baltic Sea, based on the estimation of biomass of the fish species consumed in the ICES subdivisions. We compared their results to the data and scientific knowledge from the coastal waters of Finland and show that local differences in fisheries, fish assemblages and abundance of predators should be taken into account to reliably assess potential competition. Hansson *et al*. (2017) did not include the piscivorous fish in their analysis, but these may be the most important predators. In the Archipelago Sea, for instance, the consumption by fish predators is considerably larger than that of cormorants.

## Introduction

Hansson *et al*. (2017) compared the estimated fish consumption by birds and mammals to fisheries catches and concluded that competition for some important species, e.g. perch (*Perca fluviatilis*) and whitefish (*Coregonus lavaretus*), is likely.

However, it is questionable whether this kind of analysis can tell us anything about competition between predators and fisheries. Our main concerns are the following:

1) Hansson *et al*. (2017) compared the catches of fishing and predation in the scale of ICES subdivisions, but locally the situation largely differs in different areas and habitats.

2) Hansson *et al*. (2017) ignored the natural year-class fluctuations which are common in the coastal fish stocks and largely determine the ups and downs in the abundance.

3) Fishing and natural predation were paralleled even if the predation and fishing are directed to different size classes, and the predation rate depends on the abundance of each prey species (functional response).

4) Predation by piscivorous fish was not taken into account although the diet largely overlaps with that of fish-eating birds.

## 1. Comparison of fisheries catches and predation

Hansson *et al*. (2017) stated that the cormorants and seals in some subdivisions consumed twice as much perch as caught in fisheries, and this indicated competition. We compared the perch and pikeperch (*Sander lucioperca*) catches on the Finnish coast and the amount consumed by the local great cormorant (*Phalacrocorax carbo sinensis*) population (P. Rusanen, Finnish Environment Institute) to the results of Hansson et al. (2017) (Fig. 1). Most of the perch and pikeperch catches came from the Finnish coastal areas, even though the catches in the particular year 2010 were exceptionally low (Commercial fisheries statistics, Natural Resources Institute Finland, Fig. 2). On the contrary, on the basis of the estimates of Hansson *et al.* (2017), most of the consumption by cormorants took place in other parts of the subdivisions. This is partly due to higher estimated food consumption rate by Hansson *et al*. (2017) (500 g daily consumption was assumed even for small chicks), but also to the fact that there were more cormorants in other parts of the subdivisions than in the Finnish coast. The low fisheries catches in other areas, compared to those in the Finnish coast, are most probably an indication of low fishing effort, poorly reported recreational catches or weak fish stocks. We cannot see there any evidence of competition.

Hansson *et al*. (2017) calculated the consumption of prey fish species by predators based on local diet studies and used the results to estimate the consumption in the whole ICES subdivision. However, cormorants utilize the prey species that are abundant, most easily available and of suitable size, and thus the diet varies between years, areas and colonies, or even between weeks in the same breeding season (Salmi *et al.* 2015). For instance, Hansson *et al*. (2017) used the average diet of cormorants in the Finnish Archipelago Sea (share of perch 33%, pikeperch 6%, Salmi *et al*., 2015) to estimate the amount of perch and pikeperch consumed by cormorants in the ICES Subdivision 29, which extends to the coast of Sweden and Estonia. Certainly not all coastal waters of the Subdivision 29 are such suitable habitats for perch and pikeperch as the Archipelago Sea.

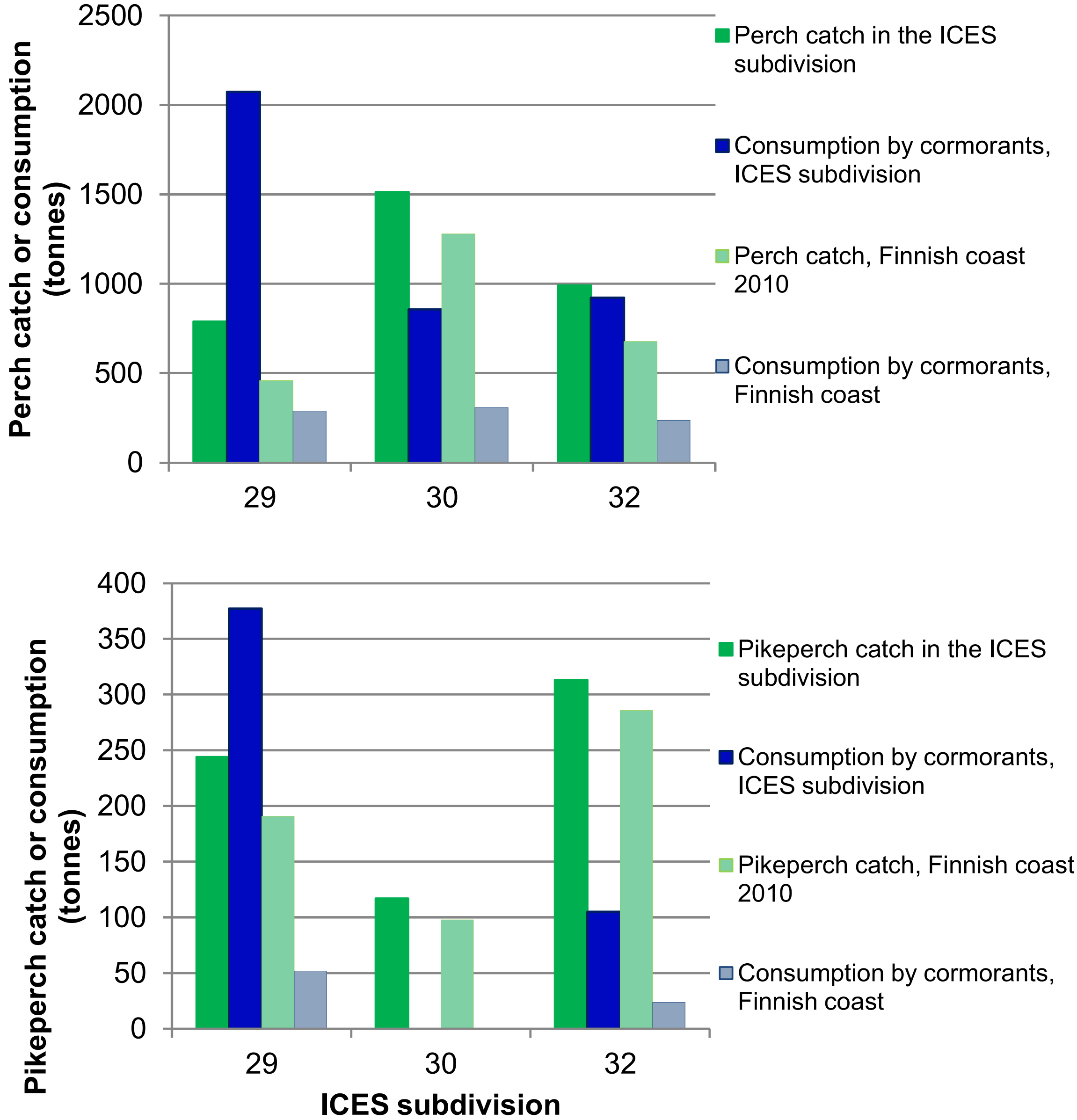


Fig. 1. Comparison of perch (upper panel) and pikeperch (lower panel) fisheries catches and consumption by cormorants in the ICES subdivisions 29, 30 and 32 according to Hansson *et al*. (2017), and corresponding values in the Finnish coast within each area. The proportions of perch and pikeperch in the diet of cormorants by Hansson *et al*. (2017) were also used for the Finnish coast.

2. Year-class fluctuations of perch and pikeperch

Hansson *et al*. (2017) stated: "Exploitative competition between fisheries and wildlife occurs if the catch/consumption of a fish species by one group has adverse effects on another consumer group. Field observations of decreased abundance of a fish species in response to fisheries and/or predation by wildlife imply exploitative competition." In fact, decreased fish catches in coastal waters are frequently observed as a consequence of natural year class fluctuations, due to temperatures affecting the reproduction success of e.g. perch and pikeperch (Böhling *et al*., 1991; Lappalainen *et al*., 1996; Heikinheimo *et al*., 2014). It is obvious that sometimes weak year classes may affect the catches simultaneously with an increase of a predator population, but such a correlation (e.g. Vetemaa *et al*., 2010) is not a sufficient evidence of a negative impact of the predator (Heikinheimo *et al*., 2016). To study such an impact, the effect of temperature and other potential factors on annual variation in fish stocks should be disclosed.

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. In fact, the decrease occurred from the end of 1990s to 2009, caused by strong year classes in the beginning of 1990s, and the weak year classes from 2003 onwards (Auvinen and Heikinheimo, 2017), but the catches then rose and almost reached the 1998 level in 2012 and 2014 (Fig. 2). The catches per unit of effort in gillnet fishing show the same development (Commercial Fisheries Statistics, Natural Resources Institute Finland). The predation by cormorants is directed to smaller perch size classes than fisheries (Salmi *et al*., 2015), about half of which are males that never grow to the sizes mainly taken by fisheries (Heikinheimo and Lehtonen, 2016). Moreover, there was no change in the mortality of perch compared to earlier periods without cormorants (Heikinheimo and Lehtonen, 2016).

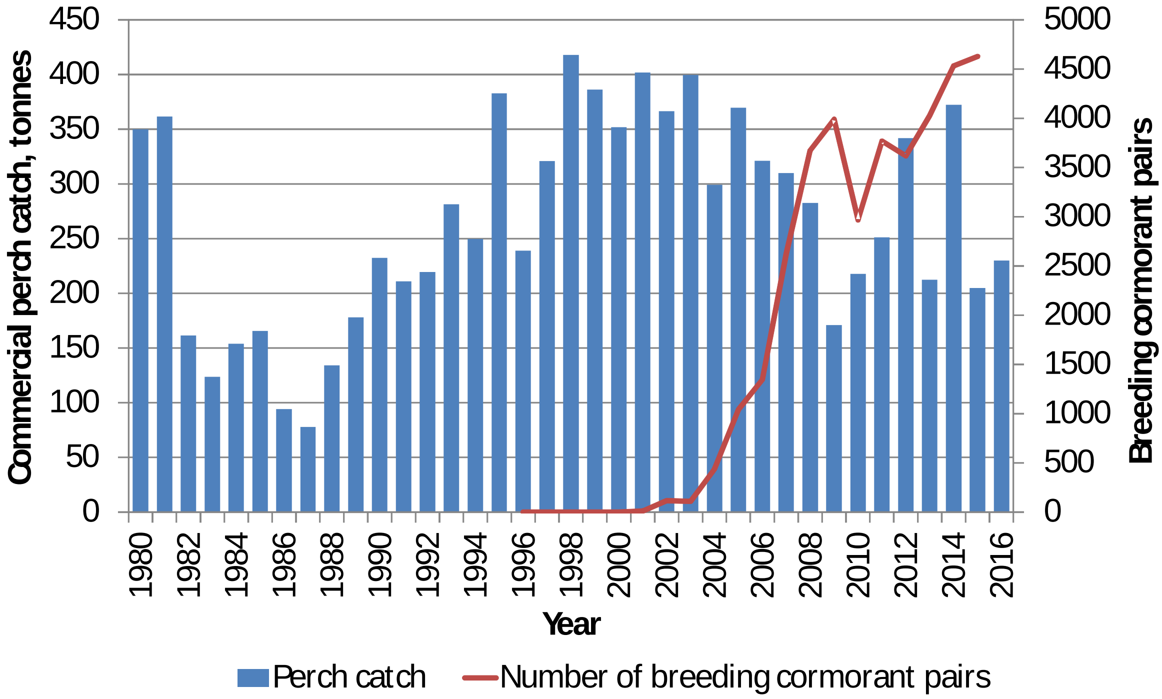


Fig. 2. Commercial perch catches in the Archipelago Sea, Finland (ICES rectangles 49H1, 49H2, 50H1) and the number of breeding cormorant pairs in 1980–2016 (Finnish Environment Institute, P. Rusanen).

According to Hansson *et al*. (2017), Östman *et al*. (2012) reported about 80% lower catch of perch in an area with cormorant colonies (Mönsterås) compared to a reference area that had no colonies within 50 km (Vinö). In time series analyses they found negative association between perch abundance and cormorant numbers in 1995–2009. A longer time series of the gillnet monitoring catches, 1995–2011 (Andersson, 2012), shows that the perch catches per unit of effort (CPUEs) were higher in the reference area during the whole period and the fluctuations were wide but rather synchronous in both areas (significant positive correlation between ln-transformed values, $R^2 = 0.25$, $p = 0.039$). There seems to be negative correlation between the number of breeding cormorants and perch CPUEs both in Mönsterås and in the reference area Vinö, but both are not  significant (Mönsterås $R^2 = 0.07$, $p = 0.31$, Vinö $R^2 =$

0.03, $p = 0.52$, ln-transformed values) (Fig. 3). Thus there is no evidence of cormorant effect but rather of synchronous year class fluctuation of perch.

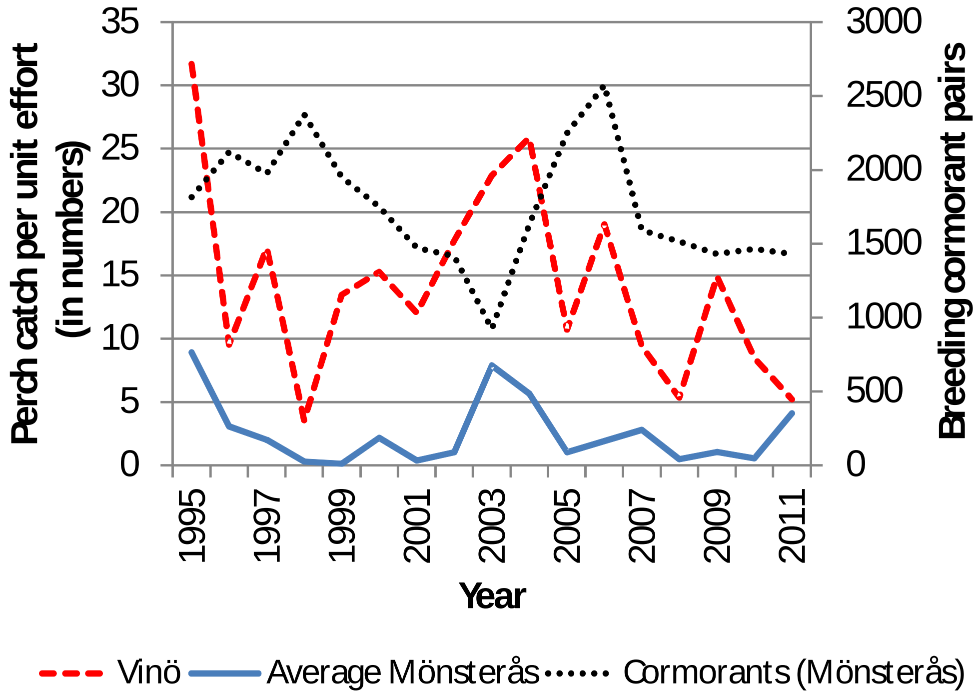


Fig. 3. Perch catches per gillnet day in Mönsterås (average of three fishing sites) and Vinö (reference area) based on the data by Andersson (2012), and the number of breeding cormorant pairs in the Mönsterås area (data by T. Larsson, T. M. Johansson, Länsstyrelsen Kalmar län).

<u>3. Are fishing and natural predation comparable</u>?

Comparing fisheries catches and fish consumption by predators does not tell us about competition. The predation rate on a prey species depends on its density in the environment as well as on the densities of other potential prey. The estimates of potential fisheries catch loss caused by predation on young fish (Östman *et al.*, 2013; Salmi *et al.*, 2015) largely depend on the assumed rate of other natural mortality. In the case of the pikeperch in the

Archipelago Sea, the other mortality exceeded the mortality caused by cormorants at all alternative assumptions (Heikinheimo *et al*., 2016).

The natural predation mostly targets individuals that are easiest to catch, i.e. fish in bad condition, sick or unable to avoid predation for some other causes (Huckstorf *et al*., 2009). Also slow-growing individuals have a higher probability to be caught because of being a longer time in the suitable size for predators (Craig *et al*., 2006). Therefore the mortality caused by predators may not be additive, i.e. the predators take individuals that have a higher probability of mortality in the first place (Hilborn and Walters, 1992). Fishing, on the contrary, mainly takes actively moving individuals and is size-selective, taking the fast-growing individuals as soon as they reach the catchable size (Conover and Munch, 2002).

## 4. Food consumption of piscivorous fish

Hansson et al. (2017) ignore an important group of predators: the piscivorous fish. We calculated the fish consumption of the pike (*Esox lucius*) population in the Archipelago Sea (ICES rectangles 49H1, 49H2, 50H1), based on annual catches in 2007–2015 and food consumption (Heikinheimo and Korhonen, 1996) (Supplementary Table S1).

The total range of the estimated food consumption, calculated from minimum and maximum catches, was 700–3800 tonnes annually, including only the size classes recruited to fisheries (Supplementary Table S1). Salmi *et al*. (2015) estimated the fish consumption of cormorants in the same area at 679–835 tonnes in 2010 and Heikinheimo *et al*. (2016) at 576–704 tonnes in 2009–2010. Thus, the consumption of the pike population is at a minimum on the same level, or manifold compared to that of cormorants, and the prey species and sizes are largely the same as those of cormorants (Eklöv and Hamrin, 1989). The food consumption of the pikeperch population (ages ≥5) is on the same level as that of pike, 1000–4300 tonnes, based on the stock assessment by Heikinheimo *et al*. (2014) and food consumption (Vehanen *et al*, 1998) (Supplementary Fig. S1). We can conclude that in the Archipelago Sea the piscivorous fish are far more important as predators than the cormorants.

Cormorants utilize mostly smaller fish than do the fisheries, and thus the effect in the fish community can be expected to be very similar to that of fish predation. Predator fish are generally considered an important part of the ecosystem, for instance counteracting extreme fluctuations in the prey fish stocks (Pauly *et al*., 1998).

Hansson *et al*. (2017) with their article aim at "supporting a more informed debate on resource competition between wildlife and fisheries". In our opinion, this kind of coarse analysis, ignoring local differences in fish abundance, fisheries and predation, tends to rather aggravate the conflicts.

Supplementary data

The following supplementary material is available at ICESJMS online: Estimation of the food consumption of pike and pikeperch populations in the Archipelago Sea.

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Supplement: Estimation of the food consumption of pike and pikeperch populations in the Archipelago Sea

It is relatively straightforward to calculate the biomass of the piscivorous fish species targeted by fisheries, based on the fisheries catches and estimated fishing and natural mortality, using the equation

$$C=F/(F+M)*(1-\exp(-Zt))*B,$$

where $C$ = annual fisheries catch, $F$ = the instantaneous rate of fishing mortality per year; $M$ = the instantaneous rate of natural mortality per year , $Z = F+M$; $t$ = time in years; $B$= the biomass of the catchable stock.

On the basis of the biomass and food consumption estimates of the given species the total consumption of the population can be estimated.

The average fisheries catch of pike in the Archipelago Sea was 354 tonnes (range 203–485 tonnes) in the years 2007–2015, and the instantaneous annual fishing mortality was assumed at between 0.5 and 0.8, and natural mortality at 0.1. The annual food consumption was estimated at three- to fourfold the biomass (Heikinheimo and Korhonen, 1996), which gives about 1300–2800 tonnes on the average (Table S1).

Table S1. Food consumption of northern pike (*Esox lucius*) in the Archipelago Sea (ICES rectangles 49H1, 49H2 and 50H1), based on mean, minimum and maximum catches in 2007–2015 (Finnish fisheries statistics, Natural Resources Institute Finland). The rate of natural mortality was assumed at 0.1. Biomass in the middle of the year ($t$ = 0.5).

| Catch (tonnes) | | Fishing mortality | Biomass (tonnes) | Food consumption (tonnes) | |
|---|---|---|---|---|---|
| | | | | 3*biomass | 4*biomass |
| Mean | 354 | 0.5 | 697 | 2092 | 2790 |
| Min. | 203 | 0.5 | 400 | 1200 | 1600 |
| Max | 485 | 0.5 | 956 | 2867 | 3822 |
| Mean | 354 | 0.8 | 428 | 1284 | 1712 |
| Min. | 203 | 0.8 | 245 | 736 | 982 |
| Max. | 485 | 0.8 | 586 | 1759 | 2345 |

To estimate the food consumption of pikeperch, the number of fish in each age group, based on the stock assessment (see Heikinheimo *et al*. 2014) and the individual food consumption of the pikeperch in Lake Oulujärvi (Vehanen *et al*. 1998) by age were used. For ages >6 we used the food consumption at age 6 because the growth of pikeperch is slower in the Archipelago Sea than in Lake Oulujärvi (Fig. S1).

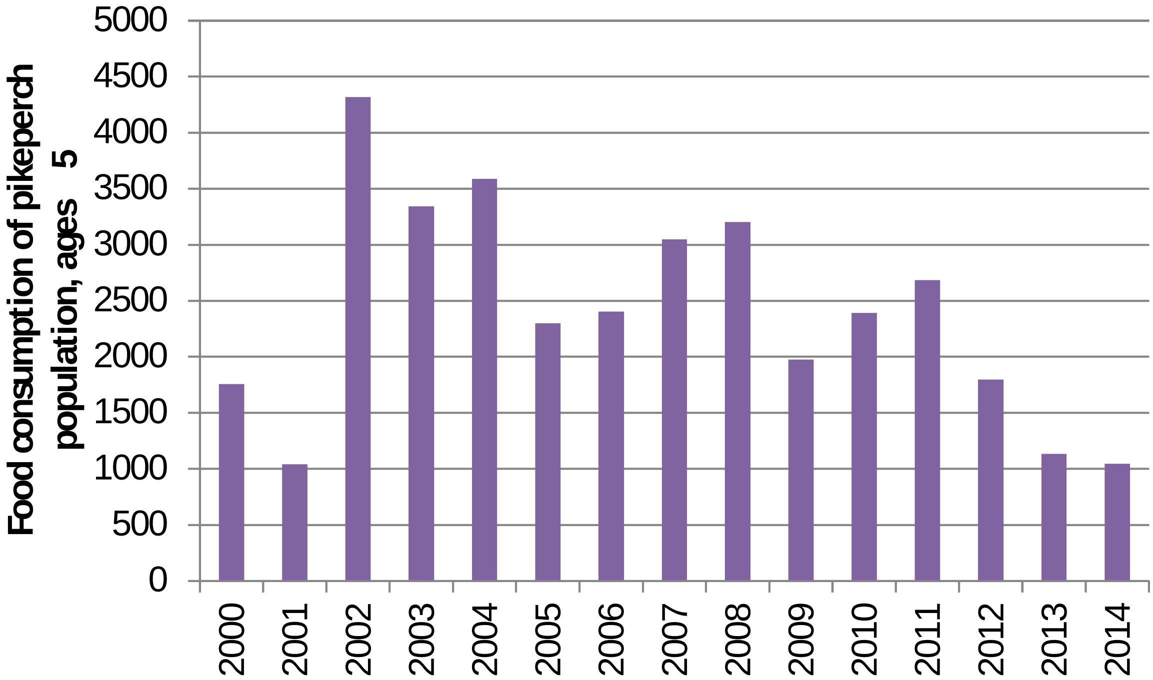


Fig. S1. Food consumption (tonnes) of the pikeperch (*Sander lucioperca*) population (ages ≥5) in the Archipelago Sea (ICES rectangles 49H1, 49H2 and 50H1) in 2000–2014, based on the updated stock assessment (Heikinheimo et al. 2014) and food consumption of pikeperch by age (Vehanen *et al*. 1998). Food consumption at age 6 was used for all older age groups due to slower growth in the Archipelago Sea.

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