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Short communication

Problems in managing a slow-growing pikeperch (*Sander lucioperca* (L.)) population in Southern Finland

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ABSTRACT

Key-words: *management, maturity, pikeperch, stunted growth*

Local fishery managers in Lake Sahajärvi tried to increase pikeperch yields by increasing the minimum allowed mesh size from 45 to 60 mm and size limit from 37 to 40 cm. However, due to the slow growth of pikeperch these measures may not be reasonable. Here, pikeperch yields were modelled with an age and size-structured yield-per-recruit model as a function of mesh size. Besides yields, also the proportion of minimum landing size and immature pikeperch caught with a different mesh size were evaluated. The results showed that maximum yields per recruit can be obtained with a 44 mm mesh size corresponding to yields of about 180 kg per 1000 age 2 pikeperch while with 60 mm mesh size the estimated yields are only 46 kg. The share of immature pikeperch is only 0.4% in 44 mm mesh size nets due to very small average size at maturity (24.8 cm *TL*) of both sexes. Because the observed growth is slow ($k = 0.11$ and $L_\infty = 65.28$ cm *TL*) and the density of pikeperch (BPUE in NORDIC nettings = 1200 g·net^{-1}) is high, the most reasonable management measure to improve growth and average size could be to radically decrease population density.

RÉSUMÉ

Questions de gestion d'une population de sandres (*Sander lucioperca* (L.)) à croissance lente dans le sud de la Finlande

Mots-clés : *gestion, maturité, sandre, croissance réduite*

Les gestionnaires locaux de la pêcherie du lac Sahajärvi ont essayé d'augmenter les rendements des captures de sandres en augmentant de 45 à 60 mm la taille minimale des mailles autorisées, et de 37 à 40 cm la taille minimale de capture. Toutefois, en raison de la lente croissance du sandre ces mesures peuvent ne pas être fondées. Dans cet article, le rendement des captures a été modélisé par un modèle de rendement par recrue dépendant de l'âge et de la structure en taille, fonction de la taille des mailles. En plus des rendements, les proportions de poissons de taille minimale et de poissons immatures attrapés par différentes tailles de maille ont été évaluées. Les résultats montrent que le rendement maximum par recrue est obtenu avec une maille de 44 mm correspondant à des rendements d'environ 180 kg par 1000 sandres de deux ans alors qu'avec des mailles

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de 60 mm le rendement estimé est seulement de 46 kg. La part de sandres immatures est seulement de 0,4 % dans les filets de maille de 44 mm en raison de la très faible taille moyenne à maturité (24,8 cm *TL*) des deux sexes. Parce que la croissance observée est lente (k = 0.11 et L_∞ = 65, 28 cm *TL*) et la densité des sandres (BPUE dans les filets NORDIC = 1200 g·filet^{-1}) forte, la mesure de gestion la plus adéquate pour accroître la croissance et la taille moyenne serait de réduire fortement la densité de population.

INTRODUCTION

Pikeperch (*Sander lucioperca* (L.)) is a very important species in recreational and commercial fisheries in Finland. It is actively fished with different methods, but gillnetting is still the most popular and the one with highest catches, even among recreational fishermen (Finnish Game and Fisheries Research Institute, 2009). Pikeperch fisheries is regulated both at a national level, with a minimum landing size of 37 cm in total length, and at local level with other limitations that normally include minimum mesh sizes of gillnets, maximum number of nets per fisherman and higher landing sizes. The minimum landing size is typically set to enable at least one spawning. This matches quite well to the average size at first maturity of pikeperch between 34 and 46 cm found in Finland (Lehtonen, 1987; Lehtonen and Miina, 1988). However, at least in some lakes, males mature at a smaller size than females (Svärdson and Molin, 1968; Lehtonen and Miina, 1988).

Finland has a total of 187 888 lakes larger than 500 m^2; in the northernmost part of the country, where the numerical density reaches the maximum, lakes are mostly small and oligotrophic (Finnish Environment Institute). In the southern half of the country, lakes are on average larger and more eutrophic, and some of these are particularly renown among fishermen for their pikeperch fisheries. Lappalainen and Tammi (1999) estimated, based on the results from lake surveys (Tammi *et al*., 1999), that pikeperch is found naturally in 657 lakes in southern and central Finland, and has been introduced to more than 1600 lakes. One of these pikeperch lakes in Southern Finland is analyzed in this study: Lake Sahajärvi (60° 43' N, 25° 28' E). The origin of the population, whether natural or introduced, is not known, however the fisheries yielded a normal catch during the 70's (Toivonen *et al*., 1981). Since then, pikeperch catches of legal-sized fish have collapsed giving a very low yield when compared with other similar lakes in southern Finland. An obvious reason for low catches was found to be the extremely slow growth of pikeperch (Vinni *et al.*, 2009).

Local fisheries managers tried to increase pikeperch yields by increasing the minimum allowed mesh size from 45 to 60 mm, and by increasing the size limit of pikeperch from 37 to 40 cm. These decisions were taken without taking into account any scientific information though sufficient data about the growth rate, for instance, were available. We tested that due to the slow growth the present management could not be reasonable, and searched for an optimal minimum mesh size limit using an age- and size-structured Y/R-model (Buijse *et al.*, 1992; Lappalainen and Malinen, 2002). The optimal mesh size was expected to be low, which might lead to endangering the pikeperch stock by allowing fishing of immature fish if the length at the onset of maturity in Lake Sahajärvi is within the range documented elsewhere (Lehtonen, 1987; Lehtonen and Miina, 1988). Thus, we were additionally forced to model the length at maturity, and because the onset of maturation can vary between sexes (Lappalainen *et al.*, 2003), we handled the sexes separately. Another potential disadvantage of a low optimal mesh size is the incompatibility between the size distribution of the catch and the national legal size limit (37 cm). The optimal mesh size for maximized yields might not be acceptable for management if the proportion of under-sized fish in catches is too high. Therefore, we also computed the proportion of under-sized fish in each mesh-size alternative. Our main aim here was to find such a management solution that would give maximum yields without endangering the stock. To this purpose estimations of both immature and undersized fish in the catches were performed. However, our research underlined severe problems with the stock that couldn't possibly be solved only by changing the recreational fisheries regulations. A different solution was therefore proposed, taking into account the present situation and likely future outcomes of management actions.

MATERIALS AND METHODS

> LAKE SAHAJÄRVI AND PIKEPERCH SAMPLING

Pikeperch is the key pelagic predator in Lake Sahajärvi while other common fish species in the lake are roach (*Rutilus rutilus* (L.)), bream (*Abramis brama* (L.)), bleak (*Alburnus alburnus* (L.)), and perch (*Perca fluviatilis* L.) (Vinni *et al.*, 2009). Lake Sahajärvi is small (1.92 km^2), clay-turbid (NTU 10–40), and eutrophic (tot. P 30–60 $\mu g \cdot L^{-1}$). Mean depth is 4.1 m and maximum depth is 10 m. The concentration of dissolved oxygen may decline below 1 $mg \cdot L^{-1}$ in deeper layers during the summer stagnation period (July to August).

Pikeperch were collected using fish-traps, gill nets and seine netting. Sampling was carried out from 2005 to 2008 especially in autumn and spring, yielding altogether 261 specimens. All these data was pooled under the assumption, based on information from local fishermen and fishery association, that the present situation of the stock has been similar during the past decade. Total length and weight was measured; also otoliths and scale samples were taken to determine age and growth. In 2006 and 2007, gonad samples were collected to assess the sex of non-mature individuals.

All fish were aged from polycarbonate impressions of scales observed with a microfilm viewer (magnification 37×). In most difficult cases also burned otolith annuli were read to confirm the determination. Length-at-ages were back-calculated using standard Fraser-Lee method (Bagenal and Tesch, 1978). The value of 44 (mm) was used as intercept term (Ruuhijärvi *et al.*, 1996).

Additional fish samples were taken in August 2006 to estimate the size-structure of pikeperch with NORDIC multi-mesh survey gillnets. Each gillnet consists of twelve 1.5 × 2.5 m panels having mesh sizes of 5, 6.25, 8, 10, 12.5, 15.5, 19.5, 24, 29, 35, 43 and 55 mm (from knot to knot) (Appelberg *et al.*, 1995). A total of 12 NORDIC nets were used in two sampling events in late August covering randomized locations in the lake. These sampling events lasted each 12 h from evening to morning. This sampling method was chosen as it was widely used in other studies, allowing a comparison between different lakes.

> SEXING OF INDIVIDUALS

Sexes of non-mature pikeperch were assessed using microslides of progonads fixed in paraffin and coloured with toluene blue (Antila *et al.*, 1988). These slides were analyzed trough a microscope (magnification 200×). Observation of fresh samples from progonads was also possible during late growth season, tissue slices or even the whole progonad could be fixed on glass and observed through an optic microscope. In mature or maturing females the progonad is filled with maturing eggs while the male progonad shows no similarly sized recognizable elements. Mature individuals were sexed trough dissection and direct observation.

> STATISTICAL AND MODELLING ANALYSES

The onset of maturity was analysed using two logistic regression models either with length or age as an independent variable:

$$Y = e^{(a+bL)} * \left[1 + e^{(a+bL)}\right]^{-1} \quad (1)$$

where Y is the maturity of the fish expressed as 0 being non mature or 1 being mature, a and b are the logarithmic constants, and L is the total length of the fish in cm or age in years. The overall sample size was 36 females and 49 males.

The possible difference between sexes in back-calculated lengths at ages was analysed using repeated ANOVA and first-order autoregressive covariance structure (Proc Mixed, SAS (2008)). The growth pattern was examined with von Bertalanffy's equation (von Bertalanffy, 1938):

$$L(t) = L_\infty * \left[1 - e^{(-k*(t-t_0))}\right] \tag{2}$$

where $L(t)$ is the total length of the fish at age t, L_∞ is the maximum theoretical length for the fish, k is the growth-rate constant and the t_0 parameter is time of length 0. The model was fitted using a SAS macro NLINMIX (available from SAS webpage, http://www.sas.com/), which follows the PROC NLIN and PROC MIXED procedures. The macro handles the fitting of nonlinear model with repeated measurements, such as $L(t)$ here. A first order autoregressive covariance structure was used in fitting based on lower AIC-values in pooled data (in use 5111.9, without 6329.3).

The obtained asymptotic lengths were compared with published values from other studies. To enable comparisons, all fork (Karabatak, 1992; Becer and Ikiz, 1999; Abdolmalaki and Psuty, 2007) and standard lengths (Raikova-Petrova and Zivkov, 1998) of pikeperch were transformed to total length according to equations from Van Densen (1987) and Erm *et al.* (2003), respectively.

The effects of gillnet mesh size on yields were examined using an age- and size structured yield per recruit model (Buijse *et al.*, 1992; Lappalainen and Malinen, 2002). The model computes steady-state yield per recruit based on growth, fishing mortality (F), natural mortality (M), and a selection factor which produces gradual recruitment to the fishery. Age 2 was used as the first possible recruitment age and it was assumed that pikeperch are harvested only with gill nets. This should be a reasonable simplification since the great majority of lure-caught pikeperch must be released as under-sized. The left-hand side of the selection curve was computed according to Buijse *et al.* (1992), whereas after the peak of the curve the selectivity was assumed to be unity. The high prevailing fishing mortality of pikeperch (Lehtonen, 1983; Salonen *et al.*, 1996) suggests that the right-hand side of the selection curve has only a marginal effect on the results. This should be a realistic approach if minimum mesh size limits are applied, but also larger mesh sizes are used. The standard deviation of length at age 2 was set to be constant using the value of 2-year-old pikeperch in Lake Sahajärvi (2.29). The applied model used lengths, and to evaluate yields these lengths were transformed to mass using a lake-specific mass-length relationship:

$$W = 0.00217 * TL^{3.3715} \tag{3}$$

where W is mass in grams, and TL is total length in cm.

The total mortality was evaluated based on iteration by setting the model mean weight equal to the observed mean weight of 640 g in 45 mm gillnets in Lake Sahajärvi (Tauno Ratia, personal communication). Natural mortality (0.15 yr^{-1}) used in the model was set according to literature data (Lehtonen, 1983; Salonen *et al*., 1996). To evaluate the effects of natural mortalities on yields, also 0.1, 0.2, and 0.25 values were tested. The fishing mortality was evaluated separately under each assumption of natural mortality.

RESULTS

In older (age $>$ 8) pikeperch, females were more numerous. The oldest and largest female caught was 11 years, 1700 g and 56 cm, while the oldest and largest male was 9 years, 1120 g and 51 cm (Figure 1). However, no differences were found in back-calculated lengths between sexes ($F = 0.14$, df = 1, $P = 0.711$) or between sexes at different ages ($F = 0.43$, df = 8, $P = 0.900$). Thus, in sex-pooled data, the length at infinity (L_∞) was 69.56 cm, the growth constant (k) was 0.10 and length at age 0 (t_0) was –0.12.

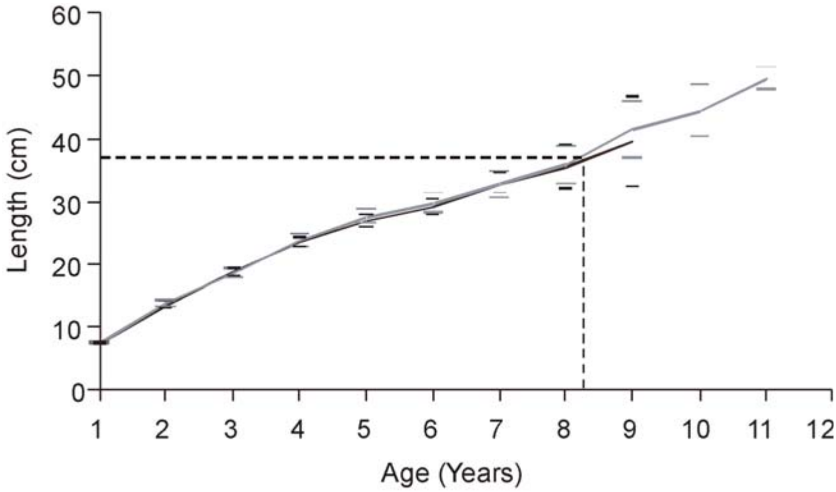

Figure 1
Back-calculated mean length-at-age of males (black line) and females (grey line) with 95% confidence limits. Dashed line shows the minimum legal landing size with corresponding age.

Figure 1
Longueur moyenne par âge rétrocalculée des mâles (ligne noire) et des femelles (ligne grise) avec limites de confiance à 95 %. La ligne en tirets indique la taille minimale de capture et l'âge correspondant.

Table I
Results from logistic regression models using maturity as dependent, and pikeperch length and age with and without interaction term as independent variables.

Tableau I
Résultats des modèles de régression logistique utilisant la maturité comme variable dépendante, et la longueur du poisson et son âge avec ou sans interaction comme variables indépendantes.

Model	Parameter	Estimate	SE	Chi-Square	*P*
1	Intercept	16.052	4.391	13.36	0.0003
	Length	–0.645	0.168	14.66	0.0001
	Length*Sex	–0.014	0.024	0.33	0.5676
2	Intercept	15.556	4.133	14.17	0.0002
	Length	–0.626	0.159	15.44	< 0.0001
3	Intercept	11.729	3.947	8.83	0.0030
	Age	–3.262	1.044	9.75	0.0018
	Age*Sex	–0.154	0.198	0.61	0.4365
4	Intercept	11.499	3.863	8.86	0.0029
	Age	–3.192	1.017	9.85	0.0017

The smallest mature female caught was 23 cm and weighted 88 g, while the smallest mature male was 26.5 cm and weighted 135 g, both being 4 years old. A value of 24.8 cm was obtained as a mean length at maturity and 4.1 years as a mean age at maturity (50% probability). No differences were found in length or age at maturity between sexes (Table I). Due to slow growth, pikeperch can spawn on average 4× before reaching to the legal minimum size of 37 cm, at age 8 (Figure 1).

The yield per recruit model showed that the maximum yields are caught with 44 mm mesh size corresponding to about 180 kg per 1000 age 2 pikeperch. With 60 mm mesh size, the estimated yields are only 46 kg. In 44 mm mesh sized gillnets, the share of undersized ($<$ 37 cm) pikeperch is 14% of all pikeperch caught, while the share of non-mature ($<$ 30 cm) pikeperch is only 0.4% (Figure 2). The 30 cm length estimate is based on the observed length at maturity in which all the pikeperch caught were mature (Figure 3).

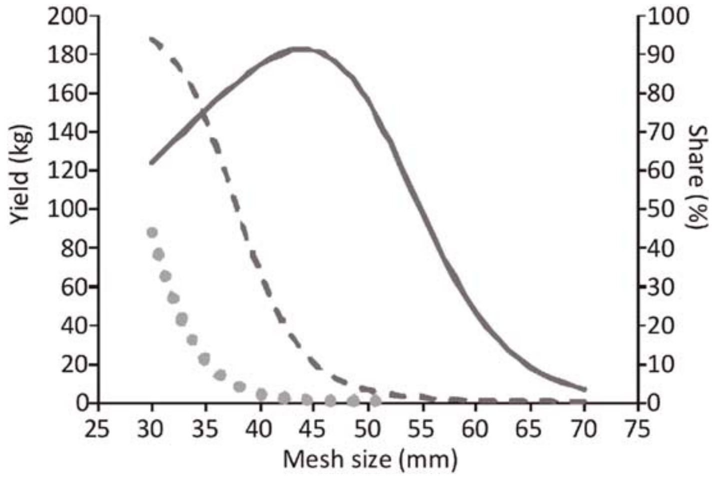

Figure 2
Estimated yields (kg per 1000 age 2 pikeperch, solid line), share (%) of both undersized (< 37 cm TL, dashed line) and non-mature (< 30 cm TL, dotted line) pikeperch with different mesh sized gillnets in yield per recruit modeling.

Figure 2
Rendements estimés (kg par 1000 sandres de 2 ans, ligne pleine), proportion (%) des poissons trop petits (< 37 cm *TL*, ligne en tirets) ou non-matures (< 30 cm *TL*, pointillés) pour différentes tailles de mailles dans le modèle de rendement par recrue.

Table II
NORDIC gillnet catches in Lake Sahajärvi. Catch is presented as BPUE (biomass per unit effort, i.e. *biomass per net during one night) and NPUE (number per unit effort,* i.e. *number of fish per net during one night) and biomass % as a share of each species from the total catch.*

Tableau II
Captures par les filets maillants NORDIC dans le lac Sahajärvi. Les captures sont données en BPUE (biomasse par unité d'effort, *i.e.* biomasse par filet pendant une nuit) et NPUE (nombre par unité d'effort, *i.e.* nombre par filet pendant une nuit) et biomass % (part de chaque espèce dans le total des captures).

Species	BPUE	NPUE	Biomass %
Perch	807.2	132.3	21.9
Pikeperch	1227.8	14.2	33.3
Ruffe	7.5	1.3	0.2
Roach	1354.5	38.6	36.8
Bleak	157.7	12.7	4.3
Bream	129.1	3.9	3.5
Total	3683.8	202.9	100.0

Maximum yields decreased from 274.1 kg to 83.7 kg with the values of natural mortalities from 0.1 to 0.25 (0.05 steps), respectively. At the same time, the optimum mesh size decreased from 46 mm to 39 mm. With all four natural mortality assumptions (0.1, 0.15, 0.2, and 0.25), yields were always much lower in 60 mm gillnets than in 45 mm mesh sized gillnets. Because natural mortality was fixed based on mean weight of pikeperch, change in natural mortality only changes the relation between natural mortality and fishing mortality. When natural mortality was increased, fishing mortality decreased, *i.e.* total mortality remained the same.

The size distribution in gillnet catches underlined that pikeperch population structure was dominated by small-sized fish whereas bigger individuals are scarce (Figure 4). The average catch of pikeperch was 1200 g·net^{-1}·night^{-1}, which was 33.3% of the total catch. Other species caught were roach, perch, bleak, bream, and ruffe (*Gymnocephalus cernuus* (L.)) (Table II).

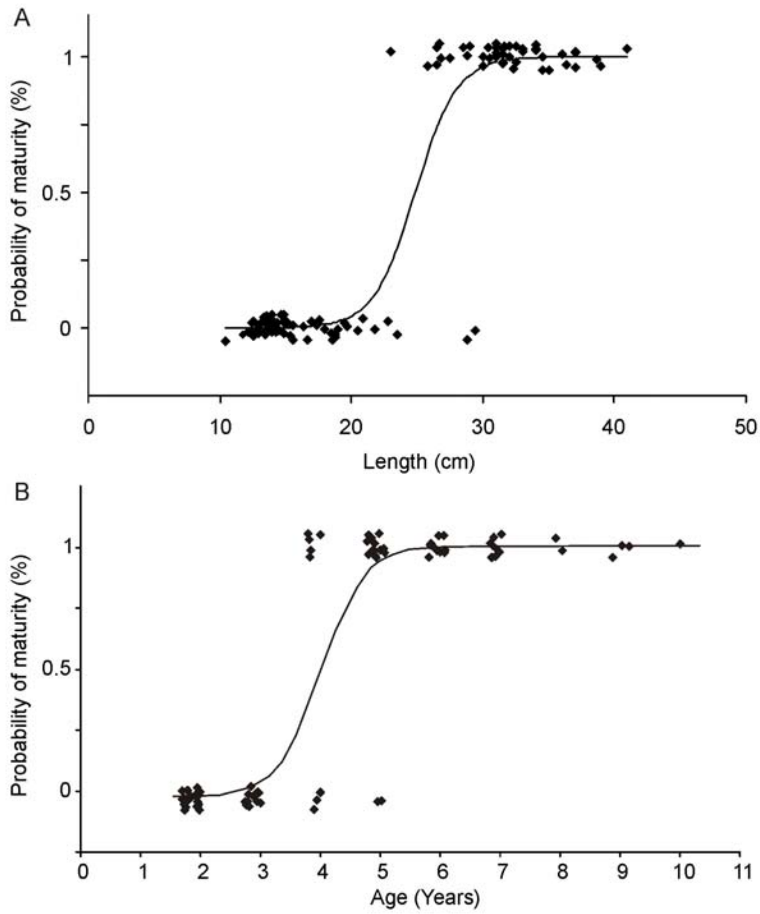

Figure 3
Onset of maturity of pikeperch in relation to length (A) and age (B) estimated with logistic regression in pooled sex data (markers are jittered). The 50% probability in length and age at maturity was 24.8 cm and 4.1 years, respectively.

Figure 3
Première maturité du sandre en relation avec la longueur (A) et l'âge (B) estimée par régression logistique pour les données groupées des deux sexes. La probabilité de 50 % est respectivement de 24,8 cm et 4,1 années pour la longueur et l'âge.

DISCUSSION

The yield-per-recruit model showed that the presently applied 60 mm mesh size is far from being optimal. The highest yields, 180 kg (per 1000 age 2 recruits), can be caught with gillnets of 44 mm mesh size. This is close to that used earlier (45 mm) in Lake Sahajärvi. However, even when the mesh size of 45 mm was allowed, catches were still low. The highest modelled yields (180 kg) in Lake Sahajärvi are, indeed, very low when compared with modelled catches in Lake Averia (about 440 kg) or in Lake Vesijärvi (575 kg) based on similar yield-per-recruit model with 45 mm as net mesh size (Lappalainen *et al.*, 2005). The applied yield-per-recruit model suggests that the catches cannot be increased with mesh size optimization. Thus, here we discuss first the possible reasons for the slow growth and then suggest possible options to be applied in pikeperch management.

Length at maturity of pikeperch was within the lowest range reported for this species (Lappalainen *et al*., 2003), the lowest reported in Finland (Ruuhijärvi and Sutela, 2002) and well below the minimum landing size. In lakes at comparable latitudes, the onset length at maturity

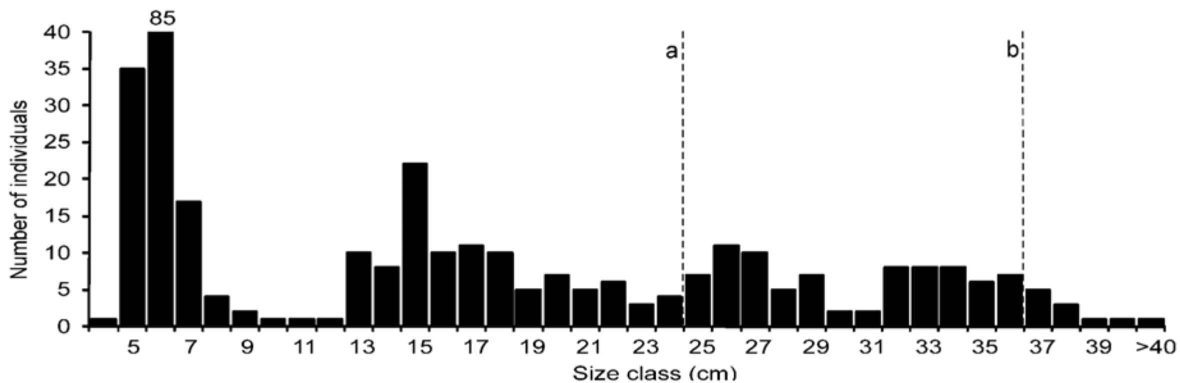

Figure 4
Length distribution of pikeperch in NORDIC gillnet catches. Vertical line a shows the average (50 %) length at maturity, and line b the legal landing size. Note that the bar for 6 cm pikeperch is reduced.

Figure 4
Distribution en longueur des sandres capturés par les filets maillants NORDIC. La ligne verticale a indique la longueur moyenne (50 %) à maturité et la ligne b la taille minimale de capture. À noter que la barre des sandres de 6 cm est réduite.

Table III
Asymptotic lengths for pikeperch in literature.

Tableau III
Longueurs asymptotiques du sandre dans la littérature.

L_∞	Observation site	Country	Reference
58.4 cm[a1]	Caspian Sea	Iran	Abdolmalaki and Psuty (2007)
64.7, 76.0 cm[a2]	Lake Hirfanlı Dam	Turkey	Karabatak (1992)
110.4 cm[a]	Lake Eğirdir	Turkey	Becer and Ikiz (1999)
77.2 cm[b]	Ovcharitsa Dam	Bulgaria	Raikova-Petrova and Zivkov (1998)
112.5 cm[b]	Batak Dam	Bulgaria	Raikova-Petrova and Zivkov (1998)
75.7, 112.2, 112.5 cm[c]	Lake Balaton	Hungary	Biro (1977, 1990)
81.8 cm	Feldberger Haussee	Germany	Wysujack *et al.* (2002)
50.0 cm[d]	Himmerfjärden Bay	Sweden	Hansson *et al.* (1997)

[1] No natural spawning, population is based on stocking.
[2] Values for two years.
[a] Corrected from fork length to total length according to Van Densen (1987).
[b] Corrected from standard length to total length according to Erm *et al.* (2003).
[c] Three different basins in Lake Balaton.
[d] Larger than 50 cm pikeperch occurs in the bay (Hansson *et al.*, 1997).

is around 30–40 cm, but the onset age is similar (4–6 years) as in Lake Sahajärvi (Lehtonen, 1987; Lehtonen and Miina, 1988; Kosior and Wandzel, 2001). In warmer environments maturity is reached already at age 1 or age 2 (Karabatak, 1992; Raikova-Petrova and Zivkov, 1998; Toujani and Kraiem, 2002; Poulet *et al*., 2004). Normally fast growing populations have individuals maturing at an earlier age and larger size (Heibo and Vøllestad, 2006), while a slow growing population should include individuals maturing at a small size as it was found in Lake Sahajärvi.

No signs of sexual dimorphism were found in length-at-age or in maturity. In fisheries management this is an advantage, because it enables simultaneous management for both sexes. However, elsewhere both mono- and dimorphism has been noted for pikeperch. The onset length and age at maturity is generally lower in males than in females (Svärdson and Molin, 1968; Lehtonen and Miina, 1988; Raikova-Petrova and Zivkov, 1998). In two Finnish lakes showing normal growth no differences were found between sexes in length at age (Lappalainen *et al.*, 2005). In Lake Sahajärvi, length at age in older ($>$ 8 years) pikeperch seemed to differ, but this was due to the fact that most of the large pikeperch caught were females. The obtained asymptotic length (69.56 cm) was, however, within the lowest range reported for pikeperch in literature (Table III).

High BPUE of pikeperch (1200 g·net^{-1}·night^{-1}) indirectly suggest that the population density is high in Lake Sahajärvi. When compared with other pikeperch lakes in southern Finland, the maximum BPUE found was 442 g·net^{-1}·night^{-1} in 12 lakes (Olin *et al.*, 2002) (Figure 5). It can be hypothesized that severe intraspecific competition for food suppresses the growth of pikeperch in the pelagic area, while on the other hand in the littoral area pikeperch has to endure interspecific competition with other predators such as perch and northern pike (*Esox lucius* L.) also present in the lake. Ultimately it appears that pikeperch fail to shift to piscivory at a typical size of 30–100 mm *TL* for the species (Buijse and Houthuijzen, 1992; Mittelbach and Persson, 1998) and even the diet of large pikeperch consists mainly of planktonic and invertebrate prey items with fish only as a seasonal prey (Vinni *et al.*, 2009).

An early maturity and several spawning events prior to capture are considered a favourable management condition for fisheries administrators (Heikinheimo *et al.*, 2006). In Lake Sahajärvi, this only promotes the feedback of stunted growth by maintaining a high population density of pikeperch. So far the local fisheries administration has acted towards an increase of limitations for the gillnet fishery. Gillnetting is still allowed but the maximum number of nets

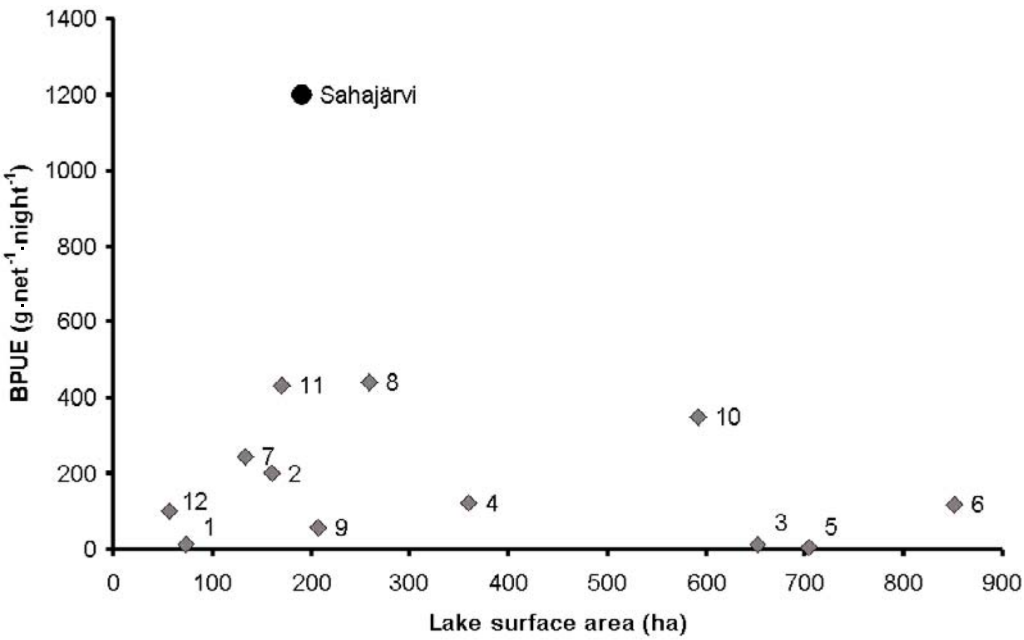

Figure 5
Pikeperch biomass per unit of effort in Sahajärvi and 12 other lakes in southern Finland. 1: Ekojärvi, 2: Hiidenvesi B1, 3: Ormajärvi, 4: Hiidenvesi B3, 5: Lehijärvi, 6: Aimajärvi, 7: Ruusutjärvi, 8: Hiidenvesi B2, 9: Pusulanjärvi, 10: Tuusulanjärvi, 11: Pitkäjärvi, 12: Lippajärvi (Olin et al.*, 2002).*

Figure 5
Biomasse de sandre par unité d'effort dans le lac Sahajärvi et 12 autres lacs du sud de la Finlande. 1 : Ekojärvi, 2 : Hiidenvesi B1, 3 : Ormajärvi, 4 : Hiidenvesi B3, 5 : Lehijärvi, 6 : Aimajärvi, 7 : Ruusutjärvi, 8 : Hiidenvesi B2, 9 : Pusulanjärvi, 10 : Tuusulanjärvi, 11 : Pitkäjärvi, 12 : Lippajärvi (Olin *et al.*, 2002).

per fisherman has been decreased during the last decade up to the actual one net per fisherman with a minimum mesh size of 60 mm. According to catchability studies the mean length of the pikeperch catch for such a mesh size should be over 45 cm (Turunen, 1996; Setälä *et al.*, 2003). Fishermen are also allowed to use one additional net with a minimum mesh size of 80 mm, which is far too large to have any impact on pikeperch population considering the size-selectivity of the mesh-size for this species (Setälä *et al.*, 2003) and the low number of large-sized pikeperch in the lake. Contrasting pressures from rod-and-line fishermen and gillnet fishermen might further hamper a rational decision-making: the general tendency in Sahajärvi administration is to promote fishing with rod-and-line while limiting even further fishing with gillnets. In Finland, local land owners run water administrations without subsequent control.

The high density of pikeperch in Lake Sahajärvi could be the main reason for the stunted growth and therefore any further restriction of the fisheries would only promote an enduring of the present situation at best. An opposite trend in regulations of the fisheries would be a more adapt response to the situation even though it might not be enough for a successful solution, given that the national landing size limitation can't be modified for recreational or commercial fisheries. A heavier removal of all sizes of pikeperch might be needed if the population density is to be effectively reduced. Such a removal could only be accomplished by means of intensive fishing with suitable gear in the pelagic area under a carefully controlled and authorized bio-manipulation project.

After the removal population parameters should be re-assessed and new management solutions, such as a data-wise regulated local fishery, could be enforced. Most likely with decreasing density growth rates and size at maturity should increase and a new optimal mesh size should be re-calculated.

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