Seasonal migrations of pikeperch (*Sander lucioperca*) from fresh to brackish waters. *In vitro* studies of salinity effect on pikeperch YOY

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Abstract

The objective of the study was to examine growth differences of pikeperch in the freshwater Curonian Lagoon and the brackish coastal zone of the Baltic Sea, Lithuania. The findings of other studies suggesting a high growth rate of pikeperch in warm and turbid water bodies with good food accessibility. The results of the study demonstrate significantly greater growth of both length and weight at the cooler and more transparent coastal waters, compared to the growth in the Curonian Lagoon, where according to available information feeding conditions are better than in the coastal waters. The findings suggested a hypothesis of beneficial affect of brackish water and experiments with YOY pikeperch under equal temperature and feeding conditions at 5 and 2 ppt salinity regimes and freshwater as control were carried out. The results of the *in vitro* studies demonstrate a significantly higher growth rate of YOY pikeperch at 5 and slightly higher at 2 ppt than in fresh water under similar feeding conditions and water temperature (17-21°C range). However, the results of the same experiments within the 9-12°C range did not indicate significant differences in growth at different salinity regimes. The last finding enables to explain the wintering and spawning of pikeperch in freshwater Lagoon and post-spawning migrations to the brackish Sea.

Keywords:
Salinity effect, brackish water, pikeperch, *Sander lucioperca*, seasonal migrations, Curonian Lagoon, Baltic Sea.

Introduction
Pikeperch (Sander lucioperca) are common in the inland waters of Europe and usually are considered typical freshwater fish species. However, they also inhabit brackish waters. Pikeperch are locally abundant in coastal and littoral areas throughout the Baltic with the exception of the northernmost areas, exposed coasts and the most saline parts of the south-west Baltic Sea (Lehtonen et al., 1996). Migrations between fresh and brackish waters in pikeperch are documented (Skora, 1996). Pikeperch are known as seasonally migrating fish species in southern part of the Baltic Sea. Pikeperch inhabit brackish coastal waters of the southern Baltic in summer time, while they usually winter in the freshwater lagoons (Lehtonen et al., 1996).

Pikeperch are common fish species in the Curonian Lagoon. Each year, after overwintering and spawning in the lagoon, where the water is fresh and water temperature higher compared to the Lithuanian coastal zone of the Baltic Sea, certain part of pikeperch population migrates to the brackish coastal waters of the Baltic Sea, while in the autumn returns back to the lagoon (Fig.1). According to both commercial catches in the coastal zone, and test fishing in the Klaipėda strait and coastal zone, pikeperch begin to migrate to the sea abundantly in April, while perch as late as in May. Pikeperch and perch return back to the lagoon in September–October. In December–February coastal fishery and test fishing catches of perch and pikeperch are negligible (Ložys, 2003). However, advantages of after-spawning migrations to the colder Baltic Sea remain unexplored.

Water salinity can change the amount of energy available for growth of fishes by altering the energetic cost of ionic and osmotic regulation, but the relation between salinity and growth is complex and not readily predicted (Iwama, 1996; Dgebuadze, 2001). The positive effect of low salinity is known on growth of some fish species of different life stage, e.g. perch Perca fluviatilis (Bein & Ribi, 1994) and yellow perch Perca flavescens larvae (Victoria et al., 1992), rainbow trout Parasalmo mykiss (Lall & Bishop, 1976) and carp Cyprinus carpio (Konstantinov & Martynova, 1990) juveniles. No studies on the effect of salinity on the individual characteristics of pikeperch in situ as well as in vitro in different temperature regimes have been published. Lind (1977) reported a slightly faster growth of pikeperch in the Baltic Sea compared to inland waters but associated that to a greater food supply in brackish water.

The objective of the study was to explain experimentally pikeperch spring migration behaviour while they migrate from the freshwater Curonian Lagoon to the brackish Baltic Sea, Lithuania, and to prove a cause of their backward migration to the lagoon in the autumn, experimentally testing salinity effect in different temperature regimes.
**Methods**

*Field study.*

Material for the pikeperch *in situ* growth study was collected during 1998 – 2000, in September when growth in length and accumulation of energy resources reached the yearly maximum. The growth study focused on pikeperch individuals of 1997-year class, since this generation dominated in both water bodies: individuals of the other age groups were scarce. All pikeperch were weighed (± 1.0 g) and measured (total length L, ± 0.5 cm). Condition factor (CF) and fatness coefficient ($K_F$) were calculated as follows (Bagenal & Tesch, 1978; Bukelskis & Kublickas, 1988):

$$CF = \frac{W}{L^3} \times 100,$$

where $W$, body weight in grams, $L$, total length in cm and $K_F = \frac{w}{W} \times 100$,

where $w$, weight of fat on the intestines, in grams, $W$, body weight, in grams. The characteristics were calculated for a certain pikeperch age group, i.e. 3+. Both sexes were combined in calculations. Fat content ($C_F$) in muscle tissues was expressed as a percentage of wet weight. Pikeperch age was estimated from growth zones of scales. Only females were aged. For statistical analysis t–tests was used.

*Experimental study of growth.*

To evaluate the effect of salinity on pikeperch growth, a survey of pikeperch YOY growth under different salinity conditions was conducted. The first experiment was performed at “high temperature” range and the second - at “low temperature” range. Available laboratory facilities restricted the experiment to YOY providing sufficient density of fish for statistical analysis. Pikeperch YOY were collected by seine netting at Ventė cape, a coastal area in the eastern part of the Curonian Lagoon (55°21’ N, 21°12’ E) in August 2002. After 5 days acclimatisation in fresh water, fish were randomly divided into 15 experimental groups. Each replicate group comprised 5
fish, which were reared in identical 100-l glass aquaria under continuous aeration. The influence of salinity on the pikeperch growth was studied under certain three experimental salinity conditions: five aquaria contained water at 5 ppt, five at 2 ppt and five contained fresh water. The duration of the experiment in “high temperature” range was four weeks, while the duration of the experiment in “low temperature” range was six weeks. Water temperature was ambient in all aquaria and during the experimental period, fluctuated from 17 to 21ºC (mean 18.0ºC), in “high temperature” range, while in “low temperature” range - from 9 to 12ºC (mean 9.7ºC). All fish were provided with the same quantity of live *Chironomus* spp. larvae, weighed with accuracy of 0.01 g. To ensure similar food consumption between replicates, each new portion of food was introduced immediately following consumption of the previous ration in all replicates. Total weight (±0.01 g after excess water removed) for each replicate was measured prior to the beginning of the experiment and after each week. To assess differences in growth under different treatments, the weight increments of pikeperch YOY groups of each replicate were analysed using Tukey honest significant difference test.

**Results**

Pikeperch start to migrate from the Curonian Lagoon after wintering and spawning. Field observations demonstrated better growth in length and weight (Fig. 3, 4) (Ložys, 2003) in the lagoon despite lower water temperature in the sea (Fig 2).

![Graph showing water temperatures](image)

**Figure 2.** Water temperatures in the Curonian Lagoon (■) and the Baltic Sea (▲) during March – September 1998–2000 (vertical bars represent 1 SD).
The results of the experiment in “high temperature” range demonstrated the significant affect of salinity on YOY pikeperch growth at both 5 and 2 ppt salinity conditions (Fig. 5). Differences in growth between 2 and 5 ppt salinity replicates were insignificant. Salinity affect was insignificant at the “low temperature” range (Fig. 6).
Figure 6. Total weight increment of pikeperch YOY in brackish and fresh water (Tukey HSD test: 5 ppt vs. fresh water, P=0.67; 2 ppt vs. fresh water, P=0.72; 5 ppt vs. 2 ppt, P=0.99).

Discussion

It is wholly accepted that the growth of percids is positively influenced by temperature (e. g. Karås & Neuman, 1981; Draulans et al., 1985; Elliott, 1985; Hudd et al., 1988; Wilkońska, 1988; Karås, 1990; Raat, 1990; Karås & Thoresson, 1992) and is food limited (e. g. Filuk, 1962; Popova & Sytina, 1977; Kjellman et al., 1996; Lehtonen et al., 1996). Available information suggests that feeding (Repečka et al., 1996; Ložys, unpubl. data) as well as temperature conditions during the growing season in the Curonian Lagoon are better than in the coastal waters. In mid September, when water temperature drop to 12-13°C, intensive pikeperch migration back to the lagoon starts. Study in situ demonstrates beneficial effect of pikeperch summer in the brackish coastal waters. It was hypothesized that water salinity could beneficially effect pikeperch in the sea. To test the hypothesis of the influence of salinity, YOY pikeperch were reared under equal feeding conditions and temperatures, at 5 and 2 ppt salinity regimes and freshwater as control. The first experiment was performed at 17-21°C water temperature and the second - at 9-12°C range.

The results of the experiment in “high temperature” range demonstrated the significant beneficial affect of salinity on YOY pikeperch growth at both 5 and 2 ppt salinity conditions (Fig. 5). The beneficial effect of salinity on pikeperch growth, most likely, is manifested only under salinities close to the internal osmotic pressure in fish. However, the affect was insignificant at the lower temperature range (Fig. 6). Consequently it is evident that temperature plays also significant role in salinity affect on pikeperch growth. According to the results of the first experiment, migration to the sea could be a result of the beneficial salinity affect on the growth of pikeperch. The second finding allows stating that after water temperature decreases, the salinity affect becomes insignificant, and migration to the protected from the stormy winds lagoon starts. However, the obtained results requires further studies to understand mechanisms of water salinity effect on pikeperch.

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References


