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Otolith Sr:Ca Ratios as Natural Mark to Discriminate the Restocked and Naturally Recruited European Eels in Latvia

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Abstract.—The restocking programs of the European eel *Anguilla anguilla* have been conducted for nearly one century in Latvia. To evaluate the efficiency of the eel restocking program and reveal the migratory life histories of European eels in Latvian waters, a total of 75 individuals were collected from the mouth of River Daugava (Daugavgriva, brackish), nearby lake (Lake Ķīšezers, freshwater), and a coastal site (Mērsrags, brackish). The naturally-recruited eels consisted of two saltwater type individuals (SW, 0–7%): eels lived in saltwater and did not enter freshwaters, and inter-habitat-shifter (IHS, 60–85%): eels had experienced both freshwater and saltwater. The restocked eels consisted of purely freshwater type (FW, 7–36.7%) that the eels permanently lived in freshwater without saltwater experience. Average otolith Sr:Ca ratios in the edge were different among sites and origins, and corresponded to the salinities of sampling sites. The mean age at first freshwater entry of IHS was 4.8 ± 2.3 years, similar to previous study in Lithuania ($p = 0.188$). The growth rates of FW eels in the river mouth and coast were significantly slower than that of IHS eels ($p < 0.001$ and 0.012), but not in the lake ($p = 0.372$), implying a site-origin interaction on the growth rate. The use of otolith Sr:Ca ratios as a natural mark to distinguish the restocked eels enabled the assessment of restocking efficiency in the future.

Introduction

European eel *Anguilla anguilla* is a facultative catadromous fish spawning in the Sargasso Sea and living in the freshwater, brackish and costal waters in Europe (Tsukamoto et al. 1998; Tzeng et al. 2000; Tesch 2003). In Latvia, *A. anguilla* was one of the most expensive fish that fishermen were most interested in. To enhance the local eel production in Latvia, the restocking plan has been conduct since 1927. Approximately 30 million of glass eels imported from France were regularly released in 51 Latvian lakes during 1960 to 1988 by the government. From 1990 to present, numerous glass eels were released in inland freshwaters by private enterprises, e.g. fishing rights or lakes leaseholder.

Although the restocking plans were conducted for a long time in Latvia, the following restocking efficiency was seldom evaluated, nor was the contribution of restocked eels to the local population examined. This might be due to the lack of appropriate marks or tags to discriminate the restocked eels from naturally-recruited eels. Recent studies indicated that the otolith Sr:Ca ratio is a useful natural mark to discriminate fish from freshwater and saltwater habitats (Campana 1999; Campana and Thorrold 2001), and has been used to reveal the migratory histories of *A. anguilla* between freshwater and saltwater (e.g., Tzeng et al. 1997; Tsukamoto et al. 1998; Tzeng et al. 2000).

The glass eels being restocked were purchased in the estuaries in France, transported across the Baltic Sea and released in the planned freshwater lakes in the middle reaches of the river. The naturally-recruited ones entered the brackish Baltic Sea and migrate across the Baltic Sea to reach the south eastern Baltic countries. The differences in route to Latvian waters resulted in different saltwater experience between restocked and naturally-recruited eels, which can be revealed by otolith Sr:Ca ratios. This approach has been applied to examine the restocking efficiency in Lithuania (Shiao et al. 2006) and the growth differences between restocked or naturally-recruited eels (Lin et al. (2007b). However, the restocking program efficiency was still unclear in Latvian waters, nor was the growth compared between migratory history types and eel origins.

The objectives of this study were (1) to identify the origins of eels (restocked or naturally-recruited) from three Latvian waters: river mouth (Daugavgriva), nearby lakes

(Lake Ķīšezers) and Baltic coastal region (Mērsrags) by otolith Sr:Ca ratios, (2) to examine the growth differences of eels among different migratory history groups and origins, and (3) to compare the results in Latvia with previous studies in Lithuania (Shiao et al. 2006; Lin et al. 2007b).

Methods

Study site

European eels *A. anguilla* were collected by fyke-nets from Daugavgriva, the mouth of River Daugava, during August to September, 2005, as well as from nearby Lake Ķīšezers and a coastal site, Mērsrags, during August to September 2006 in Riga Gulf (Figure 1). Riga Gulf is located in the eastern part of the Baltic with the salinity ranging from 2 to 7 ‰, depending on regions and seasons. The Latvian coastline of Riga Gulf is about 250 km and the average depth of the coastal zone (2 mi) is around 10 m. Bottom vegetation in the coastal waters of the gulf is unevenly distributed. The brown algae are dominant, followed by the filamentous green algae and red algae. In general, Riga Gulf can be considered as highly eutrophic.

Lake Ķīšezers is located close to the coast and connected with the Baltic Sea through lower reach of River Daugava. It is a freshwater lake but during strong western winds brackish water from Gulf of Riga can enter the lake for a short time. The area of this lake is 1,730 ha with an average depth of 2.4 m and a maximum depth of 4.5 m in the central part. Lake Ķīšezers is also characterized by brown color of water and low transparency, which is around 0.5 m in the summer.

River Daugava is the largest river in Latvia with the largest river basin as well. The width of the lower reach of River Daugava is around 500 m and the depth is around 15 m. The sampling site in the river mouth is brackish with a mean salinity of 4.2 ‰. Three big hydroelectric plants were constructed on Daugava and one located just 28 km away

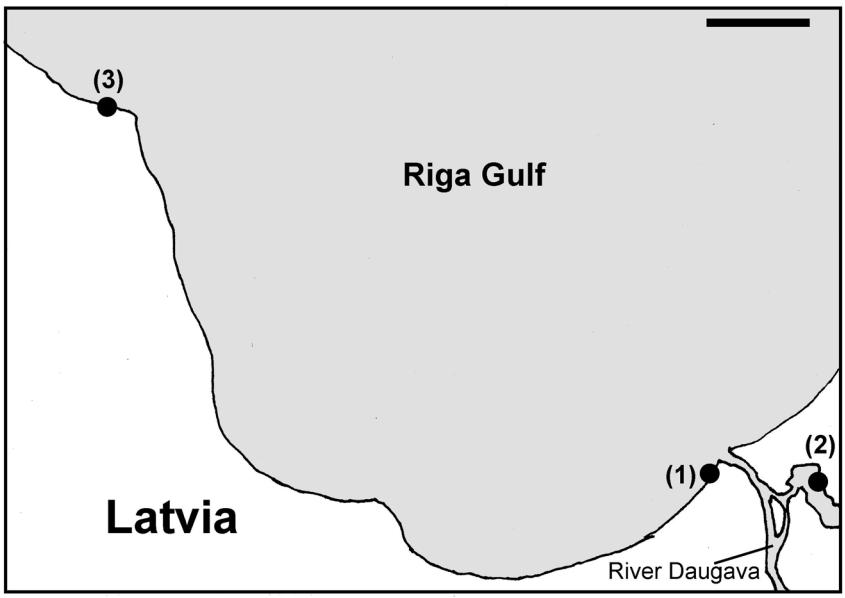

Figure 1. Sampling sites of European eel Anguilla anguilla in Gulf of Riga in Latvia. (1) Mouth of River Daugava (Daugavgriva), (2) Lake Ķīšezers and (3) Mērsrags. Scale bar = 5 km.

from the river mouth without equipped fishpass. Therefore, the upstream migration of diadromous fish in River Daugava is cut off, but downstream migration is believed to be limited.

The total length (TL) and weight (TW) of the eel were measured to the nearest 1.0 mm and 1.0 g, respectively. Sexes were determined macroscopically from the gross morphology of the gonads, where eels with thin, regularly lobed organs (Syrski's organ) were considered males, while individuals with more broad and folded curtain-like gonads were females (Tesch 2003). Nearly all eels caught were females except for one male, which was excluded in the analysis.

Otolith Sr:Ca ratio measurement and age determination

The largest pair of otoliths (sagittae) was removed, dried in the air, embedded in Epofix resin, ground and polished until the premordium was exposed. The polished otoliths were coated with carbon under a high-vacuum evaporator. Sr and Ca concentrations in the otolith (wt %) were measured from the primordium to the edge at 10 μm intervals by electron probe microanalyzer (EPMA, JEOL JXA-8900R) with the same conditions and standards described by Lin et al. (2007b). The critical otolith Sr:Ca ratio indicating freshwater residency was set at 2.24×10^{-3} (Shiao et al. 2006) and the region where two consecutive points were lower than the critical value was regarded as freshwater experience (Jessop et al. 2007). If the EPMA transect passed through the vaterite inclusion, it was not used and an alternative one without passing the vaterite inclusion was conducted to avoid the misidentification of the migratory group (Tzeng et al. 2007; Jessop et al. 2008). The otolith edge was deposited when the fish is caught, and thus contains environmental information about the sampling site. Therefore, otolith ratios of the last three points to the otolith edge were averaged. To evaluate whether the different salinities among sites and eel origins can affect average otolith Sr:Ca ratios in the edge, the average values were compared by sites and origins.

After EPMA analysis, the otoliths were re-polished to remove the carbon layer and etched with 5% EDTA for 1–2 min to reveal annual rings. The age of the fish was estimated by counting the number of annual rings and the growth rate (GR) was calculated as $(TL - L_0) \times Age^{-1}$ where L_0 is mean length of elvers (Wang and Tzeng 2000). The age of first freshwater entry was estimated by counting the number of rings corresponding to where the otolith Sr:Ca ratio below the freshwater criterion.

Data Analysis

The proportions of restocked eels between sites were compared by chi-square test. The average of otolith Sr:Ca ratios in the edge were compared by sites and origins using two-way analysis of variance (ANOVA) with Turkey's multiple comparison. The total length, age and growth rate were log-transformed to meet the assumption of normal distribution (KS Test, all $p > 0.08$) and homogeneity of variance among groups (Levene's Test, all $p > 0.29$). They were then compared among sites and migratory history types by two-way ANOVA. The effects of sites, origins and site-origin interaction on log-transformed growth rates were compared by two-way ANOVA. Although the distribution of the age of first freshwater entry was not normally distributed for eels from Latvia and Lithuania (KS test, all $p < 0.001$), they were homogeneous to each other (KS test, $p = 0.64$). Therefore, the age at first freshwater entry of the eels between Latvia and Lithuania were compared by nonparametric Wilcoxon Rank Sum test. All the statistical computation were completed in SAS® (Ver-

sion 8.01) and the significance level α was at 0.05.

Results

Migratory history types and origins of the eels

A total of 75 eels were collected, including 31 in Daugavgriva, 16 in Lake Ķīšezers and 28 eels in Mērsrags. All eels were females except one caught in Daugavgriva, which was excluded in subsequent analysis. The Sr:Ca ratios of the eels after elver stage were classified into saltwater type (SW): the otolith Sr:Ca ratios of the eels were consistently higher than the critical value of 2.24 $\times 10^{-3}$, indicating that the eels lived in saltwater since elver stage until being caught (Figure 2a), inter-habitat- shifter (IHS): the ratios were initially higher and then varied between the critical value, indicating that the eels moved between saltwater and freshwater (Figure 2b) and freshwater type (FW): the ratios were consistently lower than the critical value, indicating they persistently stayed in the freshwater since elver stage until being caught (Figure 2c). The eels examined were mainly IHS, followed by FW with very few SW individuals. Eighteen IHS, 12 FW, and 1 SW eels were found in Daugavgriva, 11 IHS and 5 FW eels were found in Lake Ķīšezers, and 26 IHS, 0 FW, and 2 SW eels were identified in Mērsrags (Table 1).

Naturally-recruited (Nat) eels have experienced saltwater after metamorphosis to elvers when migrating across the brackish Baltic Sea, and the restocked (Rst) eels did not experience saltwater. So Nat eels were equivalently SW and IHS eels, and Rst eels were the FW eels. Although from brackish Mērsrags, there are two IHS eels considered as Rst eels, because they entered freshwater after metamorphosis. At radius about 750 and 1500 μm, they moved to saltwater and showed elevated Sr:Ca ratios representative of brackish coast water (Figure 3). The proportions of Rst eels was 36.7% in Daugavgriva, 31.2% in Lake Ķīšezers and 7.1% in Mērsrags, significantly different among sites χ^2 Test, p = 0.015) (Table 1). The temporal changes of otolith Sr:Ca ratios differed substantially between Nat and Rst eels. The average otolith Sr:Ca ratios for the Nat eels were approximately 5×10^{-3} at the elver stage and gradually decreased to 2×10^{-3} at the edge. The average ratios of Rst eels remained at a low value of around 1.5×10^{-3} from the elver stage until the edge. The 95% confidence interval for the mean did not overlap until at radius of around 1000 μm (Figure 4), indicating their different migratory histories.

Average otolith Sr:Ca ratio in the edge among sites and origins

For Nat eels, the average ±SD) otolith Sr:Ca ratio in the edge were 2.69 ± 1.16, 1.35 ± 0.92 and $2.33 \pm 1.26 \times 10^{-3}$ in Daugavgriva, Ķīšezers and Mērsrags, respectively. For Rst eels, they were 0.70 ± 0.41, 0.82 ± 0.74 and $2.29 \pm 0.02 \times 10^{-3}$ (Table 2). The average edge ratios of eels were significantly different by sampling sites and eel origins (Two-way ANOVA, $p = 0.03$ and <0.001, respectively). When compared between origins by sites, the Nat eels had significantly higher average edge ratios than Rst eels in Daugavgriva ($p < 0.001$). However, their edge ratios were not significantly different between origins in Ķīšezers and Mērsrags ($p = 0.28$ and >0.5, respectively). When compared among sites by origins, the edge ratios of Nat eels from Daugavgriva and Mērsrags were significantly higher than those of Nat eels from Ķīšezers ($p = 0.01$), corresponding to the salinity of sampling sites. The edge ratios of Rst eels from Mērsrags were significantly higher than those from Daugavgriva and Ķīšezers ($p = 0.003$), because the two Rst eels have moved to the coast (Figure 3).

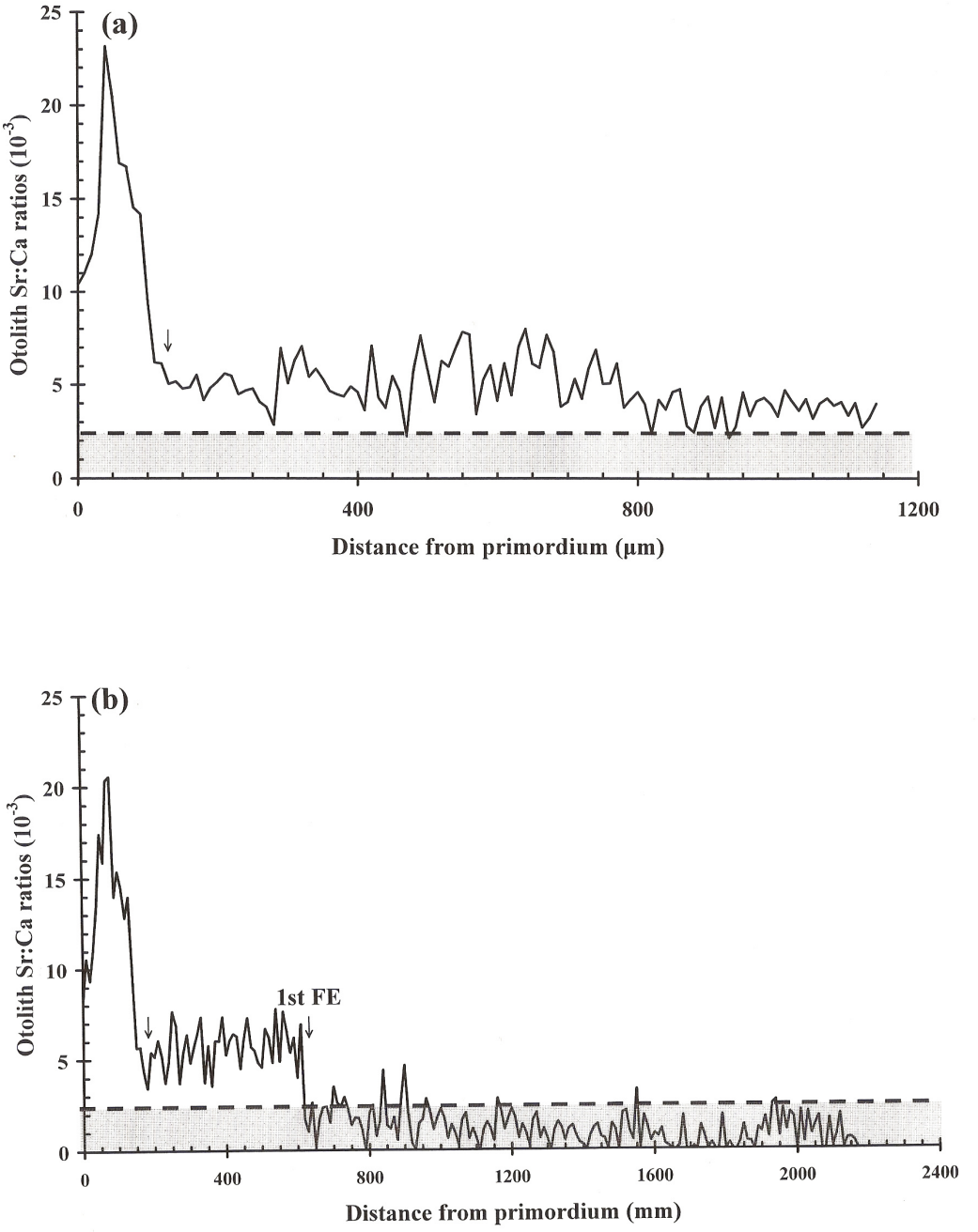

Figure 2. Otolith Sr:Ca ratios of (a) saltwater type (SW), (b) inter-habitat-shifter (IHS) and (c) freshwater-type (FW) eels. The grey area under the broken line (Sr:Ca ratio = 2.23×10^{-3}) indicated the freshwater experiences. Arrows without headings = elver check. 1st FE = the first freshwater entry.

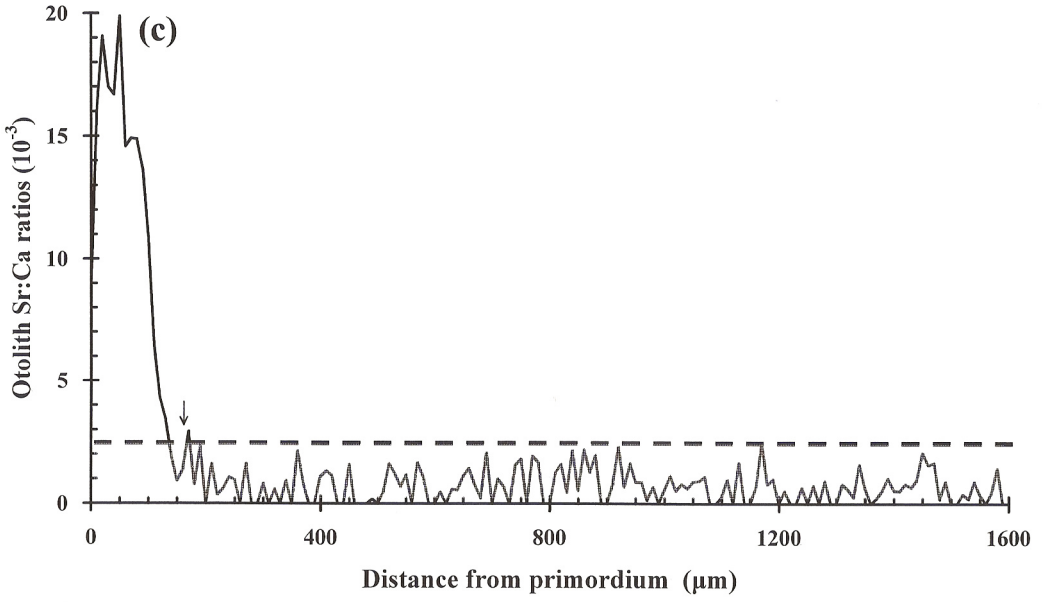

Figure 2. Continued.

Otolith annulus patterns and age at first freshwater entry

The otolith annulus patterns of Nat and Rst eels were shown in Figue 5a and b. The region from the primordium (P) to the elver check (EC), which corresponded to the marine larval period from leptocephalus to the elver stage, was dark in appearance after etching by HCl. After EC, clear circular annuli were deposited in the otolith and some less-clear pseudo-annuli were found between the success annuli. The otolith annulus patterns were generally similar between the Nat (Figure 5a) and Rst eels (Figure 5b) except that more annuli were found in Rst eels because of older ages. The mean ±SD) age at first freshwater entry of the IHS, determined by otolith Sr:Ca ratios (Figure 2b) , was 4.8 ± 2.3 years and it ranged from 1 to 11 years, which was not significantly different from the eels from Lithuania (Shiao et al. 2006; mean ±SD = 5.2 ± 2.1 year, Wilcoxon Rank Sum test, $p = 0.19$). There were seemingly two peaks in the age at first freshwater entry in both countries that 55–57% at age 3–5 years and 23–28% at age of 7–9 years (Figure 6).

Growth rate comparisons between sampling sites and migratory history types

FW (equivalently Rst) eels had significantly smaller total length and older age than the IHS (Nat) eels (two-way ANOVA, $p = 0.028$ and <0.001) in Daugavgriva, but the differences in total length and age between FW and IHS eels were not significant in Mērsrags ($p = 0.09$ and 0.13) and Lake Ķīšezers ($p = 0.40$ and 0.60). The growth rates were significantly influenced by sampling sites, migratory history types and their interaction (two-way ANOVA, all $p < 0.001$). When the sites were separated, the growth rate of FW eels was significantly slower than that of IHS eels ($p < 0.001$) in Daugavgriva and Mērsrags ($p = 0.01$). However the growth rate was not significant difference between FW and IHS eels in Lake Ķīšezers, ($F = 0.85$ $p = 0.37$) (Table 1).

Table 1. Anguilla anguilla collected in Daugavgriva, Lake Ķīšezers and Mērsrags in Latvia with mean salinities (‰) in the brackets. Percentage by origins (Nat: natural-recruited, Rst: restocked eels) and numbers of eels by migratory history types (Ntypes, IHS: inter-habitat- shifters, SW: saltwater type, FW: freshwater type eels). Mean (± SD, ranges in parenthesis) total length (TL, cm) and weight (TW, g), age (years) and growth rate (GR, cm year-1). ND = data were not available.*: All were females except one male (TL = 55.9 cm).

Site	Daugavgriva (4.2)			Lake Ķīšezers (0)		Mērsrags (5.6)		
Origin	Nat (63.3 %)		Rst (36.7 %)	Nat (68.8 %)	Rst (31.2 %)	Nat (92.9 %)		Rst (7.1 %)
Type	IHS	SW	FW	IHS	FW	IHS	SW	IHS
N_{type}	18	1	11(1)*	11	5	24	2	2
TL	58.7 ± 9.9	63.2	69.3 ± 9.9	80.3 ± 7.0	83.6 ± 7.0	78.7 ± 6.3	80.1 ± 10.9	68.3 ± 11.3
			(58.5 ~ 91)	(69.4 ~ 91.7)	(73.8 ~ 90.5)	(66.2 ~ 90.7)	(72.4 ~ 87.8)	(60.3 ~ 76.3)
TW		ND		949 ± 236	1047 ± 291	1021 ± 244	1153 ± 576	691 ± 389
				(521 ~ 1280)	(712 ~ 1330)	(543 ~ 1510)	(745 ~ 1560)	(416 ~ 966)
Age	10 ± 2	13	22 ± 5	14 ± 2	13 ± 4	14 ± 2	14 ± 1	18 ± 4
	(6 ~ 13)		(17 ~ 31)	(10 ~ 17)	(8 ~ 17)	(10 ~ 20)	(13 ~ 15)	(15 ~ 20)
GR	5.5 ± 1.1	4.4	3.0 ± 0.6	5.4 ± 0.8	6.2 ± 2.4	5.5 ± 0.9	5.3 ± 0.2	3.7 ± 1.4
	(4.1 ~ 9.0)		(2.0 ~ 4.0)	(4.5 ~ 7.0)	(4.6 ~ 10.4)	3.7 ~ 7.4)	(5.1 ~ 5.5)	(2.7 ~ 4.7)

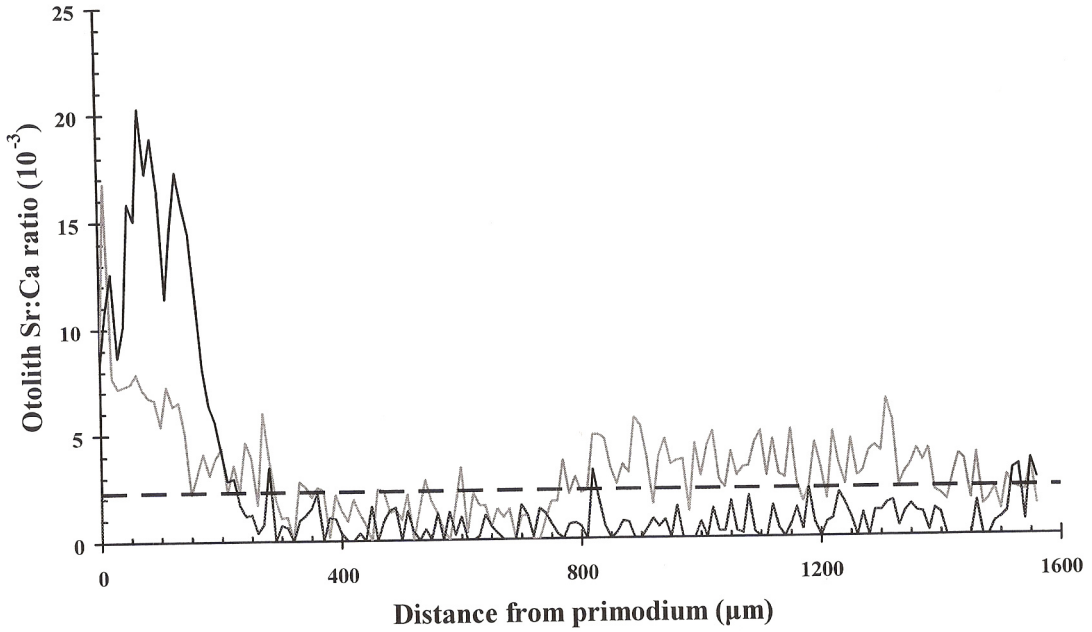

Figure 3. Mean (± 95 % CI) otolith Sr:Ca ratios of naturally-recruited (black line, *n* = 56) and restocked (grey line, *n* = 18) eels.

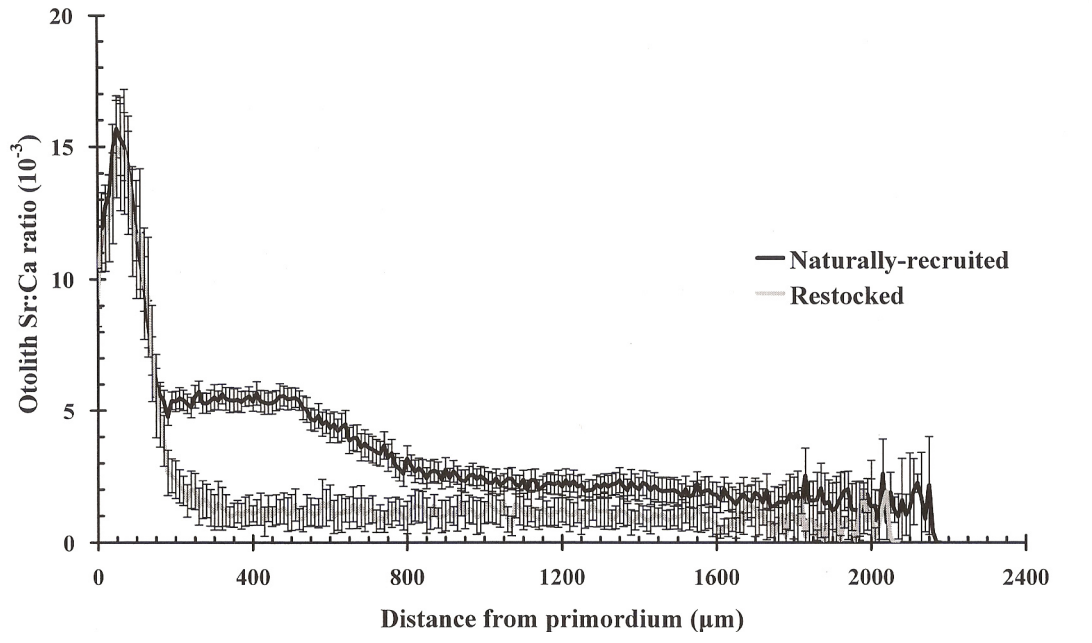

Figure 4. Sagittal plan of otoliths of (a) naturally-recruited with Sr:Ca profiles in Figure 2b and (b) restocked eels in Figure 2c. P = primordium, EC = elver check. 1st FE = 1st freshwater entry. Black cycles are annuli. The white line from the primordium to edge was the track where Sr:Ca ratios were measured. Scale bar = 1 mm.

Table 2. Mean (± SD, ranges in parenthesis, × 10^{-3}) of the average otolith Sr:Ca ratio of last three points in the edge in naturally-rectuited (Nat) and restocked eels (Rst) by sites. Different superscripts indicated significant difference in otolith Sr:Ca ratios among sites. The asterisk in Daugavgriva indicated that the average edge ratios of Nat eels significantly differed from the ratios of Rst eels.

Site	Daugavgriva*	Ķīšezers	Mērsrags
Nat	2.69 ± 1.16[a]	1.35 ± 0.92[b]	2.33 ± 1.26[a]
	(0.00 ~ 4.24)	(0.13 ~ 3.03)	(0.50 ~ 4.59)
Rst	0.70 ± 0.41[a]	0.82 ± 0.74[a]	2.29 ± 0.02[b]
	(0.13 ~ 1.44)	(0.07 ~ 2.05)	(2.28 ~ 2.3)

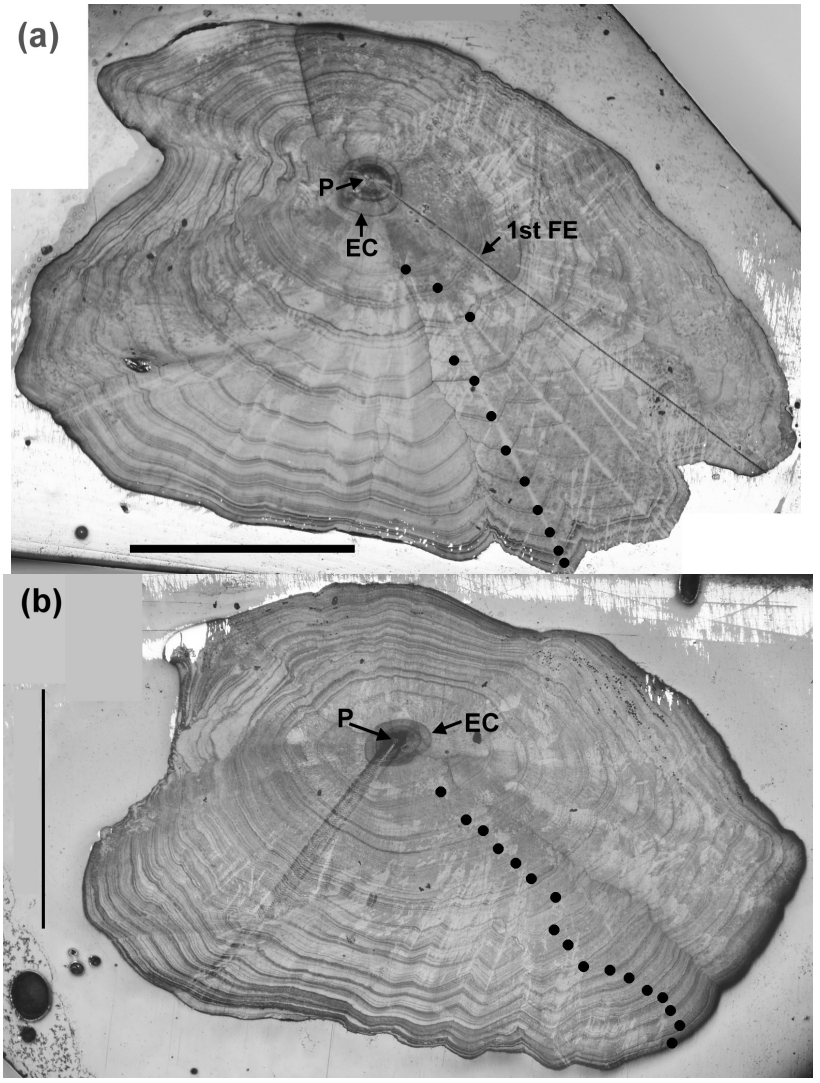

Figure 5. The otolith Sr:Ca ratios of two restocked eels from Mērsrags. The grey area under the black broken line (Sr:Ca ratio = 2.23 × 10^{-3}) indicated the freshwater experiences

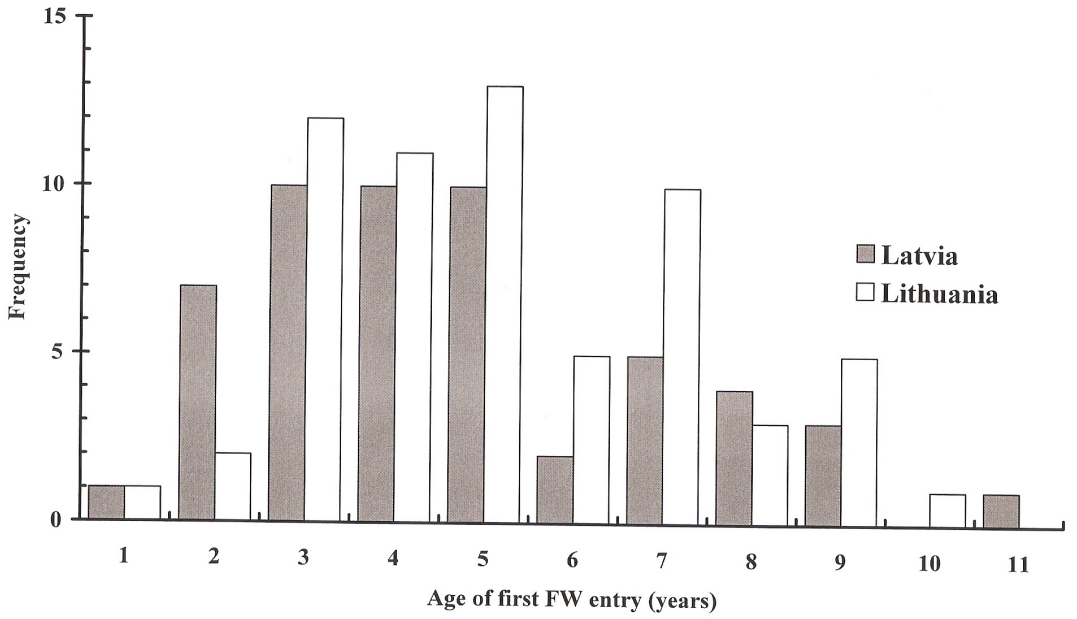

Figure 6. Age of first freshwater entry for the naturally-recruited eels from Latvia (grey, mean (± SD) = 4.8 ± 2.3 years) and Lithuania (white, 5.2 ± 2.1 years, compiled from Shiao et al., 2006).

Discussion

Implication of different migratory history types

The dominance of IHS indicated that the movement of the eels from brackish Baltic waters to freshwater habitats was frequent in Latvian waters that a majority of the eels have entered freshwaters at least once. This was also in consistent with the eels in Lithuanian (Shiao et al. 2006). The sampling sites were either near or in the coastal waters in Latvia, suggesting that the freshwaters connecting to the Baltic Sea appeared to be as crucial as the coastal waters for the European eels, which have flexible and plastic habitat uses (Daverat et al. 2006).

Proportion of Rst eels

If some of the Rst eels in Latvian waters came from other countries, such as Lithuania, they had to move though the brackish Baltic, leaving elevated otolith Sr:Ca ratios. All but two in Mērsrags entered freshwater and stayed there until being caught, so the Rst eels are probably not from other countries. The higher proportions of Rst eels in Lake Ķīšezers and Daugavgriva than in Mērsrags appeared reasonable because Rst elvers were released in some midland lakes which have connection with the Gulf of Riga through River Daugava. However, the outlets of these lakes were equipped with eel weirs, which covered practically most eel escapements. In addition, downstream migration of eels which have overcome the eel weirs was believed to be further limited by the hydroelectric power station dams without fish ladders.

The existence of Rst eels in Daugavgriva and Lake Ķīšezers implied that at least some Rst eels have passed these obstructions successfully and they were able to be caught in the waters in the lower reach of River Daugava and the Baltic coast. Sampled eels were composed of both yellow and silver eels and therefore the spawning migration of silver Rst eels

(Limburg et al. 2003; Westin 2003) appeared not as limited by the obstructive constructions as previously considered. It was unclear how these eels passed these artificial obstructions, probably through the period of water discharge. Although the eels can pass these power plants, they also suffer additional mortality from 15 to 38% (ICES 2007). Therefore, the contribution of Rst eels to downstream sites in Latvia is still constrained.

On the other hand, the proportions of Rst eels in river mouth (36.7%) and coastal lake (31.2%) in Latvia were substantially higher than that in the Curonian Lagoon in Lithuania (20%, Shiao et al. 2006). It was also slightly higher in coastal waters in Latvia (7.1%) than in Lithuania (2%). Numerous factors might result in this phenomenon, such as the number and frequencies of glass eels released, days, months, seasons and years of releasing, the geographic features, current systems, behavioral differences, productivity of the waters where the eels were released and the degree of connectivity between upper and lower reaches. So far, it has been premature to conclude that the restocking efficiency was different between the two countries examined.

Average otolith Sr:Ca ratios in the edge

The average otolith Sr:Ca ratios in the edge of Nat eels corresponded to the salinities of sampling sites, indicating that the average Sr:Ca ratios of last three points were able to distinguish the brackish sites of 4.2–5.6 ‰ from the freshwater sites (Lin et al. 2007a). Insignificant differences in the average edge ratios between Nat and Rst in Lake Ķīšezers and Mērsrags also suggested that the average edge ratios can be used to represent the salinity of sampling site. However in Daugavgriva, the edge ratios of Rst eels were significantly lower than those of Nat eels. It suggested that other factors, such as eel origins, should still be considered when applying the otolith Sr:Ca ratio in the edge as an empirical indicator of habitat salinity. This might also imply that these Rst eels have stayed in midland freshwaters for a certain time, and they were caught soon after moving to Daugavgriva.

Age at first freshwater entry

The similarity in age at first freshwater entry between eels in Latvia and Lithuania implied the similar migration behavior of IHS eels from the opening of the Baltic Sea to the freshwaters. Because the eels were sampled in different years (2003 to 2004 in Lithuania and 2005 to 2006 in Latvia), it also indicated that the migration of the eels into freshwater was in some degree spatially and temporally persistent in the studied sites during investigated period. However, this migration behavior exhibited certain degree of individual variation, as indicated by the large range from 1 to 11 years. Around the 1910s to 1920s, the elvers were found to enter freshwater in the northeastern and eastern regions of Sweden and southern regions of Lithuania (Figure 6 in Dekker 2003a), suggesting that the eels were able to cross the Baltic Sea with a young age. But the drastic decrease in recruitment of European eels in recent years (Dekker 2003b) might discourage the eels from migrating eastward (Shiao et al. 2006). Two modes at age of 3–5 and 7–9 implied that the migration of the eels toward freshwaters might be composed of two subtypes, one moved to freshwater quickly and the other did slowly. This bimodality might be partly explained by the different types of eel freshwater movement, namely founders, pioneers, home range dweller and nomads (Feunteun et al. 2003).

Differences in growth rates between migratory history types and eel origins

Because the SW eels were few, the growth comparison was focused on IHS and FW eels, equivalently between Nat and Rst eels. The

growth rates of FW (Rst) eels were smaller than those of IHS (Nat) eels in Daugavgriva and Mērsrags, but they did not differ in Lake Ķīšezers. The productivity was similar among the three studied sites, and the slower growth rate of FW eels in Daugavgriva might be due to that the FW eels have escaped from midland lakes with low productivity, in which the growth of the eel was slow (Lin et al. 2007b). Previous studies in Lithuania suggested that the sampling sites might be the major factor influencing the growth of the eels rather than origins (Lin et al. 2007b). The significant site-type interaction in this study further suggested that the influences of sampling site and eel origins on the growth of the eels might be more complicated and appeared to be site-specific.

In conclusion, the eels collected from three Latvian waters were composed of mainly IHS eels, followed by the FW and the SW eels were the least. The Rst eels contributed around 30% of the total eel caught, suggesting the substantial contribution of Rst eels to the eel production in three sampling sites. The average otolith Sr:Ca ratios of last three measuring points were able to represent the salinity of sampling site. The otolith annulus pattern was similar between Nat and Rst eels except more annuli found in the otoliths of Rst eels. The age at first freshwater entry of the eels was similar between eels from Latvian and Lithuanian waters, indicating the migration across the Baltic Sea was spatially and temporally persistent during investigated period. The growth of FW (Rst) eels was not consistently slower than the IHS (Nat) eels in the sampling sites, indicating a complicated site–origin interaction on the growth of the eel. This study further suggested the importance of otolith Sr:Ca ratio as natural mark to discriminate the restocked European eels from naturally-recruited eels in the Baltic countries. The eels in the Baltic regions were still less studied and future research efforts were still needed.

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