Fisheries Management and Ecology, 1999, **6**, 83–86

Management and Ecological Note

Variations in Atlantic salmon, *Salmo salar* L., smolt age in tributaries of the River Teno, Finland

V. ENGLUND, E. NIEMELÄ & M. LÄNSMAN

Finnish Game and Fisheries Research Institute, River Tenojoki Fisheries Research Station, Utsjoti, Finland

M. HEINO

Division of Population Biology, Department of Ecology and Systematics, University of Helsinki, Helsinki, Finland

---

The smolt age of Atlantic salmon, *Salmo salar* L., varies greatly over its wide geographical distribution, and is 1+ or 2+ years at southern latitudes under optimal growing conditions (Metcalfe, Huntingford, Thorpe & Adams 1990) but can sometimes be as high as 7–8+ years in the northern-most rivers (Power 1969; Kuzmin & Smirnov 1982; Jensen & Johnsen 1986).

Although altitude-dependent variations in smolt age have been studied intensively, interannual differences, especially fluctuations in age-structure, have attracted only minor attention. The present paper describes interannual variations in smolt age in six tributaries of the River Teno, Finland, in the extreme north of Scandinavia (70° N, 28° E).

The present analysis was based on material collected between 1989 and 1995 from the six tributaries of the River Teno, i.e. the rivers Tsarsjoki, Pulmankijoki, Kuoppilasjoki, Kevojoki, Kalddasjoki and Karigasjoki. The drainage area of the River Teno is 16 386 km^2 and more than 1000 km of the river system is accessible to salmon. It is the most productive salmon river in either Finland or Norway, and its population is based on natural reproduction.

Fishing was carried out in early summer (between June and July) using traps placed near the river mouths with wing nets stretching to either bank. Despite the wing nets and traps effectively blocking the river channel, it was evident that the trapping system was incapable of capturing all of the smolts. However, it is reasonable to assume that the number and age structure of the smolts captured were representative of the population in the river. The traps were emptied several times a day, scale samples were taken for age determination and the smolts were released into the river below the trapping site. The ages were determined using scales from near the lateral line, between the adipose and dorsal fins.

Six smolt age groups (from 2+ to 7+ years of age) were identified in the River Teno watercourse, although the 2- and 7-year-old specimens were not numerous. In 1989–1995, the mean smolt age (± SE) in each of the six rivers studied was 4.1 years (4.4 years ± 0.18, $n = 6424$; 4.3 ± 0.07, $n = 5528$; 4.1 ± 0.18, $n = 1698$; 4.0 ± 0.08, $n = 5073$; 4.1 ± 0.24, $n = 1122$; 3.9 ± 0.09, $n = 6341$; in the rivers Tsarsejoki, Pulmankijoki, Kalddasjoki, Karigasjoki, Kuoppilasjoki and Kevojoki, respectively), which agrees with the general geographical variation in smolt ages in Europe (Metcalfe & Thorpe 1990). The annual

Correspondence: Eero Niemelä, Finnish Game and Fisheries Research Institute, Pukinmäenaukio 4, P.O. Box 6, FIN-00721 Helsinki, Finland (e-mail: eero.niemela@rktl.helsinki.fi).

variations ($F_{6,23} = 6.64$, $P < 0.001$) and differences between the rivers ($F_{5,23} = 3.89$, $P = 0.011$) were significant (ANOVA, type III sum of squares).

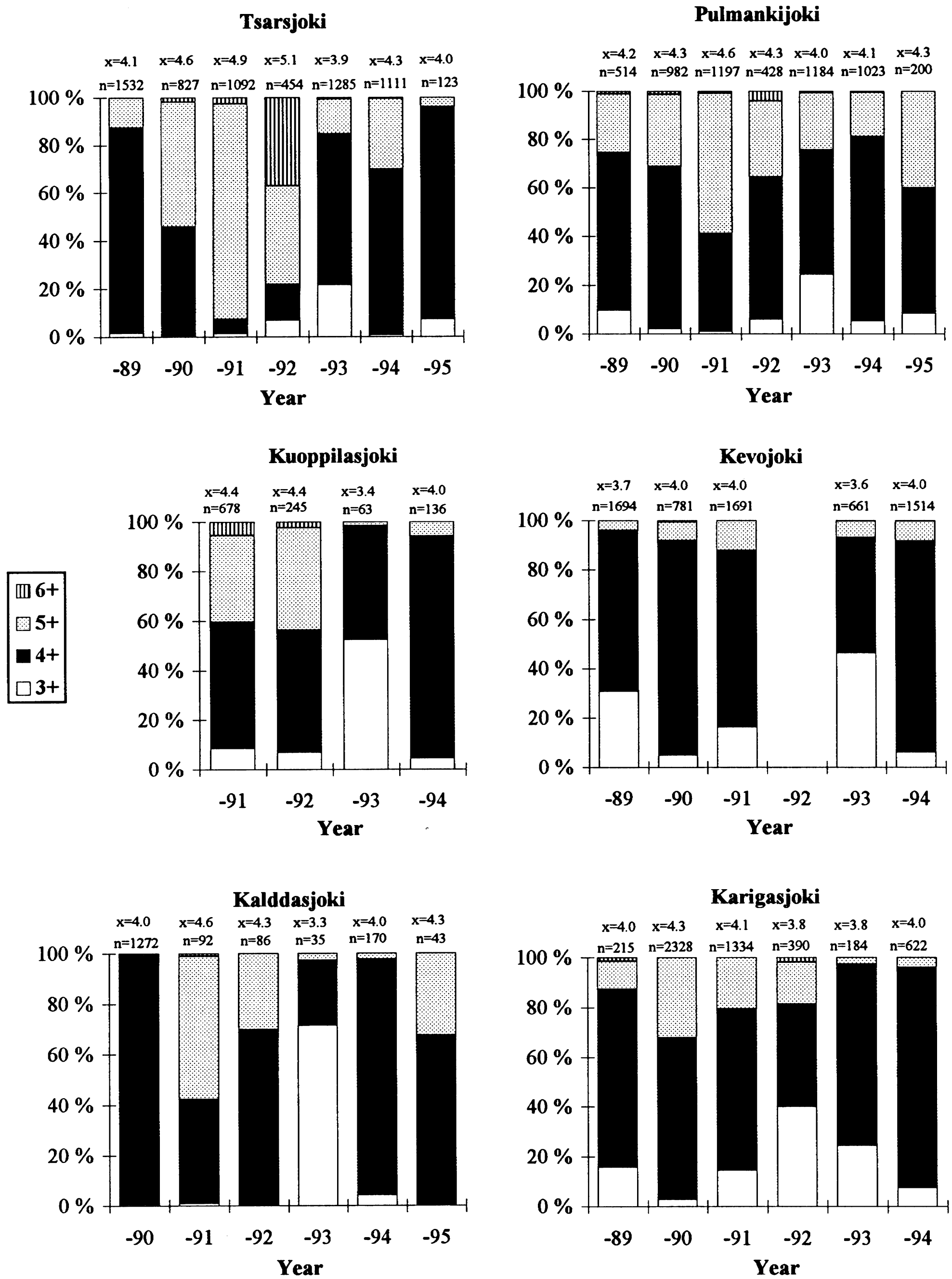

Figure 1. Smolt age structure (3–6 years of age) in the six tributaries of the River Teno, Finland: (x) mean smolt age; and (n) number of smolt trapped.

Since it is difficult to detect the differences within age groups if only mean smolt ages are used, a generalized linear model was employed to analyse the age structure because this allowed an assessment of whether the proportion of a certain age group differed between years or between rivers. The significances of the differences in the proportions of (1) 3+, (2) 3+ and 4+, and (3) 3–5+-year-old smolts in the total catch were tested. Binomial errors and a logit link function were assumed, and the Williams procedure was used to handle overdispersion (see Collett 1991). The data set for this purpose was restricted to four rivers, i.e. the Tsarsejoki, Pulmankijoki, Kalddasjoki and Karigasjoki, for which data for all years between 1990 and 1994 were available.

The proportion of the age groups tested differed between years (3+-year-old smolts: $\chi^2 = 26.2$; 3+ and 4+-year-old smolts: $\chi^2 = 28.1$; and 3–5+-year-old smolts: $\chi^2 = 63.8$; $P < 0.001$ with d.f. = 4 in all cases) and groups (3+ years: $\chi^2 = 21.9$; 3–5+ years: $\chi^2 = 45.3$, respectively; $P < 0.001$ with d.f. = 3 in both cases) between rivers, except the 3+- and 4+-year-old age groups (4.57, $P = 0.206$ with d.f. = 3). Thus, considerable interannual and river-specific differences were found in the age structure of the smolts (Fig. 1). In this respect, the results resemble those of Melnikova (1970), who also reported changes in smolt age structure.

In the rivers Pulmankijoki, Kalddasjoki, Karigasjoki and Tsarsjoki, the proportion of 5+- and 6+-year-old smolts increased markedly between 1989 and 1992, whereas, in 1993, the number of 3+- and 4+-year-old smolts increased, and the 5+-year-old smolts disappeared (Fig. 1). The same pattern was also seen in the River Kuoppilasjoki, although it was not tested statistically.

Despite all the tributaries lying within a restricted geographical area, the River Kevojoki differed from the others in that the number of 3+-, 4+- and 5+-year-old smolts remained stable throughout the study period. It is possible that the more stable temperature conditions compared with those in the other rivers were responsible for this result since the River Kevojoki flows in a deep valley well below the level of the surrounding hilly terrain.

Although water temperature is an important factor affecting fish growth, and hence, the smoltification of salmon parr (Melnikova 1970; Jensen & Johnsen 1986; Morrison 1989; Metcalfe & Thorpe 1990), many other variables may affect the situation, even in a very restricted area; for example, water depth and flow velocity, bottom quality, fish density, food quality and quantity, and lacustrine habitats. In addition, genetic variation in different parts of the river may affect smolt age (Heggberget, Lund, Ryman & Ståhl 1986). Accordingly, in spite of the small temperature variations, growth and development strategies may vary between the rivers, even in this small geographical area.

The present results underline the plasticity in salmon smolt age in the tributaries of the River Teno, which could be an important factor affecting the stability of fish stocks, especially in the extreme climates experienced at northern latitudes. It is always possible that a single year-class of hatched alevins or fry will fail to survive, or have a very low survival rate, but because of the age structure of the population, there will always be salmon of different ages in the river.

Acknowledgements

A number of people provided invaluable assistance in data collection in the field. We would like to thank Matti Kylmäaho for his help with the binary data, and Marjo Helenius, Arto

Selkee, Antti Soivio and Ilari Valta for fruitful discussions. Malcolm Hicks and an anonymous referee kindly improved the language.

References

Collett D. (1991) *Modeling Binary Data.* London: Chapman & Hall, 369 pp.

Heggberget T.G., Lund R.A., Ryman N. & Ståhl G. (1986) Growth and genetic variation of Atlantic salmon (*Salmo salar*) from different sections of the River Alta, North Norway. *Canadian Journal of Fisheries and Aquatic Science* **43,** 1828–1835.

Jensen A.J. & Johnsen B.O. (1986) Different adaptation strategies of Atlantic salmon (*Salmo salar*) populations to extreme climates with special reference to some cold Norwegian rivers. *Canadian Journal of Fisheries and Aquatic Science* **43,** 980–984.

Kuzmin O.G. & Smirnov Yu. A. (1982) Environmental factors and growth of young Atlantic salmon, *Salmo salar* (Salmonidae), in small rivers of the Kola Peninsula. *Journal of Ichthyology* **22,** 42–51.

Melnikova M.N. (1970) Some features of young Atlantic salmon (*Salmo salar* L.) in several rivers in the White Sea basin. *Journal of Ichthyology* **10,** 311–319.

Metcalfe N.B., Huntingford F.A., Thorpe J.E. & Adams C.E. (1990) The effects of social status on life-history variation in juvenile salmon. *Canadian Journal of Zoology* **68,** 2630–2636.

Metcalfe N.B. & Thorpe J.E. (1990) Determinants of geographical variation in the age of seaward-migrating salmon, *Salmo salar. Journal of Animal Ecology* **59,** 135–145.

Morrison B.R.S. (1989) The growth of juvenile Atlantic salmon, *Salmo salar* L., and brown trout, *Salmo trutta* L., in a Scottish river system subject to cooling-water discharge. *Journal of Fish Biology* **35,** 539–556.

Power G. (1969) The salmon of Ungava Bay. *Arctic Institute of North American Technical Paper* No. 22, 77 pp.