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Densities of the juvenile Atlantic salmon (*Salmo salar* L.) in the subarctic Teno River watercourse, northern Finland

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Changes in juvenile wild Atlantic salmon densities in the subarctic Teno River watercourse, northern Finland, have been studied and recorded since 1979 at 57 sites representing different biotypes. Densities were very low in the first few years, after which there was substantial variation. The lowest and highest mean densities of fry at a site in the Teno River were 0.2 and 135 fish per 100 m^2, respectively; respective values for parr were 0.9 and 50 fish per 100 m^2. The lowest and highest values in the Utsjoki, a river in northern Finland, were 0.1 and 136 fish per 100 m^2 for fry and 2.3 and 71 fish per 100 m^2 for parr. The highest densities of fry and parr ever recorded in the Teno River were 424 and 106 fish per 100 m^2, respectively. The annual densities of fry and parr were interdependent only in a few cases. Different densities in some other northern rivers relative to those in the Teno watercourse might reflect the different fishing culture, but also the stocking of juveniles can increase densities, thus, hampering the interpretation. The densities of the juvenile salmon fluctuated within sampling sites and between years, primarily as a result of fluctuations in the spawning stock, which is strongly affected by changes in the in-river fishing effort. Fluctuations in the juvenile salmon densities are obviously not affected by predation as the proportion of other species in the juvenile salmon's habitat is low. Parr densities in the Teno River catchment are on average clearly lower than those found in rivers which lack a diverse net fishery. Several fishing regulations set after the year 1984 have functioned only partly. Juvenile densities have not crashed despite the increased in-river exploitation by rod and reel anglers but densities of the juvenile salmon have not either increased.

Introduction

The Teno River watercourse is one of the most important Atlantic salmon (*Salmo salar* L.) rivers in Europe, with a mean annual catch of 134 tonnes in 1973–1995 (Niemelä *et al.* 1996). Salmon stock maintenance and enhancement is achieved only by appropriate fishing regulation measures, as all forms of fish stocking are prohibited. A joint study of the size and the development of the salmon stocks was initiated in 1979 under the bilateral fishing agreement that exists between Finland and Norway. Salmon stocks have been monitored by collecting catch statistics and simultaneously observing fry and parr densities (data collected with electrofishing methods).

Electrofishing is a widely employed research and management technique used to monitor changes in recruitment of the Atlantic salmon at different spawning levels (Chadwick and Randall 1986), to evaluate damage caused by hydroelectric development (Saksgård and Heggberget 1990) or harmful parasites such as *Gyrodactylus salaris* (Jensen and Saksgård 1987), or to monitor long-term trends in juvenile fish populations as an index of changes in natural conditions (Bohlin *et al.* 1989). Electrofishing is usually carried out as the successive removal method, in order to achieve accurate density estimates, or else using the mark-recapture technique (Bohlin *et al.* 1989).

There are several uncertainty factors that can affect the reliability of this method (Bohlin *et al.* 1989). In large rivers, where sampling sites cover only a minor part of the cross-section of the river bottom, only a narrow shore zone can be studied and sometimes only a part of the juvenile age group that exists in the river system can be caught (Saksgård *et al.* 1992). Density estimates are also affected by the sampling date, changes in water level and catchability (Jensen and Johnsen 1988). Despite the uncertainty factors associated with it, electrofishing has been used almost exclusively to estimate juvenile salmon densities (Hickley 1990). The size of the spawning run is affected by fluctuations in mortality during the marine phase (Scarnecchia *et al.* 1989). Ultimately the in-river fishing effort has an effect on the number of spawning salmon, especially females, which in turn is reflected on the juvenile densities in the following years. Correspondingly, juvenile salmon densities are used as indicators of the size of the spawning stock, especially in the Teno River watercourse where stocking is prohibited. There, the only method for assessing the condition of the salmon stock, as well as the functionality of the fisheries regulations, is the long term monitoring of juvenile densities in different habitats.

The aim of this paper is to present data on juvenile Atlantic salmon densities during the period 1979–1995, and their possible changes during introduction of new fishing regulations in the rivers Teno, Inarijoki and Utsijoki. The densities were also compared to densities in some other northern salmon rivers.

Material and methods

The Teno River area

The Teno River catchment area is located in northern Europe (70°N, 28°E). Its main watercourse, the Teno River, and one of the tributaries, the Inarijoki, form the border between Finland and Norway. The Teno River drains into the Barents Sea via the Teno fjord, where the mouth of the river is approximately 2 km wide. The area of the entire drainage basin is 16 386 km^2, of which 31% is located in Finland. There are numerous tributary systems within the watercourse, of which the most important for salmon production are those of the rivers Karasjoki, Inarijoki, Utsjoki, Vetsijoki and Pulmankijoki (Fig. 1). The length of the Teno River from the confluence of the Karasjoki and Inarijoki to the sea is 206 km, and the rivers Inarijoki and Utsjoki, which drain into it, are 145 km and 66 km in length, respectively.

The wetted surface areas of the rivers Teno, Inarijoki (up to the mouth of the Kietsimäjoki) and Utsjoki are 9 100 ha, 990 ha, and 1 100 ha, respectively. The total areas of rapids and riffles in the above rivers are 1 700 ha (19% of the total surface area), 830 ha (84%) and 60 ha (6%), respectively (Table 1).

The Teno River can be divided into three distinct areas: the Lower Sand Teno, the Riffle Teno and the Upper Sand Teno (Fig. 1). The largest area of rapids and riffles as a proportion of the total river surface can be found in the Riffle Teno and the Inarijoki (Table 1). This latter river, lo-

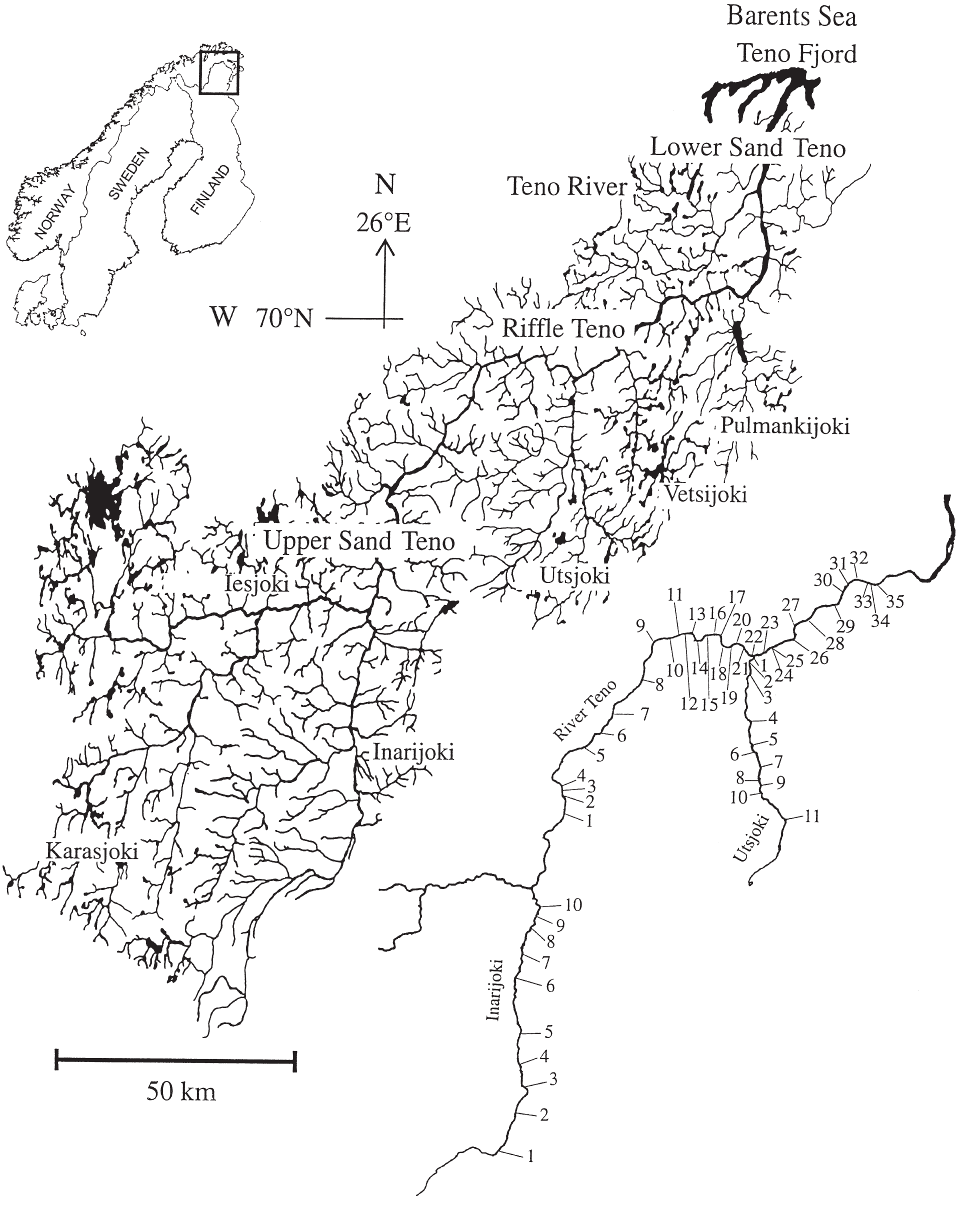

Fig. 1. Locations of the 56 permanent sampling sites in the subarctic Teno River watercourse.

Table 1. Physical characteristics of the Teno River and its major tributaries.

River/tributary	Catchment area (km^2)	Surface area (ha)	Area of salmon biotope (ha)	Length (km)	Gradient (m km^{-1})
Teno	16 386	9 100	1 700	206	
Lower Sand Teno	5 745	109	67	0.24	
Riffle Teno	1 932	1 500	68	1.29	
Upper Sand Teno	1 653	66	71	0.29	
Inarijoki	3 147	990	830	145	2.79
Utsjoki	1 665	1 100	60	66	1.63

cated in the upper reaches of the catchment, differs from the main watercourse in running through a series of shallow lakes, while the Utsjoki forms a water system that differs from the others so that it widens out to form deep lakes with steep shores.

Ten fish species occurring most commonly in the watercourse in addition to the Atlantic salmon are the brown trout (*Salmo trutta* L.), grayling (*Thymallus thymallus* (L.)), Arctic char (*Salvelinus alpinus* (L.)), whitefish (*Coregonus* spp.), minnow (*Phoxinus phoxinus* (L.)), sticklebacks (*Gasterosteus aculeatus* L.) and (*Pungitius pungitius* (L.)), pike (*Esox lucius* L.), perch (*Perca fluviatilis* L.) and burbot (*Lota lota* (L.)). Eels (*Anguilla anguilla* (L.)) are rarely found. The flounder (*Platicthys flesus* (L.)), occurs in the lower part of the Teno River, and also in its tributary the Pulmankijoki, up to some 70 kilometres from the estuary of the Teno River. The bullhead, (*Cottus gobio* L.), was accidentally introduced into the Utsjoki in the early 1970s (Pihlaja *et al*. 1998). The arctic lamprey (*Lampetra japonica* (Martens)), is found at the river mouth (Berg 1964), and two species of the Pacific salmon, the pink salmon (*Oncorhynchus gorbuscha* (Walbaum)), and the chum salmon (*Oncorhynchus keta* (Walbaum)) are also present there as a result of stocking by Russians.

Hydrography

The Teno River usually freezes over in early November, and the ice usually breaks up in late May; extensive flooding occurs in June. The mean discharge measured in the middle part of the river during the study years was 156 $m^3 s^{-1}$ with a minimum of 19 $m^3 s^{-1}$ (19 April 1988), and a maximum of 2 740 $m^3 s^{-1}$ (10 May 1984). Since there are only a few large lakes to regulate the flow, the river has rapid fluctuations in its water level. Mean water temperatures in the river in 1979–1994 were 1.5 °C in May, 8.6 °C in June, 12.9 °C in July, 11.9 °C in August and 6.9 °C in September. The water in the rivers was of a good quality for juvenile salmon (pH 7.0–7.7, alkalinity 140–450 meq. l^{-1}, conductivity 2.8–6.1 mS m^{-1} and total P 9.8–27.1 mg l^{-1} (Lapland Regional Environment Centre unpubl. data).

Sampling methods

In order to study juvenile salmon densities, 25 sampling sites in the Teno River, 11 in the Utsjoki, and 10 in the Inarijoki were chosen for monitoring in 1979–1995 (Fig. 1). Ten new sampling sites were established in the Upper Sand Teno area in 1980. The mean size of the sampling sites was 104 m^2 in the Teno River (min. 30 m^2, max. 276 m^2), 105 m^2 in the Utsjoki (min. 40 m^2, max. 235 m^2), and 105 m^2 in the Inarijoki (min. 43 m^2, max. 170 m^2). The sites were chosen to represent homogeneous parts of a homogenous habitat type of a river in terms of depth, water velocity and size and shape of the substratum. Special attention was paid to selecting the sampling sites so that both ideal sites (loose, coarse substrate, providing hiding places), and unfavorable sites (solid, compact, fine substrate, with far fewer hiding places) were represented. All the sites were rectangular in shape and aligned with the shoreline, and were of a maximum depth of 70 centimetres. Electrofishing began around 20 July each year, when the spring flood was over, and the newly emerged fry were evenly distributed over their nursery area. Each site was fished once a year in strict rotation, so that the fishing took place on almost the same date in the successive years. The density estimates are sensitive to the actual river disharge at the time when the fieldwork is carried out (Jensen and Johnsen 1986, Jensen and Johnsen 1998, Saksgård and Heggberget 1990). As a result of flooding, only 28 sites were electrofished in 1981, 28 in 1992 and 55 in 1995.

The same standardized fishing method was used throughout the period concerned. The removal method of electrofishing (Bohlin *et al*. 1989) was preferred, and the number of successive passes varied mainly from one to three, each lasting 20 to 30 minutes. A given site was fished only once if the number of salmon was five or less, but three or more times with a 30-minute pause between the passes if the number was higher than five. Altogether, there were 894 electrofishing passes, out of which 97 were single ones, 94 involved two passes in succession, 673 three in succession and 30 more than three in succession. Surround nets were used at all the sites until 1986, when they were found unnecessary; a conclusion also reached by Bohlin *et al*. (1989) and Julkunen and Niemelä (1997).

A pulsed DC current of 0.2 amperes at 900 volts was used in electrofishing, the current being supplied by a generator. The electrofishing team consisted of three experienced crew members with one using the anode and the other two using dipnets to capture the fish. The sites were fished in an upstream direction, each site being combed carefully with two-metre anode strokes in a downstream direction, after which 50 centimetre sideways steps were taken. The lengths of all the salmon were measured to the nearest millimetre, and a scale sample from the area between the lateral line and the adipose fin was taken from each individual measuring more than 45 mm. The fish were aged from their scales with a microfiche reader (30× magnification). All specimens shorter than 55 mm were classified as fry. Total number of fry and parr caught exceeded 40 000. All the fish were released after measuring.

Calculations

The maximum likelihood method (Moran 1951, Zippin 1956, Seber 1982) was used to estimate the density of the juvenile salmon population. Firstly the catchability (capture probability of fish) in removal electrofishings was estimated by iterative calculation from successive catches (Bohlin *et al*. 1989, Julkunen and Niemelä 1997). Then, the population size at a given site was calculated from with the equation N = (total catch)/ $(1 - (1 - \text{catchability})^k)$, where k is number of successive passes (Seber 1982). Separate estimates were made for fry (0+ group) and parr (all other age groups together). Finally, the number of juveniles per 100 m^2 at a given site was calculated. The total catch was used as an estimate if electric fishing comprised only one pass.

Simple linear regression analysis was used to show trends in fish densities. The data were $\log_e(x + 1)$-transformed in order to conform better to the criteria of normal distribution and homoscedasticity. Cross-correlation analysis was used to identify the relationship between the logarithmically transformed fry and parr densities, and any time delays to the relations. A correlation of positive lag indicates the relation of the fry series to the parr series, observed the indicated number (lags) of years later. The correlation at lag 0 was the usual Pearson correlation. In addition, nonlinear changes in densities were studied graphically with LOWESS regression (Trexler and Travis 1993, SYSTAT 1996).

Results

In the Teno River the mean densities of fry of the Atlantic salmon varied between 0.2 and 135 fish per 100 m^2. Corresponding figures for parr were 0.9 and 50 fish per 100 m^2. Thus, the density range of the parr is smaller than that of the fry. The highest density at any one sampling site was 424 fish per 100 m^2 for the fry and 106 fish per 100 m^2 for the parr. The long-term mean population density for all sites in the Teno River was 24.5 fish per 100 m^2 for fry and 17.9 fish per 100 m^2 for parr (Table 2).

In the Utsjoki the long-term mean densities for fry varied from 0.1 to 136 fish per 100 m^2 between sites, while the corresponding extreme densities for parr were 2.3 and 71 fish per 100 m^2. The highest density for fry at any one site was 257 fish per 100 m^2, and that for parr 165 fish per 100 m^2. The long-term mean population density in the Utsjoki was 35.1 fish per 100 m^2 for fry, and 30 fish per 100 m^2 for parr (Table 3).

In the Inarijoki the long-term mean densities for fry varied between 2.5 fish per 100 m^2 at the poorest of the 10 sampling sites, and 57 fish per 100 m^2 at the most productive one. The corresponding densities for parr were 4.5 and 36 fish per 100 m^2. The highest density at any one sampling site was 158 fish per 100 m^2 for fry and 85 fish per 100 m^2 for parr. The long-term mean population density in the Inarijoki was 18.9 fish per 100 m^2 for fry and 22.2 fish per 100 m^2 for parr (Table 4).

Salmon was the dominant species at all the sites, accounting for 87.5%, 82.7% and 78.9% of the catch in the rivers Teno, Utsjoki and Inarijoki, respectively. Second in abundance was the minnow, comprising 7.5%, 7.5% and 18.4% of the catches in these rivers, while the proportions of trout, burbot, grayling, whitefish and sticklebacks were very small, 0.1%–2.8% of the total catch. The bullhead nevertheless made up 7.8% of the catch in the Utsjoki.

Approximately half of the juvenile salmon caught were fry. The parr in these rivers belong to five age groups, although five-year-old fish as such were found only in the Utsjoki, and then in negligible proportions (Table 5).

The mean annual densities of fry in each river, all sites included, ranged from 6.5 to 39.4 fish per

Table 2. Mean density and yearly occurrence of Atlantic salmon fry and parr at the sampling sites on the Teno River.

Site code	Number of study years	Fry		Parr	
		Mean density (S.D.) (fish per 100 m^2)	Yearly occurrence (%)	Mean density (S.D.) (fish per 100 m^2)	Yearly occurrence (%)
1	16	12.7 (18.5)	75	7.0 (8.7)	88
2	16	6.4 (7.0)	81	10.6 (8.8)	94
3	16	1.5 (2.4)	44	0.9 (1.4)	50
4	16	114.4 (93.3)	94	9.9 (13.8)	100
5	16	0.8 (3.0)	6	2.5 (2.7)	69
6	16	12.0 (19.7)	81	3.6 (6.1)	56
7	16	1.1 (2.9)	31	5.0 (5.2)	81
8	15	32.5 (55.2)	87	8.7 (5.2)	100
9	15	105.9 (106.4)	100	7.8 (5.5)	93
10	15	6.5 (7.6)	80	15.4 (10.7)	100
11	15	2.0 (2.7)	53	14.3 (9.3)	100
12	15	31.1 (32.7)	87	6.5 (5.7)	100
13	15	0.7 (1.3)	33	48.7 (29.3)	100
14	15	10.5 (13.1)	73	24.9 (14.5)	100
15	15	23.4 (24.9)	80	13.2 (8.5)	100
16	15	23.8 (20.9)	100	25.8 (10.3)	100
17	15	6.9 (9.0)	73	2.7 (3.4)	73
18	15	23.9 (29.5)	87	31.9 (17.6)	100
19	15	1.0 (1.4)	53	38.0 (16.8)	100
20	15	5.0 (17.2)	33	24.0 (14.7)	100
21	15	3.4 (5.9)	60	15.3 (8.8)	100
22	15	0.8 (2.0)	33	17.1 (10.3)	100
23	15	34.5 (53.9)	73	10.4 (7.1)	100
24	15	32.0 (20.3)	93	24.6 (12.5)	100
25	15	135.1 (60.8)	100	27.5 (13.7)	100
26	15	31.9 (23.4)	100	50.4 (17.0)	100
27	15	18.3 (17.9)	87	19.4 (15.5)	100
28	15	3.1 (4.9)	53	30.0 (15.4)	100
29	15	88.9 (41.8)	100	47.6 (29.6)	100
30	15	28.5 (44.2)	93	31.8 (16.2)	100
31	15	9.0 (7.3)	93	6.2 (3.7)	93
32	15	48.2 (33.9)	100	23.8 (12.9)	100
33	15	0.4 (1.3)	13	5.3 (6.4)	93
34	15	0.2 (0.4)	27	6.2 (6.0)	93
35	14	0.8 (2.8)	21	9.3 (7.0)	100
Mean		24.5	69	17.9	94

Table 3. Mean density and yearly occurrence of Atlantic salmon fry and parr at the sampling sites in the Utsjoki.

Site code	Number of study years	Fry		Parr	
		Mean density (S.D.) (fish per 100 m^2)	Yearly occurrence (%)	Mean density (S.D.) (fish per 100 m^2)	Yearly occurrence (%)
1	17	46.6 (48.9)	88	70.8 (25.1)	100
2	17	136.2 (61.4)	100	61.3 (40.5)	100
3	17	117.4 (66.4)	100	67.3 (38.9)	100
4	17	21.8 (74.9)	35	18.5 (31.9)	88
5	17	0.6 (1.3)	24	8.4 (8.0)	94
6	17	0.1 (0.3)	6	2.3 (5.9)	29
7	17	2.3 (8.1)	24	13.1 (14.8)	88
8	16	12.8 (21.2)	63	32.8 (25.5)	100
9	16	17.0 (22.1)	56	23.6 (28.1)	100
10	17	24.9 (45.4)	53	22.4 (12.0)	100
11	17	6.1 (21.0)	35	9.7 (9.3)	88
Mean		35.1	53	30.0	90

Table 4. Mean density and yearly occurrence of Atlantic salmon fry and parr at the sampling sites in the Inarijoki.

Site code	Number of study years	Fry		Parr	
		Mean density (S.D.) (fish per 100 m^2)	Yearly occurrence (%)	Mean density (S.D.) (fish per 100 m^2)	Yearly occurrence (%)
1	17	6.8 (12.7)	65	36.2 (26.6)	100
2	17	2.5 (4.9)	47	27.1 (20.3	100
3	17	25.6 (29.0)	88	28.3 (16.3)	100
4	17	56.8 (52.8)	88	17.0 (17.1)	100
5	17	22.9 (16.6)	100	25.0 (17.4)	100
6	17	34.6 (15.3)	100	23.2 (10.1)	100
7	16	9.4 (7.6)	100	29.1 (20.9)	94
8	17	2.6 (3.5)	59	10.6 (6.2)	100
9	17	24.1 (24.0)	88	4.5 (3.8)	82
10	17	3.5 (4.5)	71	21.0 (13.6)	94
Mean		18.9	81	22.2	97

100 m^2 in the Teno River, from 6.4 to 31.1 fish per 100 m^2 in the Inarijoki, and from 7.8 to 57.2 fish per 100 m^2 in the Utsjoki (Fig. 2). The annual log-transformed fry densities increased significantly only in the Teno River (standardized regression coefficient $b = 0.12$, $p = 0.005$) but the coefficient of determination was small ($R^2 = 0.015$) due the great variation of densities in sites and in years. Correspondingly the mean annual parr densities were from 3.3 to 29.3 fish per 100 m^2 in the

Table 5. Age structure (in percentages) of the juvenile salmon populations in the rivers Teno, Utjsoki and Inarijoki.

River	Age group			
	0+	1+	2+	3+ to 5+
Teno	55.1	27.9	12.5	4.5
Utsjoki	49.7	29.2	15.9	5.2
Inari	46.2	30.3	16.7	6.8

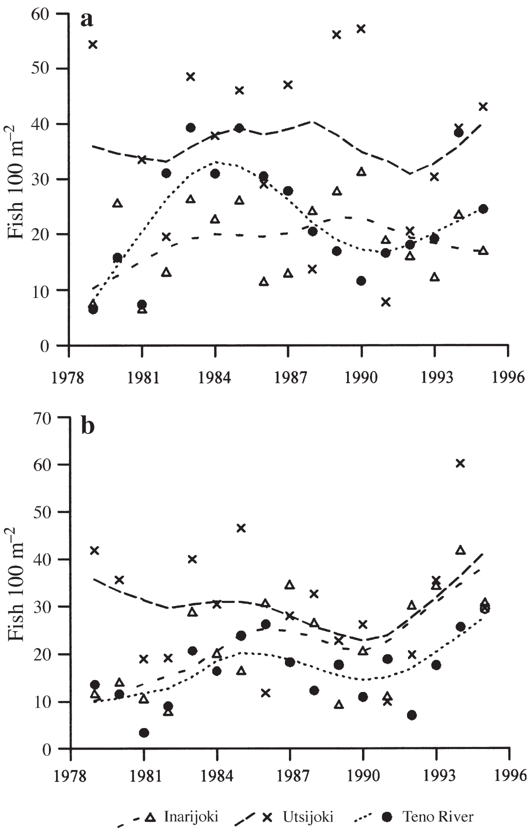

Fig. 2. Annual mean densities and LOWESS regression for fry (a) and parr (b) in the rivers Utsjoki, Inarijoki and Teno.

Teno River, 7.6 to 41.6 fish per 100 m^2 in the Inarijoki and from 9.9 to 60.2 fish per 100 m^2 in the Utsjoki (Fig. 2). The annual log-transformed parr densities increased significantly only in the Inarijoki ($b = 0.28$ and $p = 0.0002$ and $R^2 = 0.080$). Assessed on an annual basis, parr occurred more frequently at the sampling sites (90%–97% of years) than fry (53%–81% of years) (Tables 2, 3 and 4).

The annual densities of fry and parr were interdependent only in a few cases. There was a positive Pearson correlation between the fry and parr annual densities at 7 sites out of the total of 35 in the Teno River. Parr densities were positively correlated with fry densities one year earlier at two sites and three years earlier at one site. At two sites there was a negative correlation of parr density with that of fry density recorded two or three years earlier. The rivers Utsjoki and Inarijoki each had one site with a positive correlation with the value recorded one year earlier, and there was also one site in the Inarijoki with a positive Pearson correlation between the parr and fry densities.

Discussion

Fry densities of Atlantic salmon were low in the Teno River during the early years of monitoring, after which they have increased. In the Inarijoki, parr densities increased after the first four years of monitoring. A notable cause of the low fry densities were the exceptionally low salmon stocks of the late 1970s, especially those of 1978–1980, which were the lowest observed between 1972 and 1995 (Niemelä *et al.* 1996). The mean fry densities varied greatly from year to year both within the rivers and between sampling times. During the years 1992 and 1993 the catches in the Teno River watercourse have been at their highest since the mid 1970s, and correspondingly fry and parr densities increased in 1993–1995.

The very high densities of juvenile salmon at some sites in the Teno River watercourse, especially in the lower part of the Utsjoki (sites 1–3), point to a exceptionally high rate of juvenile production under these austere subarctic conditions. One reason for the high average densities there is that the spawning stock has been strong because spawners of the age 2–3 sea winter female salmon are ascending to the spawning grounds late in September after fishing season thus avoiding to be caught (Kylmäaho *et al.* 1996). In addition, the low abundance of other species minimize interspecific competition and thereby promoted high densities.

In a few sites, high fry densities resulted in high parr densities during the following year, but usually the association between these age groups was weak. This might indicate age-dependent selection of different habitats, where the properties of microhabitats are important parameters dictating the spatial distribution of juvenile salmon (Morantz *et al.* 1987). Juvenile salmon tend to shift their habitat in connection with ontogenetic changes in body size (e.g., Hesthagen 1988, Erkinaro and Niemelä 1995, Erkinaro *et al.* 1998).

The density data for the Teno River can be compared with those of other large northern salmon rivers such as the Ponoi, Varzuga and Kola on the Kola Peninsula, Alta in northern Norway, and Neiden on the border between Northern Finland and Norway. Differences in stock characteristics, local geography and year-to-year variations in climate and spawning escapement make it difficult to apply the results of specific field surveys to wide geographical areas. But for example conditions in the Alta River are similar to those found in the Teno River, in that salmon usually account for over 80% of the fish in both cases. The mean parr densities in August in the Alta River in northern Norway between the years 1981 and 1991 were 12.4 fish per 100 m^2 (min. 2.8 fish per 100 m^2, max. 29.5 fish per 100 m^2) in the lower part of the river, 24.2 fish per 100 m^2 (min. 5.3, max. 42.3) in the middle part, and 36.5 fish per 100 m^2 (min. 3.0 fish per 100 m^2, max. 109.3 fish per 100 m^2) in the upper part (Saksgård *et al.* 1992), while mean parr densities in the entire Alta River during the years 1993 and 1995 were 32.1–61.4 fish per 100 m^2 (Jensen *et al.* 1997). The mean long-term parr density in the main Teno River is clearly lower than in the middle or upper section of the Alta River. Methods and sampling times were comparable in these two investigations, as were most of the areas concerned with respect to biotope and size. Part of the reason for the differences in densities may lie in the inclusion of some marginal monitored areas in terms of juvenile production in the Teno River.

Large northern rivers such as the Ponoi River on the Kola Peninsula may yield large catches of salmon annually despite mean parr densities as low as 1.5 fish per 100 m^2 and fry densities of only 2.2 fish per 100 m^2 in the main stem. The corresponding densities in its tributaries were 2.4 and 2.7 fish per 100 m^2, respectively (Whoriskey *et al.* 1996). However, Whoriskey (1998) reported increasing juvenile salmon densities in recent years after the closure of the commercial fishery in the Ponoi River. In the rivers Varzuga and Kola on the Kola Peninsula, parr densities have varied between 19.3 and 28.8 fish per 100 m^2 in the Varzuga River in 1994 and 1995, and 32.6 and 33.3 fish per 100 m^2, in the Kola River (Jensen *et al.* 1997). In the Teno River, where gill nets of many kinds are allowed, the mean density has been similar, but in the lower section of the Utsjoki, where exploitation is low, the densities of parr have been as high as 60–70 fish per 100 m^2 (Table 3). In the lower part of the Neiden River in Norway, where gill net fishing is prohibited, the average density of parr between 1990 and 1998 has been as high as 80 fish per 100 m^2 (min. 43 and max. 122 fish per 100 m^2) at six sampling sites (Teno River Fisheries Research Station unpublished data).

It is evident, that fry-density data are particularly influenced by the sampling time so that the values are highest immediately following the emergence of the young from the substrate. To avoid overestimated misleading fry densities, sampling times should be chosen in such a way that juvenile salmon of all age-groups are evenly distributed in their respective biotopes. The elevated mean fry densities recorded in the lower section of the Utsjoki, in the Teno River (sites 4, 9, 25 and 29), and in the Inarijoki (site 4), apply to areas immediately adjacent to a gravel substrate suitable for spawning. One of the most difficult questions facing researchers planning stream surveys or studying the biology of individual species is whether to devote their limited resources to more sampling sites, or to more frequent sampling of a limited number of sites (Bohlin *et al.* 1989). Observations within a site must be numerous enough for the researcher to be able to detect differences between areas and between years. The monitoring of numerous spatially separated areas ensures that stocks genetically adapted to life in different parts of the river are all represented in the sample (Heggberget *et al.* 1986). A small number of sampling sites, where only a small portion of the juvenile production of the spawning stock takes place, can lead to the drawing incorrect conclusions regarding juvenile production in the entire catchment area. The juvenile production area in the Alta River, for instance, is approximately 46 km in length, and 14 areas have been chosen to for the assessment of changes in densities (Saksgård *et al.* 1992). In the Teno River there are 35 areas, representing density changes over approximately 80 km of river and covering 0.02% of the total area suitable for juvenile production. The corresponding figures for the rivers Utsjoki and Inarijoki are 0.19% and 0.01%, respectively. Although the spatial coverage is low it is notable that an increase in the number of sampling sites from present might increase the time-dependent changes in density and thus reduce comparability between areas.

Fluctuations in water levels and differences in the timing of the summer season have been found to have an impact on juvenile salmon densities. Jensen and Johnsen (1988), and Saksgård and Heggberget (1990) found that an increase in water level caused a decrease in the densities. In a large river such as the Teno, the time at which sampling commences in early summer is dependent on the duration and extent of the spring flood, which may extend into July. Another variable affecting the commencement of sampling is emergence of the fry, which does not take place until late July in some years.

When analyzing changes in densities of juveniles and changes in salmon stocks in large rivers like the Teno, it is vital to consider the fact that the sampling sites are restricted to shallow areas close to the river banks, and thus only a small portion of the biotope inhabited by the juveniles is studied. One explanation for the small proportion of ≥ 3+ parr could be that the deeper habitats of the large parr are probably not represented. The monitoring programme, however, covers habitats with depths down to 70 cm, and it has been shown that large fluvial salmon parr also prefer depths of 20–50 cm (Heggenes *et al.* 1991) while habitats deeper than 70 cm are little used (e.g., Heggenes 1996). According to Erkinaro and Niemelä (1995), a proportion of the older juveniles in the Utsjoki and Inarijoki river systems have migrated to small brooks or lakes (Erkinaro *et al.* 1998), or have migrated to the sea as smolt.

A basic understanding of juvenile densities within a river system can be adequately formulated without any *a priori* allocation of sampling sites to districts or biotopes (Bohlin *et al.* 1989). Electrofishing is the only satisfactory method for obtaining a quick, comprehensive picture of the status of juvenile abundance within different fluvial biotopes. The long-term monitoring of densities is of great importance, especially in a river with no stocking of fish. Reliable data on the status of salmon stocks can be obtained when sampling areas and methods are standardized and when the special characteristics of different rivers are taken into account. Catch statistics in the Teno River do not necessarily reflect the size of the spawning stock as the rod and reel fishing effort, for example, is unregulated in terms of quantity, as is the catch of all fishing methods. Juveniles produced by any given spawning run will be subject to exploitation after on average 6–9 years because of the long stay in fresh water as juveniles, followed by maturation after 1–4 years at sea. Therefore, simply catch monitoring does not adequately tell about the effectiveness of fishery regulations nor their impact on the increase of juvenile densities.

Salmon fishing in the high seas of the North Atlantic has been prohibited since the year 1984 by an international NASCO convention, although allowing a small annual quota for the Faroese fishery (Windsor and Hutchinson 1994). It was expected that after this regulation juvenile salmon production and thereafter catches in homewaters should clearly increase, but no remarkable increase has been found in the Teno River watercourse, although parr densities showed an increase for a few years in the middle of 1980s, only to fall again and continue to do so until the early 1990s. Furthermore, soon after the prohibition of the drift net fishery on the Norwegian coast in 1989 (Anon. 1990) and following the new fishing regulations in the Teno River in 1990, there has been no indication of higher spawning escapement or increased juvenile salmon densities. However, during the years 1994 and 1995 there has been a clear increase in parr densities which could be a reflection of the lower post smolt sea mortality, which has been found to fluctuate in the North Atlantic (Friedland *et al.* 1993). Fluctuations in the salmon catch and subsequent parr densities is also apparently strongly affected by annually varying environmental condition at sea (Scarnecchia *et al.* 1989), which must be taken into account when the effectiveness of the fisheries regulations are considered.

It is also important, for management as well as research purposes, to continue monitoring over a long period of time, especially because renewal of stocks in the Teno River area is extremely slow and manifestation of management measures is also slow.

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