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MONITORING OF SPORTS FISHING CATCHES OF ATLANTIC SALMON
(*SALMO SALAR* L.) OF THE PONOİ RIVER, RUSSIA,
TO DOCUMENT POPULATION CHARACTERISTICS

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ABSTRACT

Sport fishing catches were used to monitor the adult Atlantic salmon (*Salmo salar*) population of the Ponoı River, Kola Peninsula, Russia, which has discrete spring and autumn runs. Anglers caught and released large numbers of fish, with the peak catch occurring in late May and a second smaller peak occurring in August. Fish sizes increased as the season advanced. Most adults had smolted at age 3+, although some smolted at 2+ despite the short Arctic growing season. Seventy-eight percent of the fish spent 2 years at sea, and only one fish sampled was a multiple-spawner. Parr surveys yielded low numbers and densities of fish, suggesting that the Ponoı's exceptional fishing results from low levels of production over a vast area.

Key Words: Atlantic salmon, Kola Peninsula, population biology

1. INTRODUCTION

Russia's Kola Peninsula supports some of the finest Atlantic salmon (*Salmo salar* L.) rivers in the world. The cold climate which discourages agriculture, the relative absence of mining activity and dams, and the area's closure as a military reserve until recently, have all contributed to the preservation of the fish populations. Salmon populations elsewhere in Russia have been depleted due to habitat degradation, overfishing and poaching (Martynov *et al.* 1994).

Starting in 1991 a catch-and-release sports fishery was established on the Ponoı River (Fig. 1). Prior to this, commercial fisheries were conducted at this site by installing a barrier across the river by late July of each year. This barrier funnelled migrating salmon into a central trap where about 50% were harvested. The commercial catches were doubled by biologists to estimate the river's population size, although since the barrier always missed part of the run, these estimates

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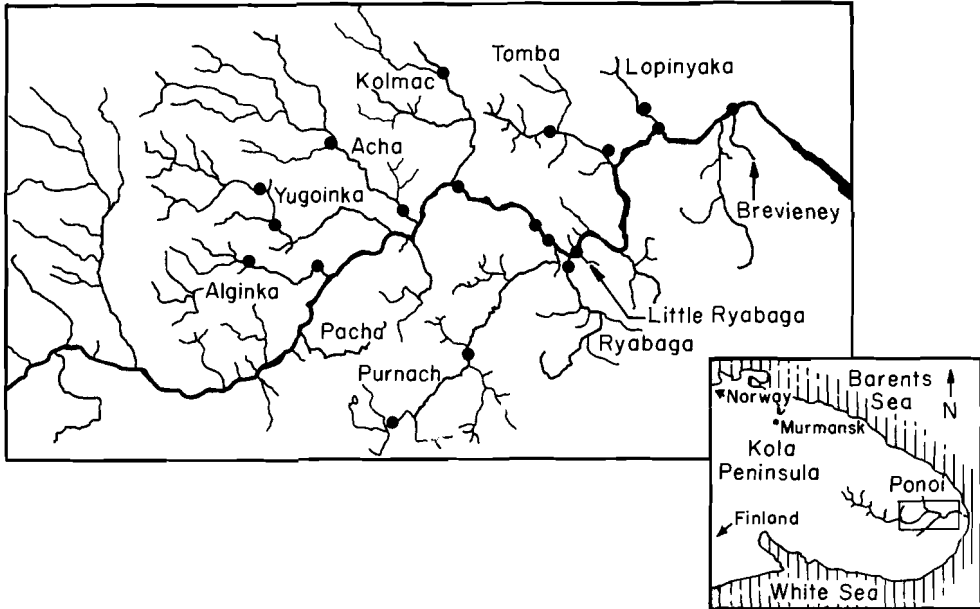


Fig. 1. The Ponoï River, showing the electrofishing stations. Angling occurred primarily in the main stem of the river

were of questionable accuracy. This commercial fishery proved incompatible with the sports fishery, and was stopped in 1993. However, the barrier's removal also eliminated scientific data collection. In 1994, as part of the sport fishing development, a multinational scientific program was established to monitor salmon population levels, and to conduct fundamental research into the factors influencing salmon production in the river.

The Ponoï River, and many other rivers on the Kola Peninsula, have two distinct runs of Atlantic salmon (Kuzhmin, unpubl. data). The spring run arrives in May and June, and spawns in the autumn. These fish may then move out to sea immediately, or overwinter and return to sea as kelts the following spring. By contrast, the autumn run enters the river as bright fish in late August and September. Fish overwinter, oversummer, spawn in the next autumn, and may again overwinter before they move out to sea as kelts the following spring.

This paper describes the Ponoï's salmon runs and presents data on angler catch-per-unit efforts and adult salmon characteristics. Information is also presented on parr numbers, obtained in the Ponoï's first parr survey.

2. MATERIAL AND METHODS

The Ponoï River is located above the Arctic circle on Russia's Kola Peninsula (67°02'N, 41°03'E). It is approximately an 9th order stream, and flows eastward from the centre of the peninsula to the Barents/White seas (Fig. 1). Most of the drainage basin lies within a Tundra zone dominated by lichens and bogs. Patches of conifers (*Pinus* sp.) occur in protected areas, and small willows (*Salix* sp.) and alders (*Alnus* sp.) grow where conditions are favourable along the banks of the main stem and its tributaries. The area has 24 hours daylight in summer (June, July and part of August), and 24 hours darkness in winter (January to March). The headwaters rise in tundra bogs, and the water of the river and its tributaries has a brown colouration. Selected water

chemistry variables were measured in late July and early August 1994 in the Ponoï main stem and its major tributaries. pH values ranged from 5.5 to 7.5, CaCO_3 levels from 28 to 68 mg dm^{-3} , and dissolved oxygen concentrations from 7.2 to 10.0 mg dm^{-3} .

Field work was centred at the Ryabaga camp, which is located at the confluence of the Ryabaga River with the Ponoï main stem. In 1992, 1993 and 1994, angling began in June and lasted for 15 weeks. Between 10 and 24 anglers fished a total of about 80 km of river, daily. Pairs of anglers either boated to their "beats" (fishing territories composed of a portion of the 80 km stretch of river), or were flown to beats where boats had been pre-positioned. All flies used were barbless and had either single or double hooks (mostly single hooks). Each angler pair had a professional guide assigned to them who kept records of fish caught. Where possible, the guides measured fish fork lengths (nearest cm), took scales for ageing, and set Floy spaghetti tags. Some guides also had landing nets with scales built into them, and recorded fish weights (to the nearest 10 g). All guides also sexed the fish based on secondary sexual characteristics (presence of a kype for males, and the absence of a kype and more rotund body form for the females). Where secondary sexual characteristics were poorly developed, no sex was recorded. After examination, fish were released. Additional data on adults were obtained from fish killed for food at the camp (one fish per angler per week), which were measured, weighed, had scales removed and were dissected to determine sex.

The camp's records were used to quantify CPUE's (catch per unit effort, in this case total number of fish (salmon, grilse and kelts) landed per rod per day), and the percentage of fish caught per week which were "bright" (presumed to have very recently arrived in the river, having a highly reflective, silver sea colouration and possibly bearing sea lice), kelts (fish which had spawned the previous fall, overwintered, and were moving back to sea in the spring), or larger than 4.5 kg. "Dark" fish were those which had been resident in the river for some months, and whose silver sheen had changed to a brownish colouration.

Juvenile fish were captured by electrofishing in 1994 (Smith Root model 15B electrofishing unit). The Acha, Alginka, Brevienny, Kolmac, Pacha, Purnach, Ryabaga, Tomba, Yugoinka, Lopinyaka, and Little Ryabaga tributaries were all sampled, as were sites on the Ponoï main stem (see Fig. 1). For each tributary, attempts were made to sample areas close to the Ponoï confluence, as well as the upstream sectors. The exact sites chosen depended on availability of flat ground for landing a helicopter, or boat access. Some areas were only accessible by walking. Similar shallow riffle areas were sampled in all river systems. This is typically the best parr habitat, can be waded with a backpack electrofishing unit relatively easily, and the similarity among sites helped insure that fishing efficiencies would be similar. At each site a single pass was made with the electrofishing unit over a measured area (average area sampled was 306 m^2 (range 60 to 2947 m^2), surface current velocities averaged 72 cm s^{-1} (range 15 to 115 cm s^{-1} ; see Martynov *et al.* 1994 for additional details on the protocol). Electrofishing times were recorded, and data were reported as fish per 100 m^2 and fish captured 100 s^{-1} . Some fish probably avoided being taken in the single pass, although second passes at three sites did not produce any further fish. However, the densities and captures per unit fishing time obtained should be considered minimum values. All fish captured were counted, and a subsample collected from each tributary and the Ponoï main stem to determine lengths (nearest mm), weights (nearest 0.1 g), sex, and state of gonad development. Scales were collected for ageing. The remaining fish were weighed, measured and released.

Statistical analyses were conducted using the Statgraphics Statistical Package. Data were first tested to see if they met (or could be transformed to meet) the assumptions of normality and homogeneity of variance. Where normal distributions were available, ANOVA's followed by LSD multiple comparison tests were used. Where data did not meet the assumptions of parametric statistics, nonparametric methods (Kruskal-Wallis ANOVA, Chi square, Mann Whitney U test, or Spearman correlations (r_s)) were employed.

3. RESULTS

Guided anglers caught 5725, 5258, and 6015 Atlantic salmon (multi-sea winter (MSW) fish, grilse and kelts combined) in the 1992, 1993 and 1994 fishing seasons, respectively. Additional fish were captured by the anglers fishing on their own. Angling CPUEs were highest in the spring, declined in mid-summer, and in autumn increased to levels as high as 60% of those of the spring (Fig. 2). CPUE's were negatively and significantly correlated with season week in 1992 ($r_s = -0.61$, $P < 0.02$), 1993 ($r_s = -0.86$, $P < 0.001$) and 1994 ($r_s = -0.69$, $P < 0.05$). Bright fish were most numerous and dominated catches in the spring-early summer period (1994 only, colouration was not recorded in spring 1993) and during the last 3 to 4 weeks of the fishing season (1993 and 1994, Fig. 3). Fish caught in mid-season for the most part had a brown, riverine colouration (Fig. 3). Assuming that the fish develop river coloration fairly rapidly once they enter the river, then these capture patterns are consistent with the entry of the two runs. Kelts were caught by anglers primarily in early June (Fig. 3). By the end of the month virtually all these fish had moved out to sea. Kelts were recorded as a separate entry in the camp logs after the 1992 season (prior to this their numbers were summed together with the totals of numbers of fish caught). In 1993 and 1994, kelts composed 3.1 and 5% respectively of the total guided catches.

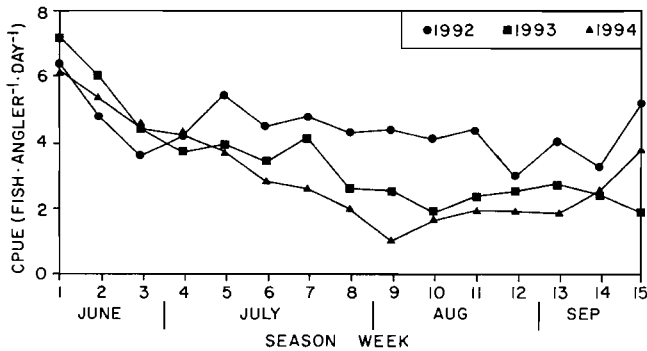


Fig. 2. Weekly summaries of the number of fish (sum of salmon, grilse and kelts) landed per rod per day for the 1992–1994 Ponoï River angling seasons

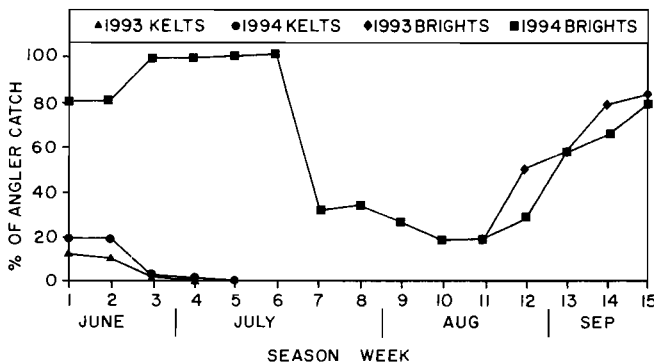


Fig. 3. Percentage of bright fish and kelts in the weekly angler catches, by angling season week. Recording of bright fish and kelts as particular catch categories started in August 1993 and June 1993, respectively. No additional kelts were taken after week five in either year

Larger fish were most abundant in the catches in the latter part of the season (Fig. 4). Spearman correlation coefficients of "percentage large fish" versus "season week" were significant for 1992 ($r_s = 0.67$, $P < 0.01$) and 1993 ($r_s = 0.90$, $P < 0.01$), and in the same direction although not significant in 1994 ($r_s = 0.40$, $p = 0.13$). However, the largest fish in our samples of the Ponoï catches were in the 7 to 8 kg range (Table I), and no "trophy fish" (i.e. greater than 15 kg) were taken despite the large numbers of fish caught in the three years.

Fig. 4. Percentage of the weekly catches composed of fish larger than 4.5 kg (large fish), by angling season week

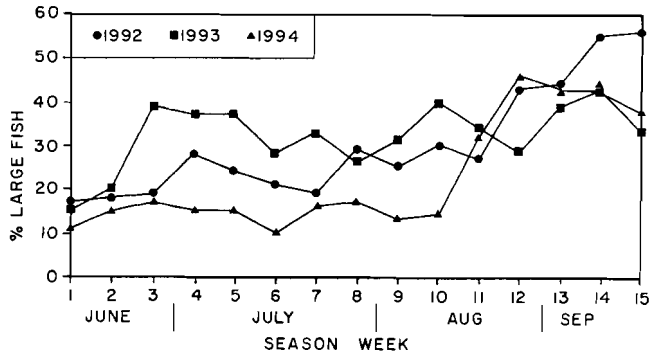


Table I. Lengths and weights of Ponoï River adults caught by anglers in 1994. SW = Sea Winter

Fish class	Variable	Mean	SD	Range	Median	N
1 SW	Fork length (cm)	55.1	11.1	45.7–85.1	50.8	16
	Weight (kg)	2.6	1.6	1.1–5.2	1.8	5
2 SW	Fork length (cm)	72.0	72.0	50.8–86.4	71.1	59
	Weight (kg)	4.8	1.7	2.7–7.7	4.5	40
3 SW	Fork length (cm)	90.2	–	–	–	1
	Weight (kg)	–	–	–	–	–

ADULT POPULATION CHARACTERISTICS

In 1994, the sex ratio of returning multi sea winter (MSW) salmon was significantly biased towards females, whereas that of the grilse we examined did not differ from a ratio of 1 : 1 (Table II). Nine percent of the angled fish had smolted at age 2+, 63% at age 3+, and the remaining fish at age 4+ (Table III). Twenty-one

Table II. 1994 Ponoï River adult salmon sex ratios. The 3+ fish was a repeat spawner, which first returned to the river at a sea age of 2+

Sea age	No. males	No. females	M:F ratio	N
1+	3	3	1 : 1	6
2+	16	51	0.3 : 1.0*	67
3+	0	1	–	78 81

* $\chi^2 P < 0.05$

percent of the fish in the sample had spent one year at sea, and the rest were MSW (mostly 2 sea winters) adults. Only one fish was a repeat spawner (Table II), and was returning for its second spawning. There was no clear relationship between smolt age and the age of return to the river for a first spawning (Table III).

Table III. 1994 Ponoï River adult salmon ages. M – Marine phase, R – River phase. Total age is the sum of river and sea time. Some scales could not be aged to determine both river and sea time

River ages	N	Sea ages	N	Total age	N
2+M	9	R+1	24	2+	–
3+M	66	R+2	89	3+	–
4+M	29	R+3	1	4+	26
5+m	0	R+4	–	5+	53
–	–	R+5	–	6+	24
–	–	–	–	7+	1
–	–	–	–	8+	–
	104		114		104

Adult ages in relation to smolt ages

2+M				3+M				4+M			
1SY	2SY	3SY	N	1SY	2SY	3SY	N	1SY	2SY	3SY	N
0	9	0	9	17	49	0	66	4	24	1	29
0%	100%	0%	–	26%	74%	0%	–	14%	83%	3%	–

JUVENILE CAPTURES

Parr (fish aged greater than 1+ but which had not yet migrated to sea) and fry (0+) densities varied among the tributaries sampled (Table IV). The Tomba parr densities and captures of parr 100 s⁻¹ of electrofishing time were significantly smaller than the same values from the Acha River (ANOVA followed by a LSD test, $P < 0.05$). Values for the other sites were intermediate and did not differ from each other or the Tomba or Acha rivers. In terms of fry densities and numbers of fry captured 100 s⁻¹ of electrofishing time, three groups of rivers were identified which had similar capture rates within groups, but which differed among groups (ANOVA, followed by a LSD test, $P < 0.05$). The first group, composed of the Lopinyaka, Little Ryabaga, Tomba and Ryabaga rivers, had the lowest values. The second group, composed of the Purnach, Alginka, and Yugoinka rivers, had intermediate values. The third group, composed only of the Pacha River, had the highest rates. Capture rates among stations within the remaining rivers (Brevieney, Kolmac, Acha and Ponoï) were highly variable. As a result, values from these rivers differed significantly (were lower) only in comparison to the Pacha River.

4. DISCUSSION

Ponoï anglers catch enormous numbers of fish. Catches per rod per day far exceed anything observed in Atlantic Canada in recent years (Science Branch 1995). Catch per unit effort data including the number of salmon caught per rod per day,

Table IV. Parr and fry densities and captures per second of electrofishing. In each cell, top line values are means \pm 1 S.D., middle line values in parentheses are medians, and bottom line values in parentheses are ranges. N – Number of stations sampled. See text for further details

Site	Parr 100 m ⁻²	Fry 100 m ⁻²	Parr 100 s ⁻¹	Fry 100 s ⁻¹	N
Acha	5.0 \pm 4.5 (4.9) (0.6–14.4)	1.6 \pm 1.4 (1.2) (0–4.2)	3.1 \pm 2.3 (3.2) (0.5–6.6)	1.3 \pm 1.2 (1.1) (0–3.5)	9
Alginka	0.8 \pm 0.7 (0.6) (0–2.3)	4.0 \pm 2.6 (3.7) (0–0.9)	0.5 \pm 0.4 (0.6) (0–1.2)	3.0 \pm 2.0 (2.9) (0–6.4)	11
Brevieney	3.4 \pm 4.3 (2.3) (0–8.9)	1.9 \pm 2.2 (1.5) (0–4.5)	1.3 \pm 1.6 (0.9) (0–3.4)	0.7 \pm 0.9 (0.6) (0–1.7)	4
Kolmac	3.1 \pm 3.2 (1.0) (0–8.7)	1.5 \pm 2.5 (0.0) (0–7.7)	1.9 \pm 1.9 (1.3) (0–5.6)	0.9 \pm 1.4 (0.0) (0–4.2)	10
Pacha	3.6 \pm 2.6 (2.8) (0.6–7.1)	11.5 \pm 4.4 (12.3) (5.5–17.3)	2.1 \pm 1.4 (1.4) (0.7–3.9)	7.4 \pm 3.4 (5.5) (4.1–12.4)	5
Ponoi	1.5 \pm 1.3 (1.3) (0–3.8)	2.2 \pm 2.0 (2.3) (0.4–6.7)	0.8 \pm 0.7 (0.7) (0–2.0)	1.3 \pm 1.4 (1.2) (0.2–4.6)	9
Purnach	1.0 \pm 1.1 (1.2) (0–2.8)	4.0 \pm 3.6 (4.3) (0–9.1)	0.4 \pm 0.7 (0) (0–1.9)	2.8 \pm 3.0 (2.8) (0–7.7)	11
Ryabaga	2.5 \pm 1.8 (1.9) (0.4–5.5)	0.4 \pm 0.4 (0.3) (0–1.1)	1.3 \pm 0.6 (0.2) (0.3–2.1)	1.6 \pm 1.1 (1.2) (1.1–2.4)	7
Tomba	0.9 \pm 1.1 (0.6) (0–3.3)	0.3 \pm 0.4 (0.3) (0–1.0)	0.5 \pm 0.6 (0.4) (0–1.6)	0.2 \pm 0.3 (0.1) (0–0.8)	10
Yugoinka	1.6 \pm 2.5 (0.3) (0–6.3)	4.9 \pm 6.2 (2.1) (1.7–17.4)	1.0 \pm 1.4 (0.2) (0–3.5)	3.2 \pm 3.3 (1.9) (0.9–9.6)	6
Lopinyaka	2.1 \pm 2.3 (1.8) (0–4.5)	0 0 (0–0)	0.5 \pm 0.4 (0.7) (0–0.8)	0 0 (0–0)	3
Little Ryabaga	2.0 \pm 2.3 (1.8) (0–4.4)	0 0 (0–0)	1.1 \pm 1.3 (0.9) (0–2.5)	0 0 (0–0)	4

have proved to be a good indicator of stock size and hence a useful tool for fishery management (Gulland 1983; Porter *et al.*, in print). Ponoi angling also generates large sample sizes, and all anglers stay at a single camp where data can be collected and collated. These circumstances create a remarkable opportunity to use

angler catches as the basis of a management scheme. The guides working at the camp are also a valuable asset because they possess excellent practical knowledge of the fish and river. 'Traditional Ecological Knowledge' (TEK) of local residents is increasingly being incorporated into conservation plans and evaluations of environmental impacts (Mailhot 1993). Anglers can sample the river under virtually all conditions and, with catch-and-release fishing, do so with little impact on the fish population. By contrast, trap nets and counting fences can be washed out by high water, and gill nets virtually always kill the fish. A disadvantage of angler-based sampling is that anglers prefer to target and catch large fish. As a consequence, size distributions in angler catches may be biased (e.g. Cooper, Wheatley 1981; Cowx, Broughton 1986). If other variables measured are correlated with size (i.e., sex or age of maturity), then these too may be biased. Determination of population means based on angler catches must be done with caution in these circumstances. The large sample sizes generated by Ponoï anglers may greatly reduce these biases, but further calibration work needs to be done at the site.

The present CPUE data for bright fish could be interpreted as indicating that the fall-run fish compose a minority of the adults in the Ponoï River. By contrast, Russian biologists currently believe that the fall run fish make up 70% of the fish in the river (O. Kuzhmin, pers. comm.). Several explanations may account for this discrepancy. A large component of the autumn run may arrive late in the fall or in early winter when angling has been stopped. No data are available to refute or support this. Autumn fish could be less motivated than spring fish to rise to a fly, perhaps because of different photoperiods, hydraulic regimes or temperatures. A third explanation is that the autumn fish are numerically more abundant than spring fish, but that they have been misidentified in angling catches because they fail to change their colour to a brown river morph despite overwintering for seven months in the river. Thus many of the "bright" fish captured at the start of the season would actually have arrived the previous autumn. This hypothesis could be tested by comparing the colour pattern of autumn fish which are tagged upon arrival with their colouration if they are recaptured the following spring. A second alternative would be to compare the burden of freshwater parasites, or state of gonadal development of bright fish caught in the spring. The presence of parasites which could be acquired only after an extended stay in fresh water, or gonads which have arrested development in an advanced state, would indicate autumn run fish (e.g. Power 1981).

In North America, rivers possessing autumn runs of salmon are rare. The Serpentine run of the Saint John river, New Brunswick, may have been one (Huntsman 1933; Saunders 1981), but these fish have been lost due to hydroelectric developments on the river. Huntsman (1933) noted that the run was composed primarily of females, intermediate in size between Grilse (1 SW) and salmon (2 SW or greater). By contrast, in Northern Quebec some of the rivers also have fish, primarily males, which arrive in an immature state and spend 12 months in the river before spawning (Power 1981). In Europe, the

Vistula River also had an autumn run (Zarnecki 1963). Little is known of the forces driving the evolution of this life history, or the physiological, energetic and behavioural adaptations required to make it successful. In the Ponoï River, both run types spawn in the autumn, and in theory could be mating with each other.

Another distinctive feature of the Ponoï Run is the absence of "trophy" (i.e., greater than 15 kg) fish from the catches. Given the number of fish caught by Ponoï anglers, and the efforts anglers undertake to catch large fish, some would be expected in the catches if they were present in the river. Fast-flowing rivers with steep gradients often have returns of large salmon. At these sites fish are presumably selected to delay maturation and remain feeding at sea to develop the body size and muscle mass required to make their difficult migration (Schaffer, Elson 1975; Power 1981). However, large body size can also develop in repeat spawners, which survive a spawning migration, move back to sea to feed, and return for further spawnings. The number of Atlantic salmon which survive to undertake future spawnings depends in part on river conditions. Where the migration is costly or fishing intense, few of the fish may return a second time (e. g. Ritter 1993). The Ponoï River has a relatively benign flow channel. There are few waterfalls and the rapids have many large rocks which break up the current and provide resting areas for the salmon. Thus migration costs for Ponoï salmon should be low and post-spawn survival high. The river exports many kelts back to sea each year, suggesting low mortality rates associated with spawning. Despite these apparently favourable conditions, few repeat spawners were captured in the Ponoï River, for unknown reasons.

The smolt ages of the Ponoï fish seem remarkably young given the short Arctic growing season. Smolts emigrating from Canadian Arctic rivers can be as old as 6+ and 7+ (Power 1969, 1981). At least one southern Kola Peninsula river even produces 1+ smolts (Kazakov 1994). The constant daylight in the summer may permit continuous feeding, and fast growth which could be coupled to the evolution of high metabolic efficiency in these northern rivers (e.g. Nicieza *et al.* 1994). Another possibility is that smolts move out to sea at a relatively small size and are thus younger. The characteristics of the out-migrant smolts of the Ponoï River have not yet been determined. However, salmon from more northern Kola Peninsula rivers tend to smolt at later ages than those from southern sites (Metcalf, Thorpe 1990).

Parr and fry densities were variable among the sites sampled. The low densities observed in several Ponoï tributaries may have resulted from several causes. No fry were caught in the Brevieny and Little Ryabaga rivers, suggesting that adult salmon did not find suitable spawning habitat at these sites. In such rivers, parr populations would result from movements of juveniles out of the Ponoï main stem and hence would be expected to be lower than those of naturally seeded tributaries. A similar phenomenon occurs in the Teno River, Northern Finland (Erkinaro, Niemelä 1995). At other low-density sites food availability, water temperature or flow regime may limit fish numbers.

Even the Pacha River juvenile densities, which were the highest observed, were low in comparison to those observed in some Canadian (e.g. Randall, Paím 1982; Gibson, Cutting 1993) and Kola Peninsula (Kazakov 1994) rivers. To generate the productive sports fishery of the Ponoí River, either the smolts which leave the river must have an exceptional sea survival, or the production of smolts occurs at low density over a vast area.

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5. REFERENCES

- Cooper, M. J., Wheatley, G. A. 1981. An examination of the fish population in the River Trent, Nottinghamshire using angler catches. *J. Fish Biol.*, 19, 539–556.
- Cowx, I. G., Broughton, N. M. 1986. Changes in the species composition of angler's catches in the River Trent (England) between 1969 and 1984. *J. Fish Biol.*, 28, 625–636.
- Erkinaro, J., Niemelä, E. 1995. Growth differences between the Atlantic salmon parr, *Salmo salar*, of nursery brooks and natal rivers in the River Teno watercourse in northern Finland. *Environ. Biol. Fishes*, 42, 277–287.
- Gibson, R. J., Cutting, R. E. 1993. Production of juvenile Atlantic salmon, *Salmo salar* in natural waters. *Can. Spec. Publ. Fish. Aquat. Sci.*, No. 118.
- Gulland, J. A. 1983. *Fish stock assessment*. New York. Wiley Interscience.
- Huntsman, A. G. 1933. St. John November salmon – The earliest run known. *Biological Board of Canada, Progress Reports of the Atlantic Biological Station, St. Andrews, New Brunswick and Fisheries Experimental Station (Atlantic), Halifax, N. S. No. 6. Atlantic Biological Station*, Note No. 25, 7–10.
- Kazakov, R. V. 1994. Juvenile Atlantic salmon in the Varzuga River (White Sea Basin). *J. Fish Biol.*, 45, 467–477.
- Mailhot, J. 1993. *Traditional ecological knowledge: The diversity of knowledge systems and their study*. Great Whale Environmental Assessment: Background paper No. 4, Great Whale Public Review Support Office, Montreal.
- Martynov, V., Chaput, G., Whoriskey, F., Anderson, J. 1994. Fishes of the shallow rapids and riffles of the Pizhma river, Pechora river basin, Russia. *Can. Tech. Rep. Fish. Aquat. Sci.* No. 2000.
- Metcalf, N. B., Thorpe, J. E. 1990. Determinants of geographical variation in the age of seaward-migrating salmon, *Salmo salar*. *J. Anim. Ecol.*, 59, 135–145.
- Nicieza, A. G., Reyes-Gavilan, F. G., Brana, F. 1994. Differentiation in juvenile growth and bimodality patterns between northern and southern populations of Atlantic salmon (*Salmo salar* L.). *Can. J. Zool.*, 72, 1603–1610.

- Porter, T. R., Reddin, D. G., O'Connell, M. F., Dempson, J. B. 1996. Scientific requirements for watershed management. In: Felt, L. F., Dominey, L. [Eds] *The challenge of community watershed management for recreational fisheries*. 109-125. St. Andrews. Atlantic Salmon Federation Special Publication.
- Power, G. 1969. The salmon of Ungava Bay. *Arctic Inst. N. America Tech. Rep. No. 22*.
- Power, G. 1981. Stock characteristics and catches of Atlantic salmon (*Salmo salar*) in Quebec, and Newfoundland and Labrador in relation to environmental variables. *Can. J. Fish. Aquat. Sci.*, 38, 1601-1611.
- Randall, R. G., Paim, U. 1982. Growth, biomass and production of juvenile Atlantic salmon (*Salmo salar* L.) in two Miramichi River, New Brunswick, tributary streams. *Can. J. Zool.*, 60, 1647-1659.
- Ritter, J. A. 1993. Changes in Atlantic salmon (*Salmo salar*) harvests and stock status in the North Atlantic. In: Mills, D [Ed.] *Salmon in the Sea*. 3-25. Cambridge. Fishing News Books Ltd./Blackwell Scientific Publications.
- Saunders, R. L. 1981. Atlantic salmon (*Salmo salar*) stocks and management implications in the Canadian Atlantic Provinces and New England, USA. *Can. J. Fish. Aquat. Sci.*, 38, 1612-1625.
- Schaffer, W. M., Elson, P. F. 1975. The adaptive significance of variations in life history among local populations of Atlantic salmon in North America. *Ecology*, 56, 577-590.
- Science Branch. 1995. 1995 Gulf Region stock status for diadromous stocks. *Can. Man. Rep. Fish. Aquat. Sci.*, No. 2286.
- Zarnecki, S. 1963. Differentiation of Atlantic salmon (*Salmo salar* L.) and of sea trout (*Salmo trutta* L.) from the Wisla (Vistula) River into seasonal populations. *Acta Hydrobiol.*, 5, 255-294.