Evaluation of the effects of catch-and-release angling on the Atlantic salmon (Salmo salar) of the Poni River, Kola Peninsula, Russian Federation


Abstract – We studied the effects of catch-and-release fishing upon the Poni River's Atlantic salmon populations. The Poni River is located on the Kola Peninsula of the Russian Federation, and has recently been developed for sports fishing. Angler exploitation rates are estimated to range from 10.4% to 19% of the river's salmon, thus the possibility of significant levels of post-release mortality is of concern. We radio-tracked fish caught and released by anglers in 1995 and 1996. Despite our simple equipment and the large size of the river, we were able to relocate most fish. These fish had high rates of survival, and anglers recaptured about 11% of them per year a second time. This is very similar to the recapture rates observed for Floy-tagged fish released in an angler-based mark–recapture assessment. We also held 62 angled fish for 24 hours in a live cage to evaluate rates of delayed mortality. Only one of the 62 fish died, and it was heavily scarred with gillnet marks. Most fish that are fatally stressed by angling die within 24 h (e.g., Booth et al. 1995). In 1996, up to 10% of our Floy-tagged fish were angled and released twice, and about 0.5% were angled and released three times. No significant biases were detected in the post-angling movement patterns of these fish. The multiple captures and lack of movement bias suggest that fish behavior was little altered by the angling experience. Nine fish Floy tagged prior to spawning have been recovered as typical emaciated kelts. Three were killed, and a post mortem exam showed all had spawned. Parr numbers at all monitored sites have been steadily increasing since the advent of catch-and-release fishing. By contrast, parr growth rates are generally unchanged or significantly better.

Un resumen en español se incluye detrás del texto principal de este artículo.

Introduction

Atlantic salmon (Salmo salar) numbers have been declining recently in many parts of the species range (ICES 1997). In some rivers, as in the inner Bay of Fundy region of New Brunswick, the species may be poised on the brink of extinction (Anon 1998a).

Managers have been searching for ways to maintain the socioeconomic benefits that stem from lucrative recreational angling fisheries, at no risk to the conservation of the species being fished. One of the conservation tools now being employed is catch-and-release fishing. In this practice, a hooked fish is released alive after having been angled, with no permanent harm having been inflicted to the fish. Done well, survival rates of released fish can be very high (Tufts et al. in press; Anon 1998b).

Sports angling has been recently introduced to
the Kola Peninsula of the Russian Federation, which harbors 62 registered salmon rivers. The area is located north of the Arctic circle (Fig. 1), is sparsely populated, has relatively few natural resources, and much of it was a closed military reserve until recently. This has resulted in very little human disturbance of salmon habitat within the rivers, and the major impact on local salmon populations has been from commercial fishing. Weirs along the coast captured salmon in the White Sea area, in-river weirs placed in some of the rivers or their tributaries harvested a maximum of 50% of the adult run, and local villagers carried on subsistence fisheries of uncertain magnitude.

In 1991, Loomis Outdoor Adventures began to develop the Ponei River for sports fishing. Subsequently, ownership for the rights to sport fishing on the River were transferred to the Ponei River Company (PRC). Key conditions of the PRC lease included the removal of the in-river weir and the initiation of catch-and-release fishing only, with the exception that each angler could kill one fish per week for consumption on site. In 1994, we began a science program to use mark-recapture methods to document annual salmon returns to the river. In addition, work was carried out to evaluate the fate of fish on the river that were angled and released. We also began monitoring juvenile densities within the system, to see whether densities would change as prior exploitation patterns were replaced by catch-and-release fishing.

The Ponei River (Fig. 1) has two discrete salmon runs (Whoriskey et al. 1996). The spring fish arrive in June to early August and spawn that autumn. By contrast, the autumn run fish arrive starting in mid-August and continue mounting the river under the ice cover. They do not spawn in the year they arrive. Instead, they overwinter, oversummer, spawn in the autumn, overwinter again, and return to sea up to 20 months after they first arrive. We have no evidence that the autumn run fish feed while they are in fresh water, so they undergo an almost 2-year fast for the sake of spawning.

Angling occurs on the river, weather permitting, from late May until September (Whoriskey et al. 1996). Anglers catch and release kelts, spring fish and autumn run fish that had both arrived the previous year, and newly arrived individuals in the late August to early September period. A priori, we predicted that the overwintered autumn run fish, which are energetically drained and caught in the summer when the river's temperatures are hottest, should be the most susceptible to mortality from post-angling stress. However, we also needed to evaluate the mortality risks posed to the other groups of salmon that were caught and released.

To monitor the impacts of the catch-and-release fishery, in 1995 and 1996, we radiotracked fish that had been taken by anglers from the Ryabaga camp, and released. We also analyzed recapture patterns of angled fish marked with Floy tags during annual mark-recapture estimates (>1000 per year), and returned to the river. In addition, in 1996, we put a holding pen at the home pool. A selection of fish taken by anglers were placed within the cage and held for 24 h to check for delayed mortality. Our intention was to correlate survival times with river water temperature, and angling or other variables (e.g., time on line until landing; sex and run time).

Methods
The study site

The Ponei River (Fig. 1) has a main stem channel length of 426 km, ranges in width from 45 to 230 m and drains an area of about 15,000 km². The basin is primarily within a tundra zone, and the river flows from west to east to enter the Barents/White sea border area. Deciduous trees (primarily birch) are found in protected areas along the river and its tributaries' banks. Fish species inhabiting the main stem are Atlantic salmon (Salmo salar), resident and anadromous brown trout (Salmo trutta), grayling (Thymallus thymallus), whitefish (Coregonus albula, C. lavareus), introduced pink salmon (Oncorhynhus gorbuscha), pike (Esox lucius), burbot (Lota lota), perch (Perca fluviatilis), and cyprinids (Phoxinus phoxinus, Rutilus rutilus and Lenciscus idus).

We worked within an 80-km section of river centered on the Ryabaga camp. The home pool is located a short walk from the camp at the confluence of the Ryabaga River with the Ponei main stem.

Average daily water temperatures in the Ryabaga camp home pool in 1995, 1996 and 1997 never exceeded 20°C (VEMCO recording thermistor, ac-

![Fig. 1. The Ponei River system and the study area](image-url)
accuracy ±0.2°C, temperature recorded at 15-min intervals). Daily maxima exceeded 20°C only in 1997, and this was only for a few days.

In addition to the sports fishery, a subsistence-angling fishery is also pursued on the river by residents of two villages (Kanevka and Krushnasheia). There are no estimates of the level of effort, or of catches, from this fishery.

Catch-and-release studies

We evaluated catch-and-release effects in three ways. The first was to take spring or over-wintered autumn run fish (as identified from combinations of date of capture, presence of sea lice or fresh water gill maggots, body morphology and scale characteristics; see Zjuganov et al. 1996) captured by anglers, hold them for 24 h, anesthetize them, then surgically implant Lotek radio tags within their abdomens. Incisions were sutured closed and sealed with tissue cement, and the fish were held for a minimum of an additional 24 hours for recovery and then released alive back into the river. Fish were operated on between 15 and 21 June 1995 and 5 and 21 June 1996 following procedures outlined by McKinley et al. (1992).

In 1995, which was a trial year used to assess the feasibility of our tracking methods, two spring run grilse and seven autumn 1994 salmon were tagged. Subsequently, in 1996, 17 fish (all autumn 1995 run, 5 grilse, 12 salmon) were fitted with the tags. We used a boat and hand-held Lotek radio receiver to relocate fish in the river. For practical reasons (primarily river size, but also problems with low water) we confined most of our tracking to the Ponoi main stem. In 1995, we searched for the fish on 11 days between 16 June and 7 August. By contrast, in 1996, a much more intensive tracking program was undertaken. Every other day between 6 June and 3 September, 40 km of the river was covered, alternating between the area upstream and downstream of the home pool where the fish were caught and released.

Fish were judged to be alive during the radio-tracking studies if they were detected moving upstream or were found holding station within fast current zones. All fish we relocated met these criteria.

In the second approach, at various times in 1996 a researcher worked with anglers in the home pool. The researcher recorded the time it took anglers to land a fish once they had been hooked up, number of hooks on the angler’s fly (one or two, all barbless), fish size (length and weight), fish origin (spring run, newly arrived autumn run, overwintered autumn run, and kelts), sex, and any injuries the fish bore (hook tears, seal scars, gillnet marks, etc.). These fish were then tagged with Floy tags, and placed for 24 h in a holding cage in the river. Previous work on Atlantic salmon has shown that fatally stressed fish die within 24 h after angling (Booth et al. 1995). The cage was checked regularly to determine time to mortality for any fish that might die. Survival time was to be used as a dependent variable in a multivariate model to predict the importance of the various parameters we measured on survival time.

Finally, large numbers (>1000) of the salmon angled each year on the Ponoi River are marked with Floy bar tags and released as part of a population assessment program. Anglers later recapture the fish, and a Petersen estimate is made (Whoriskey et al. 1996). Knowing population sizes, it is also possible to calculate the fraction of the annual salmon runs caught by anglers (termed the “exploitation rate”, although the great majority of the fish are released alive instead of being killed as the term implies). For this study, rates of recapture of the Floy-tagged fish could be used as a further indicator of how catch-and-release fishing was affecting the fish. In particular, if radio-tagged fish showed the same pattern of recaptures as the fish which we had marked with Floy tags, then this would suggest that all caught-and-released fish had survival rates similar to those of the radio tracked fish.

### Table 1. Ponoi River population estimates, and exploitation rates. 95% confidence limits are given in brackets. NA—not available.

<table>
<thead>
<tr>
<th>Year</th>
<th>Kelts</th>
<th>Spring run</th>
<th>Autumn run</th>
<th>Previous year</th>
<th>Angler exploitation rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>2,416 (3,954–1,567)</td>
<td>8,454 (13,865–5,495)</td>
<td>23,776 (38,993–15,454)</td>
<td>Entered river in 1994</td>
<td>18</td>
</tr>
<tr>
<td>1996</td>
<td>5,231 (9,519–3,138)</td>
<td>7,099 (12,920–4,259)</td>
<td>24,658 (44,877–14,795)</td>
<td>Entered river in 1995</td>
<td>10.4</td>
</tr>
<tr>
<td>1997</td>
<td>NA</td>
<td>6,030 (8,781–4,200)</td>
<td>24,539 (38,037–17,788)</td>
<td>Entered river in 1996</td>
<td>19*</td>
</tr>
</tbody>
</table>

*Kelts not factored into calculation.*
Parr studies

Since 1994, except for 1995, mid- to late August annual parr surveys using a Smith Root backpack electrofishing unit have been undertaken in the Ponoï main stem (6 riffle areas), and in the lower reaches of the Ryabaga, Purnach, and Tomba tributaries (3 riffle sites each). All electrofishing sites covered areas of at least 100 m².

The surveys were carried out as described by Martynov et al. (1994). To calculate densities in 1996 and 1997, we fished open sites (minimum of 3 sweeps), and used Zippin's method to compute densities (Zippin 1956). For each sweep, we recorded the fishing time, areas, and the number of parr and fry captured. This was done so our data could be compared to 1994 exploratory surveys, where a single pass over the same riffles was done. Results from the first sweep at each site in 1996 and 1997 were thus directly comparable to the 1994 data.

Samples of parr were killed in all years to determine age-specific growth rates.

Results

Salmon estimates and exploitation rates

Autumn run fish numerically dominate the Ponoï's salmon population (Table 1), and annual angler exploitation rates ranged from 10% to 19%.

Radiotracking studies

For the 1995 radiotagged fish, one spring grilse and one autumn run salmon were never relocated. They may have moved upstream or downstream of our tracking area, swum into a tributary, or died. Of the remaining fish, two autumn-run salmon were relocated only once, four and five days respectively from the release date. The other fish were all found on multiple dates and sites in the river, at between 33 and 53 days from release. Of the nine fish, one (11%) was angled again and killed in the local subsistence fishery. It was healed and strong.

In 1996, only one of the 17 fish fitted with radio tags was never relocated after the June release. A second fish was followed for two weeks before we lost it. All the others we tracked into late August or early September. These fish were active within the river, and two of them (11.7%) were recaptured by anglers. Both were completely healed. One was killed by local people in the subsistence angling fishery, the other was re-released by a camp client on 7 August and subsequently relocated at a variety of places in the river on 6 days between then and 3 September.

Home pool monitoring

Fish held in the home pool cage were: 15 kelts (8 salmon, 6 grilse; caught between 2 and 20 June 1996), 17 spring run fish (all grilse; caught between 13 July and 31 August 1996), and 30 autumn run fish which had entered the river in autumn 1995 and were caught in 1996 (15 salmon, 15 grilse; caught between 3 June and 15 August 1996).

The average time the fish were played by anglers did not differ significantly among kelts, spring run or autumn run fish. This probably is due to a large variability that reflects both angler experience (clients ranged from novices to experts) and natural differences in stamina of the fish within these groups. Pooling all fish, the average time they were played by the anglers was 192 s (range 50 s to 600 s).

Obvious wounds from the angling were evident in one of the 17 kelts (7%), one of the spring grilse (6%), and 7 of the autumn run fish (2 grilse, 5 salmon; 23%). These wounds were all tissue erosion about the jaws, except for one of the autumn run salmon that was hooked in the isthmus.

We failed in our attempt to construct the multiple regression model, because all but one of the 62 fish we followed (98%) survived the 24-h holding period. The one mortality was a fish heavily scarred with gillnet marks. It had lost all its

Table 2. Recapture summaries of Floy-tagged fish. Anglers—fish caught and released by anglers. Inspectors—fish angled and killed for food by local people and reported to the fish inspectors. Tag year—the year the fish were initially tagged.

<table>
<thead>
<tr>
<th>Tag year</th>
<th>1996</th>
<th>1995</th>
<th>1994</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Anglers</td>
<td>Inspectors</td>
<td>Total</td>
</tr>
<tr>
<td>No. of fish with tags</td>
<td>82</td>
<td>14</td>
<td>96</td>
</tr>
<tr>
<td>No. of fish marked</td>
<td>1142</td>
<td>1201</td>
<td>177</td>
</tr>
<tr>
<td>% of marked fish recaptured</td>
<td>7.2</td>
<td>1.2</td>
<td>1.6</td>
</tr>
<tr>
<td>No. of second recaptures</td>
<td>5</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>% of tagged fish recaptured twice</td>
<td>0.4</td>
<td>0.1</td>
<td>0.3</td>
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</tbody>
</table>
scales in roughly a 5-cm-wide ring around its body at the level of the pectoral fins. The fact that only one fish died suggests that such variables as run origin or sex played little role in determining whether or not a fish survived after being angled, at least under the conditions we encountered.

Recaptures of floy-tagged fish

1995. Eighty recaptures of salmon tagged in 1994 ($n=4$) and 1995 ($n=76$) were recorded during the 1995 season (Table 2). Sixty recaptures (75%) were made by anglers in the camp, 17 (21%) were reported by the fish inspectors from local subsistence fisheries, two were brought to us directly by local people (2.5%), and one (1%) came from a net site in the White Sea. Fish recaptured by the anglers were released back to the river, whereas those reported on by the fish inspectors or local people were dead. Also, due to the vague reports of the time and place of recapture of these dead fish, we have restricted our analysis of the days at liberty between marking and recapture, and the distances moved, to fish taken by Pono camp anglers.

The four recaptures in 1995 of fish marked in 1994 were of salmon originally tagged as newly arrived autumn run individuals (177 fish tagged). An average of 307 days (range 288–344 days) had passed between marking and recapture. One was tagged and recaptured at the same site. Two of the others moved upstream (7 km and 26 km respectively) from their original marking points, the other moved downstream 18 km.

The 76 recaptures in 1995 from fish tagged in the 1995 angling season were 6% of the total number of fish marked ($n=1201$). For the 1995 fish, the average time between marking and recapture was 36.8 days (SD 27.5, range 0–107, $n=73$). Fish moved an average of 16.8 km between tagging and recapture (SD 24.5, range 0–118, $n=73$). There was no correlation between time at liberty and distance moved $r_{5}=0.17, P<0.14)$. Tagging did not apparently bias fish movements. Similar numbers of fish ($\chi^2, P>0.05$) moved upstream ($n=25$), downstream ($n=30$) or stayed on the same beat ($n=20$). Fish moving upstream had similar times to recapture and moved similar distances as fish that moved downstream (ANOVA, followed by a LSD test, $P>0.05$). By contrast, the times to recapture of fish which stayed on the same beat (average of 20 days, SD 20.8, range 0–62 days) were about half of those of fish which moved either upstream (average 44 days, SD 31.7 days, range 5–107 days) or downstream (39.7 days, SD 23.9, range 6–95 days) (ANOVA followed by LSD test, $P<0.05$).

Two fish were caught and released three times (once for tagging, followed by two more captures and releases). One marked on 21 August 1994 was recaptured 26 km upstream on 31 July 1995 (344 days later). Subsequently, it was angled again on 15 August 1995 at the same area of its previous recapture, 359 days after its initial tagging. The second was tagged on 1 June 1995, recaptured at the same site on 18 June 1995, then moved 6 km downstream where it was taken and released again, 49 days after initial marking and 32 days after its first recapture.

1996. A total of 133 tagged fish were recaptured during the 1996 fishing season. Ninety-six of them were tagged during 1996, 35 during 1995, and two, marked in the river in 1994, spawned, went back to sea, and were recaptured in 1996 as they returned for a second spawning (Table 2). Recap-
tural patterns were made by the camp anglers fishing on the river \( (n=93) \), and by local subsistence fishermen \( (n=30) \).

For fish tagged in 1996, the average time between marking and first recapture was 32 days (26.4 days SD, \( n=82 \)). Three of these fish were marked and then caught a second time the same day (i.e., 0 days between marking and first recapture). By contrast, the longest period between marking and first recapture was 93 days. Thirty-two fish moved downstream, 11 moved upstream, and 37 were recaptured in the same area. We could not establish movement patterns or times at liberty for a few fish because of incomplete records.

Five of the fish tagged in 1996 were recaptured a second time. Time between initial marking and second recapture averaged 41 days (SD=19.3, range 2–71 days). Time between first recapture and second recapture averaged 20.6 days (SD=20.4, range 2–55 days), and the fish had moved a mean of 14 km (SD=15, range 0–36 km) from their last location. The period between captures, and the distances moved, did not differ between the first and second recaptures (Mann-Whitney test, \( P<0.30 \)). Three fish had moved downstream, and two were angled within the same beat.

In 1996, nine tagged kelts that had been tagged prior to spawning, were recaptured in the spring before they moved back to sea. Only three could be sampled to insure that they had spawned because of a delay in the issuance of our sampling permits. All were female salmon (2 SW), and all had spent ovaries.

Parr populations

Combined salmon parr and fry numbers captured during electrofishing surveys have been steadily climbing since the closure of the weir and inception of catch-and-release fishing (Fig. 2). Parr densities are also rising (Table 3).

Sizes at age of parr have varied among sites and between years (Fig. 3). Generally, inter-year variations in length at age at a given site are not significantly different, although in a few cases at some sites, sizes now are significantly larger than they were in 1994 (ANOVA followed by a LSD test, \( P<0.05 \)). Thus, at most sites, as density increased, growth either improved or was as good as previously observed.

Discussion

Considering the long history of Atlantic salmon sport fishing and the economic importance of the Atlantic salmon recreational angling industry, it is in some ways surprising that in comparison to other fishes, so little work has been done on the impacts of catch-and-release fishing upon salmon (e.g., Barnhart 1989; Muoneke & Childress 1994; Dempson et al. 1998; Anon 1998b). This is beginning to change.

In North America, recent experimental investigations (reviewed in Tufts et al. in press) have assessed the physiological stress and biological effects that Atlantic salmon cope with when being caught and released. This work shows that most caught and released salmon probably do survive and spawn. However, at warm temperatures (>22°C), in extremely soft water, or when the fish have very recently moved from the sea to fresh water, the magnitude of physiological disturbances may be increased and the fish may suffer higher rates of mortality. Good angler care is also essential for high survival of released fish.

Our results show low rates of mortality for caught-and-released Poni River, including the autumn run individuals that undergo such a long fast. Similar evidence showing low mortality of hooked-and-released Russian autumn run salmon from a previous year’s run was provided by a study on the Varzuga and Umba rivers. Post-release mortality of salmon was related to the duration of their residence in the river before they were first hooked, and salmon that were in fresh water for a fairly long time showed better survival than those newly arrived from the sea (Zjuganov et al. 1996). Catch-and-release fishing on the Poni River principally

<table>
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<th>Year</th>
<th>Parr</th>
<th>Fry</th>
<th>Parr</th>
<th>Fry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>22.5</td>
<td>10.5</td>
<td>29.1</td>
<td>9.9</td>
</tr>
<tr>
<td>1997</td>
<td>15.4</td>
<td>13.5</td>
<td>17.4</td>
<td>6.7</td>
</tr>
</tbody>
</table>

Range | 5.4–47.1 | 1.4–37.2 | 6–53.6 | 1.2–21.1 |

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<th>Fry</th>
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<td>66.1</td>
<td>19.0</td>
<td>77.5</td>
<td>33.4</td>
</tr>
<tr>
<td>1997</td>
<td>44.6</td>
<td>13.9</td>
<td>10.4</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Range | 19.8–108.8 | 4.3–32 | 65.5–84.4 | 42.8–84.4 |

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<th>Parr</th>
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<th>Fry</th>
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<td>32.6</td>
<td>12.2</td>
<td>69.9</td>
<td>25.0</td>
</tr>
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<td>1997</td>
<td>31.8</td>
<td>3.7</td>
<td>48.1</td>
<td>10.4</td>
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</tbody>
</table>

Range | 30.8–34.3 | 8.9–16.2 | 41.5–125.4 | 16–36.4 |

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<th>Year</th>
<th>Parr</th>
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<th>Parr</th>
<th>Fry</th>
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</thead>
<tbody>
<tr>
<td>1996</td>
<td>20.5</td>
<td>1.0</td>
<td>28.1</td>
<td>16.2</td>
</tr>
<tr>
<td>1997</td>
<td>9.7</td>
<td>1.7</td>
<td>14.3</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Range | 13.7–31.6 | 0.3 | 17.8–44.1 | 13.8–19.5 |

<table>
<thead>
<tr>
<th>Year</th>
<th>Parr</th>
<th>Fry</th>
<th>Parr</th>
<th>Fry</th>
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<tbody>
<tr>
<td>1996</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
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</tr>
</tbody>
</table>
exploits autumn run fish from the previous year’s run (60–80% of the captures). It also occurs fairly far upstream from the river’s estuary (the camp is located about 70 km up from the river mouth). Thus the majority of fish caught by Ponoi anglers will have been river residents for more than 6 months at the time of capture, and good survival is expected.

In this study, angled fish that had been fitted with radio tags and released were active, and those recaptured by anglers (~11% of those released) were healthy and strong. It is almost miraculous considering our simple technologies and the size of the river that were able to follow as many fish as we did for as long as we did. The fish we never relocated might have moved into a tributary or might have died. We made a small-scale effort to locate fish with radios in a single tributary (the Purnach River, Fig. 1). One was found, which shows that the missing individual could have moved out of our usual tracking area.

Caught-and-released salmon have also been radiotracked in the United Kingdom on the Aberdeenshire Dee (Webb 1998a,b). High survivals were reported (80%), and anglers recaptured a fraction of the radiotagged fish (two of 25; 8%) that is similar to the fraction recaptured on the Ponoi River.

Further support for low rates of mortality came from the high survival (98%) of the 62 fish caught in the Ponoi home pool and kept for 24 h in a holding cage. In addition, about 11% of the radiotagged fish were recaptured by anglers, very similar to the recapture rate of 7.2% for the Floy-tagged fish. Our radiotracking work, and that of Webb (1998), showed that the great majority of the fish angled and released with surgically implanted radios were alive and active even if they were not recaptured by anglers. This suggests that recapture rates for Floy-tagged fish could be calibrated to those of radiotagged fish to provide a cost-effective management tool to monitor the impacts of catch and release fishing. Recapture rates of 4.5% to 10% of caught-and-released Floy-tagged fish have been reported for the Aberdeenshire Dee (Webb 1998a), and the River Grimsa in Iceland (Grant 1980, and personal communication).

Water temperatures are relatively cool during the angling season on the Ponoi River. In the 1995 to 1997 period, temperatures rarely exceeded 20°C, and never hit 22°C, which under experimental angling conditions can result in post-angling mortalities (Wilkie et al. 1996). Nothing is known of the thermal tolerance limits of the Ponoi fish. However, it is difficult to compare the Ponoi results with those from “experimental angling” studies. In experimental angling, the fish are involuntarily hooked after being held (i.e., stressed) for varying periods. They were also angled to “exhaustion”, which may be beyond the levels of fatigue the fish experience in normal angling. For example, the anglers we monitored took an average of only 192 s to land a salmon once it was hooked. Thus, thermal and other tolerances of salmon caught and released are probably higher than those reported in the scientific literature under conditions of experimental angling (Tufts et al. in press). Managers contemplating river closures to angling due to high temperatures need better information on the true thermal limits of fish angled under normal conditions.

The captures of salmon a second and even third time by anglers on the Ponoi River within a season is further evidence of a robust tolerance of the Atlantic salmon to catch-and-release fishing, at least in conditions of relatively cool water temperatures.

The existence of multiple captures of caught-and-released fish in a season may also have important implications for fishery managers. Catch-per-unit-effort (CPUE) data are often used as indicators of fish population size (Hilborn & Walters 1992). In salmon fisheries, catches per rod per day are frequently employed as indicators of population size. Catch-and-release fishing is beginning to be widely implemented as a conservation measure in many jurisdictions. Where harvest levels are dictated in part by information from angling CPUE statistics, the levels will need to be calibrated for the existence of multiple captures if unintended overfishing is to be avoided. Similarly, scientists who are attempting to make population estimates of adult salmon runs using angler-based mark-recapture methods will also have to calibrate their sample sizes for the possible repeated captures of fish.

Since the removal of the barrier fishing weir and beginning of catch-and-release fishing, juvenile populations in the Ponoi River have been increasing at no cost in individual growth rates. While there is not much published information available on what constitutes a “healthy” parr density for subarctic and arctic Atlantic salmon rivers, it appears that Ponoi densities are now at about the level of those reported for the neighboring subarctic Teno river, in Finland (Erkinaro 1995). The numbers of returning adults to the Ponoi appear to be stable, we have confirmed that caught-and-released fish have spawned and some caught-and-released fish have returned as repeat spawners and were angled again. Overall, this suggests that the river has been systematically underseeded for years and that catch-and-release fishing regime is contributing to its recovery.

Resumen

1. Estudiamos el impacto de la pesca tipo “captura-y-suelta” sobre las poblaciones de Salmo salar del Río Ponoi. Este río de
Catch and release of Atlantic salmon on the Kola Peninsula


