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Integration of satellite reared Atlantic salmon (Salmo salar) parr to the Upsalquitch river, New Brunswick.

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Abstract

Satellite rearing uses volunteers to raise 0+ salmon parr from hatch until age four months for an autumn release to the wild. The volunteers benefit by helping to repair depleted salmon populations which they value, and their presence on the river discourages poachers. The use of volunteers also results in inexpensive production costs, provided the fish survive. We followed the integration of satellite-reared fish into one river as winter loomed. These fry were 30% larger than similar aged wild fish, but had assumed the sky-blue color of their rearing basin and were evident to predators. They dispersed little following their release and tended to occupy areas of higher current velocity than wild fish. Satellite reared fish and wild fish both used the gravel as a refuge, but the reared parr were slow to adopt indigenous foodstuffs. One year after release we recaptured 0.1% of the satellite-reared fish we had released. This may reflect both dispersion and mortality, however, this recovery rate was similar to that of a sample of wild fish we had also marked and released. By contrast, the 1+ satellite reared parr were now no larger than comparably aged wild fish. Thus, the satellite reared fish quickly adapted to fall riverine conditions, but growth advantages may not extend to a second year.

Introduction

The use of hatcheries to supplement natural fish production has generated concerns about the potential genetic and ecological impacts of inappropriate hatchery stocks (Stickney 1994), about hatchery production costs, and about the relatively poor return rates of hatchery fish (Farmer 1994). By contrast, well executed hatchery programs can help maintain or restore fish populations where the potential for natural reproduction has been lost (e.g. Stickney 1994).

In eastern Canada, "satellite rearing" uses volunteers to raise Atlantic salmon 0+ parr for release into natural waters (Sherer 1990). Brood stock native to the target waters are spawned and raised in hatcheries until first-feeding. Then the fish are transferred to the volunteer organizations which assume the responsibility and cost for growing the fish for about five months (May or June - October or November), at which point they are released into the wild. The process provides modest numbers of fish (generally a few thousand to a few tens of thousands per rearing station) for release into sites which need help. It also empowers local people with one means to help repair their rivers, and it discourages poaching because of the presence of conservationists on the river. The late season release may also permit the fish to avoid the intensive predation by mergansers, which commonly occur on many rivers in Canada's Atlantic provinces. After release, the additional time spent in the river as parr prior to smolting gives natural selection an opportunity to act, weeding out weak individuals.

Programs based on volunteers must be successful: if they are not, the volunteers find more productive uses for their time. We undertook an investigation of the ecology of satellite reared fish following their release at one site on the Upsalquitch river (a tributary of the Restigouche River), New Brunswick, in an effort to identify any problems encountered by the newly released fish and their potential solutions. We were particularly concerned that the late-released fish would fail to develop appropriate behaviour (habitat choice, feeding) before the onset of difficult winter conditions. We documented the movements, habitat choice, and diet of the satellite reared fish and compared them to those of wild fish occurring at the same place at the same time. We hypothesized that the satellite reared fish would be as adapted as their wild counterparts when they displayed behaviour similar to that of same aged wild fish. We also sampled 10 months after the fish were released, to continue to monitor their success at integrating into the river.

Methods

We worked out of the Boland Brook Camp in Northern New Brunswick. The camp is located at the confluence of Boland Brook with the Upsalquitch river. The Upsalquitch river, in turn, flows into the Restigouche main stem. The satellite rearing station consisted of a single 1.5m X 1.5 m, blue swede tank, which received water via gravity feed from Boland Brook. An automatic feeder provided food throughout the day.

On Oct 5, 1994, the 3897 satellite reared fish, progeny of Upsalquitch parents, had their adipose fins clipped and were released at a single point in the main stem of the Upsalquitch River. We sampled from then until the 1 of November when encroaching winter conditions stopped our work. In 1995, two sampling campaigns were undertaken, one from 11-13 July and a second from 26 Sept - 28 September.

To follow fish movements, we conducted weekly electrofishing campaigns. We concentrated our work within areas 500 m above or below the release site because electrofishing at greater distances caught no satellite reared fish. When satellite reared fish were captured, the distance and direction back to the release point were noted. For comparative purposes, we also electrofished a sample of 553 0+ wild parr, an additional 374 1+ or older parr. These fish were taken at various points within the study area, marked with individually numbered petite visual implant tags placed in the adipose tissue above the masseter muscle and a ventral fin clip, then released back at the point where they were captured. Movements of these fish were compared to those of the satellite reared fish.

To document the evolution of habitat choice, snorkelling or electrofishing transects were conducted within a 10 X 10 m grids within the study area on 6 October (24h post release) and 15 Oct (10 days post release). Snorkelling was used on the first date when fish were "active", and out of the substrate (water temperatures exceeded 10 C). As temperatures declined below 10 C, we switched to electrofishing, which brought the fish out of the gravel where they were hiding. When we spotted or electrofished either a wild or satellite reared fish, the point the fish came from was marked with a coloured weight. At each of these points, we recorded current velocity (General Oceanics current meter), distance to the nearest river bank, water depth, distance of the fish above the substrate, and the percentage of the substrate in the 1 m area surrounding the fish composed of: bedrock, boulder (> 461 mm), rock (180 - 460mm), rubble (54 - 179 mm), gravel (2.6 - 53mm), sand (0.06 - 2.5 mm), and fines (0.005 - 0.05mm). An indice of substrate size was calculated by scoring each of these substrate types from 1 (bedrock) to 6 (fines), multiplying each score by the percent of the 1 m^2. area that each size fraction made up, and then summing the totals of all fractions. Thus the index ranged from a value of 1 for a fish in an area composed entirely of bedrock, up to 6 for fish positioned over a bottom composed exclusively of fines.

Each week a sample of about 10 satellite reared and 10 similar aged wild fish were taken for diet analyses. Stomachs were initially preserved in 70% EtOH, and later in the laboratory we determined the degree of stomach fullness (% fullness), and counted and identified prey to the lowest possible taxa (In some cases genus or species, in others order).

Statistical analyses: All data were initially tested for normality and homogeneity of variances. Much of the data violated these assumptions, and could not be transformed to meet them. In addition, we had small sample sizes in some cases which make interpretation of tests for normality and homogeneity of variances problematic. For these reasons, we opted to use appropriate nonparametric statistics (Mann Whitney U test, Spearman correlations (r_s).

Results

The fish

The median fork lengths (FL) and weights of the 0+ satellite-reared fish (N = 36) at the time of release were 5.9 cm (range 5.4 - 6.4 cm) and 1.99 g (range 1.02 - 2.69 g) respectively. These lengths and weights were significantly greater (Mann Whitney U tests, $P < 0.05$) than those of the Upsalquitch's 0+ wild fish at this time (wild fish median FL = 4.9 cm, range 4.4 - 5.9 cm; median weights = 1.12 g, range 0.84 - 1.17 g, N = 40). By contrast, condition factors did not differ significantly between satellite-reared and wild fish (satellite-reared fish, K = 1.01, range 0.52 - 1.13; wild fish, K = 0.98, range 0.53 - 6.74), and sex ratios of both groups did not differ significantly from a 1:1 Male:Female ratio (X^2, $P > 0.40$). The satellite reared fish's growth advantage was not maintained into a second season. Recaptured satellite reared fish (N = 3) had a median length of 7.5 cm (range 6.6 - 7.7 cm) and weight of 3.7 g (range 2.8 - 4.1 g). This compares to median lengths and weights of 7.5 cm (range 7.1 - 8.5 cm) and 3.9 g (range 3.4 - 5.7 gm). Neither lengths nor weights differed significantly between these two groups (Mann Whitney U test, $P > 0.20$).

Rearing in a blue basin led to the satellite-reared fish losing or reducing the number of parr marks they bore. Fifty eight percent of a sample of 120 fish which we examined for parr marks as we were clipping fins had no marks at all, and the rest retained only faint traces. All wild fish which we caught at this site had well developed parr marks. In addition, all satellite-reared fish developed a bright blue body sheen, as opposed to the cryptic golden colour of wild fish. The blue colour was still bright five weeks after release when our sampling season terminated. This blue sheen made the fish clearly visible against the stream substrate, at least to the human observers. While our electrofishing and snorkelling transects did not spot or capture any large fishes (notably brook trout, Salvelinus fontinalis) which would prey on the satellite-reared fish, mergansers were present. The first pair found the satellite-reared fish within 22 mins of their release and consumed 5 fish before they could be chased off. Our regular presence on the river from this point on discouraged further merganser predation. However, a normal golden colour with pronounced parr marks had developed on the satellite reared fish which we captured after 10 months at liberty (N = 5).

Movements

Only 7% and 10% respectively of the autumn 1994 recaptures of wild (N = 75) and satellite-reared (N = 58) fish were made at distances of > 100m from the point of release. Satellite-reared fish moved significantly farther than their wild counterparts (Mann Whitney U test, $p < 0.05$, $n_1 = 75$, $n_2 = 58$). None of the satellite reared fish were recaptured in Boland brook during the autumn, even though it was readily accessible and the source of the water in which they were reared. By contrast, the only recaptures we made of tagged wild parr (N = 2), or satellite reared parr (N = 5) during extensive electrofishing in the summer and fall of 1995, were in Boland brook.

Habitat use

In early Fall, wild fish differed significantly from the satellite reared fish in that they occupied sites closer to shore in areas with coarser substrates, and they were found more frequently off the bottom than the satellite-reared fish (Table 1). However, current velocities and depths were similar for the two groups.

As the season progressed and water temperatures dropped, the wild fish significantly changed patterns of habitat use for most of the habitat variables we measured. In comparison to early October, by late October they had moved out of the water column, closer to shore and to areas of lower current velocities and finer substrates (Table 1). Comparing wild and satellite-reared fish at this time, the wild fish habitat shift resulted in their occupying areas of significantly slower current velocities, closer to shore and of shallower depths (Table 1). However, at this time wild and satellite-reared fish used substrates of similar sizes and were both found exclusively on the bottom, usually under rocks or in crevices.

The satellite-reared fish showed a less pronounced seasonal shift in habitat-use patterns than the wild fish (Table 1). They were positioned in deeper water and slightly but significantly closer to the river bank in late compared to early October (Table 1). By contrast, current velocities, depths in the water column and substrate sizes in zones used by the fish were not significantly different between sampling dates.

Not enough satellite reared fish were captured during the second field season to permit addition comparisons of habitat use.

Diet

It took only a few weeks for the satellite reared fish to shift from their artificial diet to one similar to that of the wild fish (Table 2). By the second and third weeks respectively after release, the number of prey per stomach and stomach fullness of the satellite-reared fish were statistically indistinguishable from those of wild fish.

These patterns were due to the satellite reared fish increasing their consumption of wild foods with time (Spearman correlations between diet variables and weeks post-release: stomach fullness, $r_s = 0.38$, $p < 0.01$, $N = 47$; prey number, $r_s = 0.44$, $p < 0.01$; $N = 48$). By contrast, wild fish consumption patterns did not change significantly over this time period (no significant Spearman correlations between week post release and any diet variable). Nor were any trends evident in prey diversity (number of prey taxa per stomach) either in comparisons of satellite-reared to wild fish, or for either group with time (Table 2). This may be due to the fact that there was little diversity in invertebrate production in the stream this late in the season.

Recaptures 10 months after stocking

Only 5 of the 3897 (0.1%) satellite reared fish were captured in the summer and fall campaigns 10 months after the fish were initially released. By contrast, none of the 553 0+ marked wild parr were recaptured, and only 2 of the 374 1+ or older fish were taken. Both of these were recaptured in Boland brook, where they were originally tagged.

Discussion

There was good news and bad news from this study. The good news was the fish rapidly adapted to their new conditions following their release. While they had not completely matched the habitat choices of wild fish of similar ages, they were rapidly converging upon them. They had identified and begun to use the indigenous food stuffs in the river, and even though they had started life with an inappropriate colour, fish recaptured ten months after release had developed a wild type coloration. Crypsis can be very important for salmonid survival (Donnelly and Whoriskey 1993).

The bad news was that very few satellite fish were recaptured when we sampled 10 months after release. Those that were taken had moved out of the area where we had stocked them, into the tributary stream which had provided the water to their rearing basin. Also, the initial growth advantage which these fish had over similar wild fish of the same age had been lost by 10 months post hatching.

Possible causes for the poor capture rates one year after stocking include predation or other mortality, and dispersal. Legault and Lalancette (1987) had trout predation troubles, but we do not believe that trout predation was a significant factor at this site. No trout of sufficiently large size to be predators were spotted or captured during our work, or by anglers fishing at the site. Mergansers may be a significant source of mortality at some sites (e.g Elson 1962, Feltham 1995), however our presence on the river probably discouraged their predation on satellite reared fish, at least during the autumn. We also note that while only 0.1% of the satellite reared fish were recaptured, none of the markded 0+ wild fish were taken and only 0.5% of the older, marked, wild parr. This suggests that whatever affected the satellite reared parr, affected the wild fish similarly. Dispersal, or mortality due to competition (e.g. Kelly-Quinn and Bracken 1989, Whalen and Labar 1994) are potential causes, but were beyond the scope of this study.

The fact that we only recaptured fish in Boland brook is curious. The year 1995 was exceptional for its hot temperatures and low water levels (Cassie 1995). The satellite reared fish which were reared in Boland brook water (4 - 8 degrees cooler than the Upsalquitch river) may have developed a preference for cold water, and returned to it. Wild fish spawned in this river could exhibit similar preferences.

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TABLE 1. Habitat use patterns of wild (W) and satellite reared (SR) fish, 24h (5 October, 1995) and 10 (15 October) days after release. See methods for description of substrate size classes. The bottom row in the Table gives the significance level for the comparison of 5 versus 15 October.

DATE		CURRENT CM(S)$^{-1}$		SHORE (M)		DISTANCE OFF BOTTOM (CM)		DEPTH (CM)		SUBSTRATE CLASS SIZE	
		W	SR	W	SR	W	SR	W	SR	W	SR
OCT. 5, 1995	MEDIAN	5	1.5	5.5	10.0	0	0	45.5	42	3.5	3.3
	RANGE	0-72	0-27	1.5-10.4	3.7-18.6	0-28	0-0	19.5-111.7	22-107	2.8-6.0	(0-4.7)
	N	25	34	27	34	27	34	27	33	27	34
	P	NS		**		**		NS		**	
OCT. 15, 1995	MEDIAN	0	1.0	3.0	8.32	0	0	38	66	3.1	3
	RANGE	0-18	0-26	0.1-9.7	2.8-9.6	0-0	0-0	6-106	35-92	1.1-4.4	1.4-3.9
	N	58	9	58	9	58	9	58	9	58	9
	P	**		**		NS		**		NS	
EARLY SAMPLE VS LATE SAMPLE		**	NS	**	**	**	NS	NS	**	**	NS

LEGEND: * P< 0.10 ** P< 0.05 NS Not Significant

TABLE 2 Diets of wild (W) and satellite reared (SR) fish, by date. Prey density is the number of taxa per stomach. Prey number is the number of identifiable prey taxa per stomach.

	OCT 6		OCT 12		OCT 21		OCT 28		NOV 3	
	W	SR	W	SR	W	SR	W	SR	W	SR
STOMACH FULLNESS (%)										
Median	10	0	30	5	13	0	28	3	5	10
Range	0-30	0-5	0-60	0-15	0-50	0-5	0-75	0-10	0-50	0-25
N	9	10	9	12	10	10	9	9	10	10
P	*		*		NS		NS		NS	
PREY DIVERSITY										
Median	1	------	2	1	1	1	2	1	1	1
Range	1-2	------	1-3	1-2	1-3	1-2	1-3	1-2	1-2	1-2
N	5	0	8	6	7	3	8	5	7	9
P	*		*		NS		NS		NS	
PREY NUMBER										
Median	1	0	2	1	1	0	3	1	1	1
Range	0-3	0-0	0-4	0-3	0-7	0-2	0-13	0-6	0-4	0-2
N	9	10	10	11	10	10	9	9	10	10
P	*		NS		NS		NS		NS	
LEGEND:	*Marginally Significant, P<0.10			** <0.05			*** <0.001			