North American Journal of Fisheries Management
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/ujfm20

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Published online: 08 Jan 2011.

North American Journal of Fisheries Management 13:86–95, 1993

Survival, Growth, Movement, and Distribution of Two Brook Trout Strains Stocked into Small Adirondack Streams

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Abstract.—Six field trials were conducted in two streams to compare the survival, growth, movement, and distribution of young-of-year Assinica strain and Temiscamie strain brook trout *Salvelinus fontinalis* 15–91 d after stocking. No consistent differences between strains in recovery after stocking or in growth were detected; however, movement and distribution within streams differed consistently between strains. Approximately four Temiscamie to one Assinica fish moved downstream 2–15 h after stocking. At the conclusion of five trials, the strains were dissimilarly distributed within streams (distribution was not assessed in the sixth trial): a large proportion of Assinica fish were found in the most upstream section of the streams, whereas a large proportion of Temiscamie fish were found in the most downstream section. These differences in movement and distribution may be related to the origins of the strains in large lake systems in Quebec, where spawning occurs in inlet and outlet streams. Assinica fish, which have a probable outlet origin and which moved upstream in this investigation, may be better suited for stocking in areas downstream of where brook trout are to be established. Conversely, their probable inlet origin and demonstrated downstream movement make Temiscamie fish candidates for stocking in upstream areas.

Stocking of wild and domestic salmonid strains with different performance and behavioral characteristics has become an effective technique for achieving fishery management objectives. The term "domestic" or "hatchery" strain here refers to genetic sources of fish that are maintained by brood stocks propagated in hatcheries for more than two generations. The term "wild strain" refers to genetic sources of fish that are maintained by native or natural brood stocks (see discussions by Moyle 1969a and Kincaid 1981). Studies that compare performance (e.g., survival, growth, harvest) and behavior (e.g., movement, food habits) among salmonid strains provide information useful for choosing strains for stocking.

Performance and behavior after stocking has been reported to differ among domestic strains and between wild and domestic strains of brook trout *Salvelinus fontinalis*. For example, substantial differences among domestic strains in harvest and growth have been observed after fish were stocked in Wisconsin waters (Hunt 1979). Differences between domestic and wild strains after stocking have been reported for survival, reproduction, and harvest. For example, wild strains of brook trout had higher survival than hatchery strains after they were stocked into lakes and ponds in New York (e.g., Flick and Webster 1976), Michigan (Gowing 1978), Ontario (Fraser 1981), and Quebec (Lachance and Magnan 1990). Wild strains of brook trout introduced into Ontario lakes established naturally reproducing populations where domestic strains previously had failed to reproduce (Fraser 1989). Some domestic brook trout strains were more susceptible to angling than wild strains after they were stocked into lakes (Brynildson and Christenson 1961) and streams (Mason et al. 1967).

Few studies have focused on differences among wild salmonid strains after stocking. Feeding habits and susceptibility to angling differed between two wild strains of cutthroat trout *Oncorhynchus clarki* stocked into a Colorado reservoir (Trojnar and Behnke 1974). Differences in survival among strains of wild lake trout *Salvelinus namaycush* have been reported from New York (Plosila 1977) and Ontario waters (MacLean et al. 1981). Small differences in survival were observed in a comparison of wild brook trout strains stocked in streams (Mason et al. 1967). In lakes and ponds, age to maturity, maximum life span, and maximum size were reported to vary among stocked wild strains of brook trout; however, only small differences in survival and growth were observed among wild strains stocked (Flick and Webster 1976; Fraser 1981, 1983). In two Michigan lakes, Assinica and Temiscamie strain brook trout ex-

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hibited similar survival and growth characteristics (Alexander et al. 1990).

Performances of Assinica and Temiscamie strain brook trout have been the focus of several investigations in ponds in the Adirondack Mountains, New York, since these two strains were first introduced from Quebec in the early 1960s. These strains were of particular management interest because the fish were long-lived and attained larger sizes than brook trout of other strains available for stocking (Flick and Webster 1976). In a series of comparisons in Adirondack ponds, Temiscamie fish survived better after stocking than Assinica fish (Webster and Flick 1981). In a later comparison of these strains, no significant differences in short-term survival were found between strains stocked as fry into ponds; however, differences in growth, movement, and distribution between strains were observed (Cone and Krueger 1988). In that study, conducted at two small Adirondack ponds with inlet streams, 50% of Assinica fish were found in the ponds' inlets and 50% were recovered from the ponds. In contrast, only 25% of Temiscamie fish were located in inlets whereas 75% were found in the ponds. This marked difference in distribution indicated that the strains may have different preferences for lotic and lentic habitats.

The objective of our study was to compare the survival (recovery after stocking), growth, movement, and distribution of age-0 Assinica and Temiscamie strain brook trout stocked in small streams. This study focused on stocking in streams because few studies have compared performance between wild strains of brook trout in flowing waters (Mason et al. 1967) and because fish of these two strains may differ in their preferences for stream habitats (Cone and Krueger 1988).

Study Sites

Two study areas were selected for investigation: Laramie Pond and its inlet (here called the Laramie system) and a tributary to Woods Lake. Laramie Pond is a 0.19-hectare artificial impoundment with a maximum depth of 1.5 m located in the northern Adirondack Mountains, New York (74°25'W, 44°23'N). Its inlet stream, which originates in a sphagnum wetland, is approximately 350 m long with an average width of 0.7 m and a maximum depth of 0.5 m. The bottom of the stream was composed of sand and silt with intermittent patches of gravel. During the 1988 and 1989 field trials, stream discharge varied little and averaged 0.4 m^3/s. A road culvert occurred in the stream approximately 25 m above the pond (when the pond was full). An inclined screen trap was maintained at the pond's outlet to monitor fish movement out of the system (Wolf 1951). Abiotic conditions, including pH, were adequate in the Laramie system for sustaining brook trout throughout the year. This site was used in past strain comparisons (Webster and Flick 1981; Cone and Krueger 1988).

Woods Lake is a 23-hectare headwater lake in the west-central Adirondacks (71°58'W, 43°52'N). The small tributary stream to Woods Lake is impounded near its origin by a beaver pond. Downstream from the impoundment, the stream is 150 m long and has an average width of 0.5 m and a maximum depth of 0.7 m. The bottom of the stream was composed of granitic cobble interspersed with sand. During the 1988 and 1989 field trials, the daily stream discharge averaged 0.1 m^3/s and varied little (U.S. Geological Survey data). A barrier trap approximately 20 m upstream from Woods Lake prevented fish from moving out of the stream. The Woods Lake inlet stream is susceptible to episodic pH fluctuations (range, 4.1–6.4) from atmospheric acidic deposition; however, abiotic conditions during the study were adequate for sustaining brook trout.

Methods

Fish strains.—Assinica and Temiscamie strain brook trout used in this study originated in Quebec from two adjacent river systems flowing into James Bay (Flick 1977; W. A. Flick, Livingston, Montana, personal communication). The Assinica strain came from Lake Assinica near the headwaters of the Broadback River (75°15'W, 50°30'N). The founder population of the Assinica strain in the USA comprised four females and three males captured near the outlet of Lake Assinica in September 1962. Adult Assinica brook trout were transferred to a holding facility and held until they were ripe. Fertilized Assinica eggs were then brought to the Brandon Park Hatchery in the northern Adirondack Mountains. The Temiscamie strain came from the Temiscamie River, the major tributary to Lake Albanel in the Rupert River system (75°10'W, 51°10'N). The strain was established with gametes from adults captured in 1965 and 1967 approximately 128 km upstream of Lake Albanel. Both collections of Temiscamie gametes came from 20–30 adults believed to have been residents of Lake Albanel that had migrated upstream to spawn. Wild brood stock populations (>100 Assinica adults; >400 Temiscamie adults) of both strains have been maintained in Adiron-

TABLE 1.—Number of Assinica and Temiscamie strain brook trout stocked, and starting date and duration of six field trials conducted in the Laramie system and the inlet to Woods Lake during 1988 and 1989.

Field trial	Number stocked of each strain	Trial start	Trial duration (d)
	Laramie system		
Pond and inlet	1,500	6 Jun 1988	91
Trial A—inlet	433	12 Jun 1989	17
Trail B—inlet	440	7 Jul 1989	22
Trial C—inlet	440	9 Aug 1989	60
	Woods Lake		
Inlet	250	26 May 1988	15
Inlet	210[a]	10 Aug 1989	16

[a] Thirty fish (of each strain) in each of seven sections.

dack ponds since their original introduction. Both strains are genetically distinct, based on allozymes detected by electrophoresis (Perkins et al., in press).

Hatchery rearing and marking.—Age-0 fish reared at the Brandon Park Hatchery were stocked in all trials. Both strains were propagated at approximately equal densities in the hatchery. Water temperatures were adjusted to produce fish of equal weight and length for stocking. One day before stocking, approximately 100 fish of each strain were measured and weighed. All stocked fish were given left (Assinica) or right (Temiscamie) pelvic fin clips to permit future identification of the strains. In the second of three 1989 Laramie trials, fish of both strains were given an additional adipose fin clip to evaluate the effectiveness of rotenone treatments conducted between the first and second and between the second and third field trials. In the 1989 Woods Lake trial, fish of both strains in alternate sections (the inlet stream was divided into seven sections) were given an additional adipose fin clip to permit detection of movement between adjacent sections.

Field trials and stocking.—Four field trials were conducted in the Laramie system and two field trials were conducted along the Woods Lake inlet stream (Table 1). In the Laramie system, a field trial was conducted in 1988 to replicate Cone and Krueger's (1988) study. In early June, 1,500 fish of each strain were stocked into Laramie Pond. In August the trial was concluded after 91 d and the pond was drained. All fish that remained in the pond were collected and counted by strain. In addition, the inlet stream was divided into four sections with 6.4-mm rigid-mesh polypropylene barriers, and each section was electrofished to obtain population estimates for each strain.

In the Laramie inlet stream (hereafter called simply the "inlet"), three trials (A, B, C) were conducted in 1989 to compare strains in terms of immediate movement after stocking, performance (recovery and growth), and distribution within the inlet at the end of each trial (Table 1). Two weeks before the first trial, the Laramie system was treated with rotenone and the pond was drained to create more stream habitat; a small portion (80 m^2) of the original pond remained. Approximately 440 fish of each strain were stocked in each of the three trials conducted in June, July, and August. In each trial, fish were stocked in Laramie inlet 15 m upstream of the culvert. Additionally, to evaluate poststocking mortality, mesh enclosures with 10 fish of each strain were placed in the inlet. The three field trials in 1989 were concluded after 17, 22, and 62 d. At the end of each trial, the inlet was divided into sections with rigid-mesh barriers, and each section was electrofished to obtain population estimates for each strain. In trial A, the inlet was divided into four sections. In trials B and C, two of the original four sections were subdivided, to provide six sections. After each trial, the inlet was treated with rotenone (2 mg/L). Fish recovered during the rotenone treatment were counted by strain.

In the tributary (inlet) to Woods Lake, one field trial was conducted in 1988 to compare the performance and distribution of the strains after stocking (Table 1). In late May, 250 fish of each strain were stocked approximately 50 m upstream of Woods Lake. For 24 h before stocking, fish were placed in plastic minnow traps in the inlet to adjust to the stream's pH. During the trial, the stream pH varied from 4.8 to 5.4. Two minnow traps with 45 fish of each strain remained in the inlet throughout the trial to evaluate poststocking mortality. The trial was concluded after 15 d. The entire inlet was electrofished to obtain population estimates for each strain in upstream, middle, and downstream sections of approximately equal length.

One 16-d field trial was conducted in Woods Lake inlet during 1989 to compare the survival and growth of the strains, but not their distributions (Table 1). Before stocking, polypropylene-mesh barriers were placed in the stream to divide the inlet into seven sections, each composed of one pool–riffle area. Thirty fish of each strain were stocked into each section in July. One mesh enclosure with five fish of each strain was placed in each section to evaluate poststocking mortality. At the end of each trial, each section was electrofished to derive a population estimate for each strain.

Fish sampling.—To evaluate immediate downstream movement after stocking, a net was placed at the downstream end of the culvert below the stocking site used for the three 1989 trials in Laramie inlet. The net was monitored for 2 h in trial A, for 12 h in trial B, and for 15 h in trial C. Fish captured in the net were counted by strain and returned to the inlet downstream of the culvert. To assess movement out of the Laramie system, an inclined screen trap at the pond outlet was monitored every 2 d throughout the 1988 and 1989 trials. Fish captured in this outlet trap were counted by strain and removed from the system. A downstream barrier trap was also used in the Woods Lake inlet trial in 1988 to assess outmigration. The trap was monitored every 2 d. All dead fish found at the trap were removed and counted by strain; live fish were counted by strain and returned to the inlet upstream of the trap.

Electrofishing was performed with a gas-powered backpack electrofishing unit (Coffelt model BP1-C). Output power was maintained at 75–125 W. To reduce the likelihood of changes in capture probabilities between electrofishing runs, inlet sections were electrofished only once a day (Cross and Stott 1975; Mesa and Schreck 1989). In the 1988 trials, fish were removed after sampling, and all fish of both strains within each inlet section were measured and weighed. In 1989, fish were given temporary caudal fin clips during each sampling run and were returned to the area of capture. Fish captured in individual sections during the final electrofishing run and fish recovered during the rotenone treatments were measured and weighed.

Statistical procedures.—Three-capture removal estimates were used to calculate numbers of each strain remaining at the end of each trial (method of Junge and Libosvarsky 1965, from Seber 1982). Associated variances, probabilities of capture, and goodness-of-fit parameters were calculated with equations described by Seber (1982). When a three-capture estimate failed the goodness-of-fit tests, a two-capture removal estimate was calculated and tested. In the 1989 Laramie trials, direct counts were also made from the sum of fish killed during the first two electrofishing runs, fish captured in the last electrofishing run, and fish recovered during rotenone treatment. Similar counts were made for the Woods Lake inlet trials, except that rotenone treatments were not used and did not contribute to the count.

TABLE 2.—Recovery of Assinica (A) and Temiscamie (T) strain brook trout after stocking in the 1988 and 1989 Laramie system field trials. Estimated recovery was calculated from three-capture removal estimates; 95% confidence intervals for estimated recoveries are given in parentheses. Direct counts include all fish captured in the final electrofishing sampling, the rotenone treatment, and all fish killed during the first and second electrofishing samplings.

Field trial (duration)	Strain	Estimated recovery	Percent recovery	Direct count
1988 system	A	780 (735–825)	52	
(91 d)	T	881 (851–911)	59	
Trial A—1989	A	244 (226–261)	56	203
inlet (17 d)	T	186 (174–199)	42	203
Trial B—1989	A	213 (190–236)	48	204
inlet (22 d)	T	226 (212–240)	51	196
Trial C—1989	A	88 (78–98)	20	73
inlet (60 d)	T	121 (111–131)	27	118

Daily instantaneous growth rates were calculated from weight measurements of each strain taken at stocking and at recovery (Cone and Krueger 1988). Instantaneous growth (G) and its variance (V) were estimated by

$$G = \log_e \bar{w}_{t+1} - \log_e \bar{w}_t, \quad (1)$$

$$V(\log_e \bar{w}_t) = V(\bar{w}_t)/\bar{w}_t^2, \quad (2)$$

and

$$V(G) = V(\log_e \bar{w}_t) + V(\log_e \bar{w}_{t+1}); \quad (3)$$

$\bar{w}$ is the average weight of the group of fish at time t. Equations (1) and (3) are equivalent to equations (1) and (3) of Cone and Krueger (1988). However, equation (2) above is a corrected version of Cone and Krueger's equation (2).

We used t-tests to compare weights between strains at stocking and at recovery and to detect differences between the strains found in individual stream sections. Analysis of variance was used to compare weights of the strains among stream sections in the individual 1989 field trials. Two-way contingency tables were used to compare the distribution of strains among stream sections. Statistical differences were recognized at the 0.05 level.

Results

Survival

In the 1988 and 1989 Laramie trials, no consistent differences in survival (recovery after stocking) were found between strains (Table 2). More

TABLE 3.—Recovery of Assinica (A) and Temiscamie (T) strain brook trout after stocking in the 1988 and 1989 Woods Lake inlet trials. Estimated recovery was calculated from three-capture removal estimates; 95% confidence intervals for estimated recoveries are given in parentheses. Direct counts include fish captured in the final electrofishing sampling and all fish killed during the first and second electrofishing samplings (no rotenone treatments were used).

Section	Strain	Estimated recovery	Percent recovery	Direct count
		1988 inlet trial		
Entire inlet	A	78 (24–132)	31	54
	T	39 (14–64)	16	14
		1989 inlet trial		
Section 1[a]	A	27 (26–28)	90	27
	T	28 (25–31)	93	27
Section 2	A	18 (17–20)	60	18
	T	26 (23–29)	87	25
Section 3	A	26 (25–27)	87	26
	T	23 (15–32)	77	20
Section 4	A	31 (21–41)	100	26
	T	25 (14–36)	83	20
Section 5	A	29 (26–31)	97	28
	T	25 (23–27)	83	24
Section 6	A	19 (18–20)	63	19
	T	24 (21–27)	80	23
Section 7[b]	A	21 (19–23)	70	20
	T	20 (17–22)	67	19

[a] Most upstream. [b] Most downstream.

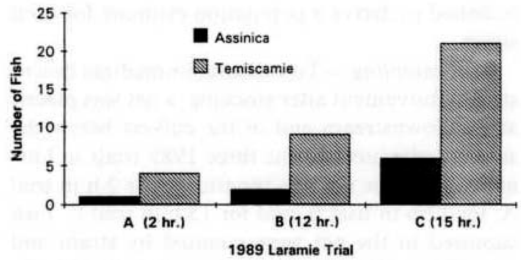

FIGURE 1.—Numbers of Assinica and Temiscamie strain brook trout captured in a net 15 m below the stocking site just after stocking in 1989 Laramie field trials A, B, and C. Numbers in parentheses indicate the time elapsed since stocking.

Assinica than Temiscamie fish were recovered in trial A, but more Temiscamie than Assinica fish were recovered in trial B. Significant differences occurred in the 1988 trial and in 1989 trials A and C, when more Temiscamie than Assinica strain fish were recovered ($P < 0.05$). No differences between strains in survival were observed in enclosures used to assess poststocking mortality; 80–100% of both strains survived during 1989 trials.

At the end of the 1988 Woods Lake inlet trial, no differences occurred in the number of Assinica and Temiscamie fish based on population estimates ($P > 0.05$; Table 3). No differences in survival were observed in enclosures used to assess poststocking mortality; 95 and 96% of the Assinica and Temiscamie strains survived, respectively.

TABLE 4.—Mean total lengths, weights, and sample sizes at stocking and recovery and daily instantaneous growth rates (G) of Assinica (A) and Temiscamie (T) strain brook trout during 1988 and 1989 field trials. One standard error of each variable or parameter is given in parentheses.

	At stocking			At recovery			
Strain	Mean length, cm	Mean weight, g	N	Mean length, cm	Mean weight, g	N	G per day
				1988 Laramie inlet			
A	5.7 (0.35)	1.5 (0.03)	100	8.3 (0.56)	4.6 (0.08)	383	0.0123 (0.0015)
T	5.3 (0.44)	1.2 (0.03)	100	8.0 (0.56)	4.1 (0.08)	373	0.0135 (0.0023)
				Laramie trial A—1989 inlet			
A	5.5 (0.49)	1.4 (0.04)	101	5.7 (0.55)	1.8 (0.05)	84	0.0141 (0.0037)
T	5.3 (0.37)	1.2 (0.02)	98	5.4 (0.49)	1.5 (0.04)	79	0.0117 (0.0034)
				Laramie trial B—1989 inlet			
A	6.8 (0.63)	2.9 (0.09)	100	6.9 (0.45)	3.7 (0.07)	195	0.0111 (0.0014)
T	6.7 (0.52)	2.8 (0.07)	100	6.5 (0.38)	3.0 (0.05)	179	0.0031 (0.0013)
				Laramie trial C—1989 inlet			
A	8.0 (0.70)	5.3 (0.16)	100	8.1 (1.40)	5.5 (0.19)	67	0.0006 (0.0013)
T	7.3 (0.60)	4.0 (0.10)	100	7.3 (0.67)	3.9 (0.11)	115	−0.0004 (0.0013)
				1989 Woods inlet			
A	8.0 (0.70)	5.3 (0.16)	100	7.6 (0.61)	4.7 (0.11)	133	−0.0025 (0.0006)
T	7.3 (0.60)	4.0 (0.10)	100	7.1 (0.54)	3.6 (0.08)	120	−0.0025 (0.0008)

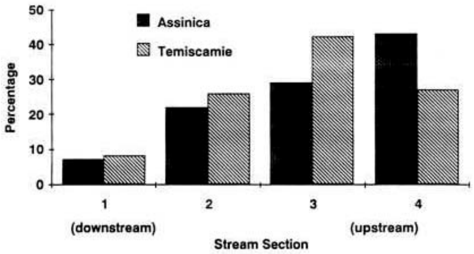

FIGURE 2.—Percentages of Assinica and Temiscamie strain brook trout present in four stream sections at the conclusion of the 1988 Laramie system trial.

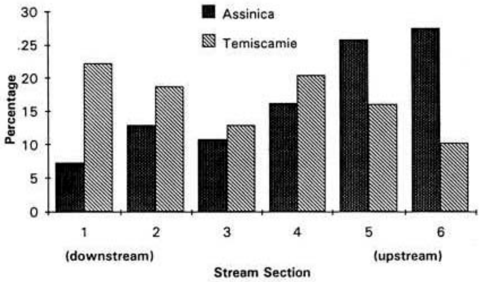

FIGURE 4.—Percentages of Assinica and Temiscamie strain brook trout present in each of six stream sections at the conclusion of the 1989 Laramie inlet trial B.

Similarly, at the end of the 1989 Woods Lake inlet trial, no consistent differences in population estimates were found in the seven stream sections (Table 3). Estimated recoveries ranged from 60 to 100% for the Assinica strain and from 67 to 93% for the Temiscamie strain. In four sections, more Assinica than Temiscamie fish were recovered; the opposite occurred in the other three sections. The strains exhibited similar survival within the enclosures placed in each section used to assess poststocking mortality.

Growth

Assinica strain fish were significantly heavier and longer than Temiscamie fish at stocking and at recovery in all trials (Table 4). Among all field trials, Assinica fish at stocking were on average 0.5 g heavier and 0.4 cm longer than Temiscamie fish. At recovery, Assinica fish averaged 0.7 g heavier and 0.4 cm longer than Temiscamie fish.

No consistent differences in growth rates between the strains were evident at the conclusion of five field trials in which growth was measured (Table 4). In the 1988 Laramie trial, Temiscamie fish grew significantly faster than Assinica fish. Conversely, in Laramie trial B, Assinica fish grew significantly faster than Temiscamie fish. No growth differences were present in Laramie trials A and C or in the 1989 Woods Lake inlet trial. Growth was not evaluated in the 1988 Woods Lake inlet trial.

Movements and Distribution

Large differences between strains were found in immediate downstream movement after stocking in the three 1989 Laramie inlet trials ($P < 0.01$; Figure 1). In trial B, for example, 12 Temiscamie but only 4 Assinica fish were captured below the culvert downstream of the stocking site during the 12-h period immediately after stocking. Among these three trials, Temiscamie and Assinica brook trout moved downstream immediately after stocking in an average ratio of 3.2:1. In addition to immediate movements, 14 Temiscamie but 9 Assinica fish were captured in the outlet trap over the trial periods.

At the conclusion of the 1988 and 1989 Laramie trials (12–91 d after stocking), the two strains were not distributed evenly among the Laramie inlet sections ($P < 0.01$; Figures 2–5). In all Laramie trials, disproportionately more Assinica than

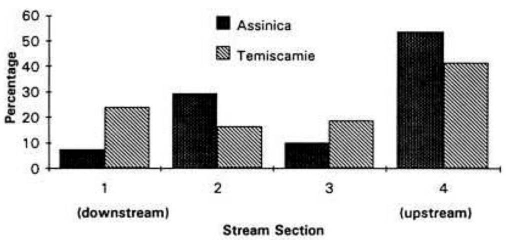

FIGURE 3.—Percentages of Assinica and Temiscamie strain brook trout present in each of four stream sections at the conclusion of the 1989 Laramie inlet trial A.

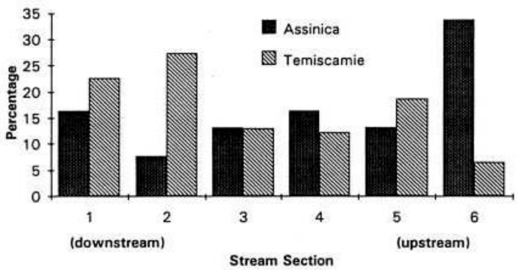

FIGURE 5.—Percentages of Assinica and Temiscamie fish present in each of six stream sections at the conclusion of the 1989 Laramie inlet trial C.

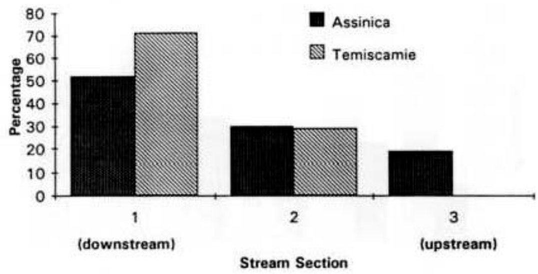

FIGURE 6.—Percentages of Assinica and Temiscamie fish present in each of three stream sections at the conclusion of the 1988 Woods Lake inlet field trial.

Temiscamie strain fish were found in the most upstream sections of Laramie inlet ($P < 0.01$). Disproportionately more Temiscamie than Assinica fish were found in the most downstream sections of the inlet. In trial B, for example, 53% of the Assinica fish were recovered in the two most upstream sections compared to only 26% of the Temiscamie strain (Figure 4). In the same trial, 41% of Temiscamie fish but only 20% of Assinica fish were found in the two most downstream sections. Results from trials A and C were consistent with trial B results (Figures 3, 5).

Differences in distribution were also found between strains in Woods Lake inlet in 1988, although movement for both strains was generally downstream (Figure 6). Nineteen percent of Assinica fish in the inlet were estimated to occur in the most upstream section, and no Temiscamie fish were captured there. In the most downstream section, 52% of the Assinica fish and 71% of the Temiscamie fish were estimated to occur.

Discussion

In five of the six field trials, differences in survival between strains were small. Neither strain was consistently estimated to occur in greater numbers (Tables 1, 2). Although recovery of the Temiscamie strain was statistically greater than that of the Assinica strain in the two longest Laramie trials (91 and 60 d; Table 2), the differences were only seven percentage points. Estimated population size of both strains in the Laramie system was probably underestimated in all trials because the upper 70 m of stream between the study area and the stream's origin was impossible to sample. The headwater channel was highly braided and in many places completely covered by mats of terrestrial vegetation that prevented electrofishing. Brook trout were observed in this headwater region. If Assinica fish were disproportionately more abundant there than Temiscamie fish, as Figures 3–5 suggest, the recovery of the Assinica strain would have been underestimated. Percent recovery of both strains in the 1988 Laramie trial was consistent with the results of studies conducted at the same site in the past (Webster and Flick 1981; Cone and Krueger 1988). Similarly, little evidence of a consistent or significant difference in the survival of Assinica and Temiscamie brook trout was reported from two Michigan lakes (Alexander et al. 1990).

In the four Laramie trials ranging from 17 to 91 d, differences in growth were small between strains (Table 4). Given the small magnitude of these growth differences and short duration of the trials, any conclusions drawn from these results must be viewed cautiously. The Temiscamie strain exhibited faster growth than the Assinica strain only in the 1988 Laramie trial (91 d duration). The Assinica strain exhibited significantly faster growth than the Temiscamie strain only in trial B (22 d). No differences in growth were observed in trials A and C (17 and 60 d). The highest growth rates were observed when fish were stocked at the smallest size. An inverse relationship between size at stocking and growth rate has also been observed for fry of rainbow trout *Oncorhynchus mykiss* (Hume and Parkinson 1988) and may account for the faster growth of the Temiscamie strain than the Assinica strain in the 1988 trial and in the previous study conducted by Cone and Krueger (1988).

At stocking, more Temiscamie than Assinica fish moved downstream in Laramie inlet (Figure 1). At the end of four Laramie trials and one Woods Lake inlet trial, disproportionately more Temiscamie fish were recovered from downstream sections of the inlets and disproportionately more Assinica fish were recovered from upstream sections (Figures 2–6). The movement and distributional differences between strains may indicate an inherent tendency of young-of-the-year Temiscamie fish to move and occupy areas downstream from a stocking site and, conversely, for Assinica fish to move upstream after stocking. Differences in movement after stocking have been observed among other salmonid strains and among wild populations. Catchable-size rainbow trout of the Roaring River and Oak Springs strains moved downstream in significantly greater numbers than fish of the Cape Cod strain after they were stocked in an Oregon stream (Moring and Buchanan 1978; Moring 1982). The distinct differences in movement of these rainbow trout strains was attributed to the historical influence of breeding with steelhead (anadromous *O. mykiss*). Similarly, differences in response to current have been observed among stocks of age-0 rainbow trout (Northcote 1969; Kelso et al. 1981), sockeye salmon *Oncorhynchus nerka* (Raleigh 1971), cutthroat trout (Raleigh and Chapman 1971; Bowler 1975), and Arctic grayling *Thymallus arcticus* (Kaya 1989). The differences in rheotactic response of fish in these investigations have been attributed primarily to the origins of the stocks from populations spawning in either inlet or outlet streams.

The origins of the Assinica and Temiscamie strains may explain the differences in movement and distribution observed in this investigation. The Assinica strain originated from brood stock taken near the outlet of Lake Assinica (Flick, personal communication). These adults, captured in the lake in September, may have aggregated adjacent to the outlet in preparation for moving downstream in the Broadback River to spawn. The Temiscamie strain originated from brood stock captured in the Temiscamie River. These adults presumably had migrated 128 km upstream from Lake Albanel to spawn. The ecology of brook trout in the combined Lake Albanel–Temiscamie River system was probably similar to that reported for Matamek Lake, Quebec (Saunders and Power 1970). In Matamek Lake, young brook trout began to move downstream in their natal tributary streams to the lake during their first year of life. By age 2, most fish had moved into Matamek Lake. This life history pattern is similar to that described for other salmonids that reside in natal streams until they move to lakes or the ocean.

Some studies have demonstrated that temperature and water chemistry can have a large effect upon the direction and magnitude of movements by salmonid fry (Northcote 1962; Raleigh 1971; Bowler 1975). These abiotic factors probably did not cause the differential movements observed between the Assinica and Temiscamie strains in this study because both strains were reared under similar conditions at the same hatchery and were stocked into the same waters. Additionally, these strains were reared at a hatchery located only 6 km from the Laramie system, where surface waters and geologic conditions are similar to those at the hatchery. Lastly, consistent differences between strains were observed in two years, in two streams, and in trials started at different times of the year.

The results of this investigation may help explain apparent differences in survival between these strains reported in previous comparisons. Webster and Flick (1981) reported 50 and 52% survival of Assinica and Temiscamie strains, respectively, in a paired stocking in Laramie Pond in 1978. In 1979, survival rates were 36 and 57% for Assinica and Temiscamie strains, respectively. The inlet to Laramie pond was not sampled during these studies, but a mesh barrier was installed to prevent all fish from moving from the pond upstream beyond the culvert. The apparent lower survival rate of the Assinica strain than of the Temiscamie strain in 1979 may reflect undetected upstream movement of proportionately more Assinica than Temiscamie fish.

Based on these results, site selection for stocking may affect the management success experienced with these two strains. Because age-0 Temiscamie brook trout moved downstream after stocking, they probably should be stocked in areas upstream of where they are to be established. Conversely, Assinica fish in our study consistently moved to upstream locations; thus they should be stocked in downstream areas. Additional investigations of adult Assinica and Temiscamie brook trout in lakes and ponds with inlet or outlet streams may confirm that these strains differentially prefer to spawn in inlets or outlets. Use of inlet- and outlet-spawning strains of brook trout could help speed naturalization of brook trout in barren lakes and ponds with suitable inlets or outlets for spawning.

The similar survival and growth of the two strains in streams but the consistent differences in their movement and distribution emphasizes the importance of investigating behavioral traits in addition to performance traits in strain evaluations. Most studies of salmonid strains have compared characteristics such as survival, growth, production, and harvest in selected waters. Studies such as these are useful for site-specific understanding of strain responses to a particular water body, but they may have little predictive power for choice of the best strain(s) to use in other waters. An example is found in two comparisons of three strains of rainbow trout (Hudy and Berry 1983; Babey and Berry 1989). In the first investigation, no significant differences in performance were found among strains; in the second investigation, in a different lake, one strain clearly outperformed the other two. The second study demonstrated that the results of the first could not be applied universally to all waters. Behavioral characteristics such as food habits, habitat preferences, and movement, can help explain the mechanisms that cause differences in strain performance. Knowledge of these mechanisms will result in better predictions of the response of salmonid strains to different sets of environmental conditions, and thus improve decision making about stocking. Matching traits of strains to best suit the environmental characteristics of waters to be stocked will help achieve management goals of programs ranging from put-grow-and-take fisheries to species restoration.

Acknowledgments

Chris Keleher, Mike Vaughn, Dave Fanion, Alex Chmielewski, Allen Creamer, Peter Grewe, Dave Perkins, and Ellen Marsden provided helpful field assistance. We are grateful for assistance provided by Leo Demong, Fred Joost, Susan Grenier, and Andrew Manchester of the Brandon Park Hatchery. Research facilities at Laramie Pond were provided by Mrs. Donald Ross. Funding for this project was provided by the U. S. Fish and Wildlife Service through Research Work Order 9 from the New York Cooperative Fish and Wildlife Research Unit under agreement 14-16-0009-1553, and from the New York Agricultural Experiment Station, New York State College of Agriculture and Life Sciences, Cornell University, Hatch projects 1476402 and 1477402.

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