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AN EXPERIMENT TO INDUCE ANADROMY IN WILD BROOK TROUT IN A QUÉBEC RIVER ON THE NORTH SHORE OF THE GULF OF ST. LAWRENCE[1]

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Résumé

À cause d'une chute infranchissable située à 0,7 km de la mer, il n'y a pas de migrations d'omble de fontaine anadrome dans la rivière Matamec (côte nord du golfe du Saint-Laurent, Québec). Des individus capturés entre le 29 mai et le 29 juillet 1978 en haut et en bas de cette chute furent relâchés en aval, dans l'estuaire de la rivière. Des 931 poissons libérés, 284 (30,5%) furent recapturés entre le 15 août et le 29 septembre 1978. Les recaptures furent plus faibles pour les poissons de 1 et 3 ans (respectivement 5,3 et 16,5%) que pour ceux de 2 et 4 ans (30,8 et 55,4%). Une proportion plus grande des poissons relâchés en mai et juin ont vu leur poids augmenter (69,8%), par comparaison aux individus libérés en juillet (45,5%). Au total, 62,8% seulement ont montré une augmentation de poids; environ 15% d'entre eux semblaient être des «truites de mer». Ceux dont le poids ne s'est pas accru étaient probablement restés dans l'eau non salée. Des proies d'origine marine ne furent trouvés que dans les estomacs des poissons de 2 et 3 ans (fréquence de 12,4 et 10,1%). La proportion des poissons à chair colorée s'est accrue avec l'âge. Ceux qui étaient restés dans l'eau non salée avaient un pourcentage plus élevé d'individus à gonades développés.

Abstract

The Matamek River (North Shore of the Gulf of St. Lawrence, Québec) does not have a natural run of anadromous brook trout, due to a falls impassable to this species 0,7 km from the sea. Wild trout were captured above the falls, and below the falls, and transplanted downriver to the estuary between 29 May and 29 July 1978. They were recaptured by various methods between 15 August and 25 September 1978. Nine hundred and thirtyone fish were released, and two hundred and eighty-four were released, and two hundred and eighty-four were recovered (30.5%). Poorest recovery was with sizes corresponding to age classes 1+ (5.3%), and 4+ (16.5%), and best recovery was with sizes corresponding to 2+ (30.8%) and 3+ (55.4%). A greater percentage of recaptured fish released in May and June gained weight compared to those released in July (69.8% vs 45.5%). Only 63.8% of the recoveries had gained weight and only about 15% appeared to be "sea trout". Those that lost weight or did not change probably remained in fresh water. Amonst the recaptures marine food was found in the stomachs of 12.4% of the 2+, 10.1% of the 3+ and in noneof the other groups. The percentage of fish with coloured flesh increased with age. The percentage of fish with developed gonads was less than occurs in the freshwater population.

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Introduction

The brook trout *(Salvelinus fontinalis)* is anadromous in many rivers providing free access to and from the sea (Scott & Crossman, 1964). This "sea trout" is a highly desired sport fish in eastern North America, and is an important commercial species in southern Labrador. However, relatively little research has been conducted on this "sea trout" in recent years, and despite the success of sea ranching other salmonids, few attempts have been made with brook trout.

Taxonomic studies by Wilder (1952) suggested that anadromous and river dwelling brook trout were genetically the same stock. If this is the case, it should be possible to create a run of "sea trout" by planting wild river fish in the estuary.

General observations in the Matamek River suggested that food would be available in the estuary, as organic detritus accumulates here from woody debris, leaves and marine algae. Amphipods and mysids were abundant amongst this organic matter and along the shore, and small fish such as *Ammodytes* and *Gasterosteus* were common. The species and abundance of fish in the Matamek estuary change considerably with the season (Dickson, 1978). White (1942) reports that sea-run brook trout travel in schools along the seashore and feed largely upon small fishes of various species and upon Crustacea. Brook trout in the Matamek River are abundant but growth is slow (Gibson *et al.*, 1976). Preliminary studies by Haedrich (1975) showed that a limited number of "sea trout" occurred in the estuary and that they exhibited exceptional growth compared with trout above the first falls.

The purpose of these transfer experiments was to obtain some estimates of the relative estuarine survival rate and growth rate of different year classes of brook trout. The possibility of using such transfers as a method of enhancing the recreational fishery is also considered.

Study area

The Matamek River is located on the North Shore of the Gulf of St. Lawrence (Fig. 1). The Matamek Research Station was used as a base of operations (Gibson, 1979).

The river basin covers an area of 684 km^2 and the lower Matamek River, 10 km long, drains a lake of 1620 ha. Average width of the river is 45,7 m. The mean width of the river between the first falls and the sea is 23 m. Mean daily discharge of the river is 21.8 m^3/s, but there is a wide seasonal range, with an average daily flow of 2.1 m^3/s during low water periods to 113.3 m^3/s during flood periods (M. Frenette, pers. comm.). There are five waterfalls on the river (Fig. 1). Brook trout occur throughout the river, but marking data for population estimates have shown that each falls blocks upstream migration for the species; the fourth falls, 5.5 km from the sea, is an obstruction to Atlantic salmon (*Salmo salar*). The second falls is 2.3 km from the sea, and the first falls 0.7 km from the sea.

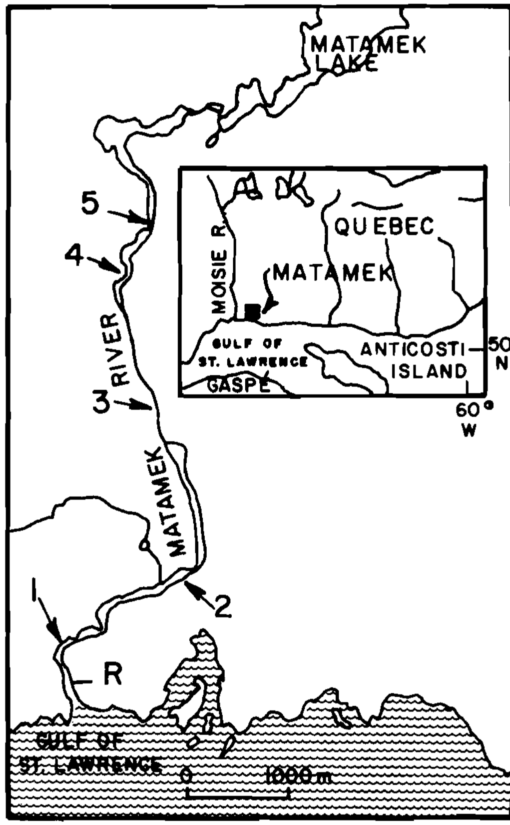

Figure 1. Map showing the Matamek River and its location on the North Shore of the Gulf of St. Lawrence. R = release site, and the numbers indicate positions of the waterfalls.

Brook trout for this study were caught between the first and second falls, and between the first falls and the sea. The river between the first falls and the sea has a substrate of bedrock and boulders and provides no suitable spawning substrate for salmonids. If anadromous brook trout generally have a genetic trait for running to sea, this could not have been selected for in the Matamek River as they cannot ascend the first falls. The river discharges directly into the sea, wich has a rocky shoreline, so that there is no gradual transition from river to sea as is found in many estuaries.

Fish were released in a small bay immediately upstream from the sea. Diving observations in June showed a wedge of clear cold salt water intruding below the brown river water at high tide just downstream from the release site. The site was affected by the tide, and the water here was brackish. The salinity was measured at the release site once in June and twice in July, and each time was found to be 5‰. The mean water temperature at the release site was 10.3°C (S.D. = 3.12) in June, taken daily when fish were released, and was 16.8°C (S.D. = 1.87) for July. The first water temperature recorded above 9°C was on 16 June, and the highest recorded was 21°C on 18 July. The water temperatures were higher at the second falls, reaching 9°C on 9 June (Whoriskey, 1979).

Materials and methods

Fish were caught in the river (29 May-29 July, 1978) by fyke nets, beach seine, small purse seine, and by angling with small flies. These gears, especially fyke nets, had been very successful in catching brook trout in the Matamek River previously (Gibson, 1973) so similar methods were used to collect fish for this study. Below the second falls the trout were held temporarily in net pens, then transferred by vehicle and transport tank a short distance to the estuary, where they were placed into a second net pen. Trout caught below the first falls were transferred in plastic bins directly to net pens.

Each trout was anaesthetised with MS-222, the weight and fork length measured, and tagged with a green 2.5 cm Floy anchor tag, each individually numbered. The fish were then placed into another net pen to recover before being released. A number of yearling trout below 10 cm in fork length were left untagged but were marked by clipping the left ventral and adipose fins. Water temperature was determined at the time and site of release and was also recorded at the second falls. Salinity was measured on thre occasions at the release site.

Fish were recaptured between 15 August and 25 September 1978. Recapture methods were: angling with flies and spinners up to 21 September; gill nets (3.6 cm and 5.1 cm stretched measure) 17 to 25 September; and capture in a fish counting ladder at the first falls up to 4 September (operated since 1975 to capture salmon for population estimates). Each recaptured fish was weighed and measured, and a scale sample taken from between the dorsal fin and lateral line for age determinations. The stomach contents were examined for the presence and origin of food, and flesh color, sex and stage of maturity recorded. Flesh colour was categorized as white or greyish, yellow, pink, and orange or red to deep pink. The fish were considered to be mature if the gonads indicated that the fish would spawn that season (stages 4 and 5 of Vladykov, 1956). Spawning in the Matamek system starts in September (Gibson *et al.*, 1976), so that maturity was easily recognized at the time of recapture. Condition factor K, ($Wt \times 100 \times L^{-3}$) was calculated for all recaptured fish.

The recaptures were later analyzed in age groups. Scales were taken only from recaptures, as we wished to put as little stress as possible on released fish.

Results

From 29 May to 29 July 1978, a total of 931 tagged trout were released into the estuary, and between 15 August to 25 September, 284 were recaptured, or 30.5%. Eight hundred and nine of the released trout were from between the second and first falls and these had a recovery rate of 28.8%. One hundred and twenty-two were from below the first falls and 32.0% of these were recaptured.

The sizes of the fish at release are shown in Table I, the numbers released and recovered in Table II, and the relative numbers that gained or lost weight in Table III. The majority of recaptures were made by angling (58%), 23.7% by gill nets, and 18.3% in the fish ladder at the first falls. Most angling was between 4 and 21 September. Only 0.8 hours were spent angling in August. Altogether 31.5 man hours (by four people) were spent angling, with a mean success rate of 5.8 trout/h (S_x 1.28). Gill nets were set overnight for eight sets each, between 17 and 25 September. The 3.6 cm net had a mean of 3.1 trout/set (s_x 1.48) and the 5.1 cm net, 3.1 trout/set (S_x 1.28). Unfortunately,

TABLE I

The mean size of recaptured brook trout at their release time. The ages were taken from the recovered fish. Standard deviation is given in parenthesis

Release time	*Year class*				
May and June					
	1+	2+	3+	4+	5+
Sample size	4	98	79	9	4
Fork length (cm)	11.3	15.3	19.5	25.1	23.5
	(1.04)	(2.16)	(3.33)	(4.77)	(2.90)
Weight (g)	14.4	36.8	80.6	132.3	143.3
	(4.05)	(16.84)	(53.34)	(56.83)	(51.36)
July					
Sample size	6	41	28	3	—
Fork length (cm)	12.2	15.4	19.2	28.2	
	(1.57)	(2.19)	(3.67)	(0.3	
Weight (g)	19.8	50.0	80.4	297.7	—
	(7.12)	(18.98)	(43.69)	(104.22)	

TABLE II

Total recoveries from 15 August — 25 September 1978 of brook trout released into the Matamek estuary from 29 May-29 July 1978. The recoveries from the May and June releases are considered separately from those of the July releases, and recoveries are also considered in size groups which closely correspond to age classes

Released			*Recoveries*			
Group	*Number*	*Weight (kg)*	*Number*	*Weight (kg)*	*% of number*	*% loss in released biomass*
May-June releases						
1+	94	1.386	4	0.062	4.3	95.5
2+	349	10.774	98	4.186	28.1	61.2
3+	155	11.536	79	9.457	51.0	18.0
4+	82	20.346	13	2.970	15.9	85.4
TOTAL	680	44.042	194	16.675	28.5	62.1
July releases						
1+	96	1.638	6	0.110	6.1	93.8
2+	102	3.597	41	2.133	40.2	40.7
3+	38	3.089	28	2.316	73.7	25.0
4+	15	2.751	3	0.641	20.0	76.7
TOTAL	251	11.075	78	5.200	31.1	53.1
TOTAL, May-June and July						
	931	55.117	272	21.874		
Plus lost tags						
2+			5	0.196		
3+			7	0.709		
Complete TOTAL						
	931		284	22.779	30.5	58.7

the fish ladder had to be closed off on 4 September, probably before the main run.

By using several methods of capture, selectivity is minimized. The relative percentage of year class in the sample caught by each method is as follows. The percentage of the total recaptures represented by each year class is in brackets.

	Angling	Gill nets	Fish ladder
1+ (4)	7.1	0	0
2+ (49)	57.1	44	31.0
3+ (41)	33.2	50.7	53.4
4+ (4)	2.2	5.3	10.3
5+ (1)	0.5	0	5.2

Therefore 100% of the yearling recaptures were caught by angling, and they were 7.1% of the total caught by angling. The fish ladder appeared to catch more of the 4+ and 5+ fish, although these were relatively few.

The mean number of days between release and final recapture was 81.4 (S.D. = 13.5) for fish released in May and June, and 60.3 (S.D. = 12.0) for fish released in July. If the recovery from the May-June releases is compared to that of the July releases, the results are similar. With the early group 28.5% were recaptured, and 31.1% were recovered from the July group. However, if the fish are compared by size groups, which approximate age groups, a different pattern emerges (Table II). The mean length and weight for each year class is shown in Table I. Fish at release did not have scale samples taken, so they are considered in size groups corresponding to age groups estimated from the age and size of recaptures at their release time. The May and June releases were analyzed in the following groups: 1, 10.0 cm-12.4 cm; 2, 12.5 cm-17.4 cm; 3, 17.5 cm-22.5 cm; 4, > 22.5 cm. The July releases were put in the following groups: 1, 10.0 cm-13.4 cm; 2, 13.5 cm-17.4 cm; 3, 17.5 cm-22.5 cm; 4, > 22.5 cm. These groups approximated the year classes, 1+, 2+, 3+ and 4+ and older. Although there is a range in size for each year class, the mean size below the second falls has remained fairly constant over several years (Gibson, 1973, 1978; Gibson *et al.*, 1976).

It can be seen from Table II, for both the release dates, poor recoveries were observed in groups 1 and 4, and best recoveries in groups 2 and 3, with group 3 showing the best returns. Comparing the biomass recovered with that released, all groups showed a loss. However, group 3 showed the least loss in biomass.

Over half of the recoveries had gained weight (Table III). However, more of the fish

TABLE III

The numbers and percentages of fish that gained or lost weight and the changes in weight

	No. that gained weight (and %)	*Mean gains (g) (and S.D.)*	*% gain of original body weight*	*No. that lost weight (and %)*	*Mean loss (g) (and S.D.)*	*% loss of original body weight*
May and June						
1+	3 (75%)	2.2 (0.35)	15	1 (25%)	1.9	13
2+	63 (65%)	12.1 (12.36)	33	34 (35%)	4.0 (3.23)	11
3+	55 (70.5%)	43.3 (33.16)	54	23 (29.5%)	11.9 (10.53)	15
4+	13 (100%)	67.1 (42.08)	51	0		
July						
1+	1 (16.7%)	0.7	2	5 (83.3%)	1.9 (1.26)	11
2+	22 (55%)	20.1 (21.63)	40	18 (45%)	5.1 (3.51)	10
3+	12 (42.9%)	16.1 (19.07)	20	16 (57.1%)	10.7 (7.29)	13
4+	0			3 (100%)	27.7 (13.27)	9
TOTAL	169 (62.8%)			100 (37.2%)		

from the May-June releases had gained weight (69.8%) than the later releases (45.5%). The yearlings showed least growth, whereas the larger fish showed better growth, both in amount of weight and as a percentage of the original weight.

A number of yearling trout below 10 cm in fork length were captured and these also were released in the estuary. They were considered too small to tag, but after 30 June they were marked by clipping the left ventral and adipose fins. On 30 June seven of these small marked fish were released. Previous to this 65 small trout were measured but were released unmarked into the estuary. In July 43 marked trout under 10 cm F.L. were released. Three unmarked yearlings were captured, but none of the small marked trout was recovered. If the three recoveries were from the released fish, this gives a recovery of 2.6% for these small yearlings of under 10 cm F.L.

A number of older trout were captured which did not bear tags. These included five 2+ trout and seven 3+ trout which had wounds corresponding to lost tags (Table II). Others untagged were 31+ trout weighing 57.0 g, 16 2+ trout weighing a total of 1030.4 g, 19 3+ trout weighing a total of 2787.8 g, and 2 4+ trout, weighing a total of 507.1 g. Three of the latter 3+ fish and one 4+ fish had fin clips used in population estimates between the first and second falls in previous years, indicating that at least some of these fish were from the Matamek system. These 40 untagged fish plus the 122 tagged below the first falls could be considered as a source of the small population of sea trout that would normally occur in the Matamek estuary.

The condition factors of fish caught for release in July (1.05 for 1+, 2+, and 3+, 1.17 for 4+) were higher than those caught earlier (0.97 for 1+; 0.98 for 2+; 1.00 for 3+; 1.02 for 4+; 1.05 for 5+). This was probably due to the longer feeding period in the river. Aquatic insects suitable as food are most abundant in the river and greatest growth is during June (Gibson & Galbraith, 1975).

The majority of the captured fish were examined for flesh colour and stomach contents. All 1+ fish had white flesh, 78.3% of the 2+, 57.4% of the 3+ and 11.8% of the 4+ fish had white flesh. In the 2+, 3+ and 4+ classes the percentages with yellow flesh were consecutively: 3.1, 7.0, 5.9; with pink flesh, 14.9, 28.7, and 58.8; and with orange or deep pink, 3.7, 7.0, and 23.5. Marine amphipods, mysids, or *Ammodytes* occurred in 20 (12.4%) of the 2+ fish. Only four of these had white flesh and all had shown growth. Thirteen (10.1%) of the 3+ fish had marine food in their stomachs. Of these only one had white flesh, and this had lost weight. Ten had gained weight, and two did not have the differences recorded.

All 1+ fish were immature; amongst the 2+ fish 6.7% of the males and 30.1% of the females were mature. With 3+ fish, 28.6% of the males and 61.6% of the females were mature. With the 4+ fish, 70% of the males and 75% of the females were mature.

A 34.7 cm trout caught in the estuary, and therefore not necessarily originating in the Matamek, was tagged and released on 20 June. It was recaptured approximately 9 August in the Moisie River, about 27 km upstream. The estuary of the Moisie River is 12 km to the West of the Matamek River. A 26.5 cm fish caught below the second falls on 12 July and tagged and released in the estuary the same day was recaptured on 11 August in a tributary of the Moisie River about 16 km from the Matamek River estuary. The sizes at recapture were not recorded.

Discussion

The recovery of tagged trout was relatively high (30.5%). This was a minimum survival, as not all planted fish would be caught. One hundred and eighty-four or 58% of these recoveries were by angling. The mean success rate was 5.8 trout/h ($S_{\bar{x}}$ 1.28). In 1975, considerable angling effort in late August produced only 20 specimens (Haedrich 1975).

Good recoveries of brook trout planted into estuaries have been made in Prince Edward Island. Saunders and Smith (1964) planted underyearling brook trout into the estuary of Ellerslie Brook, and these resulted in a survival of 28% to the anglers in the following season, and recovery of 48.6% of the planted weight. Hatchery reared underyearlings and yearlings planted in the estuary contributed 7-27% of the total catch from the Ellerslie system from 1962-1965 (Smith & Saunders, 1968), whereas such trout planted directly into the stream made relatively insignificant contributions to the catches. However, they do not say if the fishes' growth was enhanced.

The yearlings in the present study had a poorer recovery than this (5.3%), but older year classes fared better. Tagging may have increased the mortality of smaller fish. However, 50 finclipped and 65 unmarked trout averaging 8.9 cm in fork length (S.D. = 0.97) were released into the estuary but only three unmarked yearlings were recaptured (2.6%), suggesting that small trout had poor survival. Tomcod *(Microgadus tomcod)* were abundant in the estuary, and mergansers, loons, osprey, terns and gulls were seen. These, including fish such as larger trout, eels *(Anguilla rostrata)* and cod *(Gadus morhua)* could be predators of small trout. Also small trout would be at a competitive disadvantage with the larger trout if trout density were high. At their small size they would probably have difficulty with osmoregulation, and not be able to migrate to sea where density dependent factors would be less severe.

Trout of the 4+ and 5+ age class size had fewer recaptures than the 2+ and 3+ fish. This could be related to age dependent natural mortality but it is possible these fish were less available to recapture, or strayed more than the smaller fish. Only brook trout of weight greater than 150 g can tolerate full strength sea water (Sutterlin *et al.*, 1976), so these larger trout would be most likely to stray than the smaller fish, especially with increased population pressure in the estuary. The two tagged fish that were caught in the Moisie River system were both large (199.7 g and 466.0 g at release). Although sea-run brook trout generally show fidelity to their home river, there is some straying (White, 1940).

The effects of tagging on mortality and growth are unknown, but probably tagging did have adverse effects. The condition factors of the untagged recaptures were slightly better than those of the tagged recaptures. This may have been related to other factors such as the time of release, or origin of the fish from a river with a faster growing strain of trout, but may have been related to the effects of tagging. The mean condition factors of recaptures compared with untagged recaptures (in brackets) was: 1+, 0.92 (0.98); 2+, 0.96 (1.00); 3+, 1.00 (1.06); 4+, 1.08 (0.99). In future studies a proportion should be fin clipped, or marked by a method other than external tagging.

The prevalent theory that anadromous and resident brook trout have no genetic differences in this respect, and that population pressures create anadromous sea trout (Smith & Saunders, 1958), is not substantiated by the results of this study. Only 62.8% of the recoveries had gained weight and possibly only about 15% of the recoveries could be said to be sea trout (Fig. 2). Haedrich (1975) found sea-run brook trout to have a condition factor of 1.1, and to have bright silvery sides and rich pink flesh. In this study most of the fish had lower condition factors than this and the majority had white flesh. However, there was a wide range of growth, and some river trout could be said to have become typical sea trout. A number of trout were found with marine organisms in their stomachs. Others probably had used the marine environment, but it was not possible to say how long trout were in freshwater before capture, and some fish caught in gill nets may have regurgitated their food.

Fewer fish released in July gained weight and relatively more lost weight than fish released in May and June but it is not possible to say whether this was related to the time of release, amounts of available food, or to duration of stay in marine or brackish water.

Probably many trout remained in freshwater, substantiated by one collection. On I July two poachers were apprehended fishing close to the first falls, and they had caught there 21 trout, 18 of which were tagged. These latter had been tagged between 29 May and 18 June, 1978, indicating that many fish promptly attempted to return upriver. These fish were not used in the final analyses.

A greater percentage of the larger fish had coloured flesh than the smaller fish. This may have been a function of the size of the fish or the type of food consumed. Fat soluble carotenoids present in crustaceans are responsible for the colouration of trout in nature (Peterson *et al.*, 1966). In some other salmonids the smaller sizes usually have white flesh whereas a greater proportion of the larger fish have coloured flesh (Nilsson & Anderson, 1967; Gibson & Johnson, 1969).

Possibly a reason for the relatively poor growth in this study is that the brackish water habitat was limited for the number of trout released. Only fish of 150 g, or larger than about 24.7 cm, i.e. 4+ and older, could predominantly use full sea water. Smaller fish would have to be limited to short forays

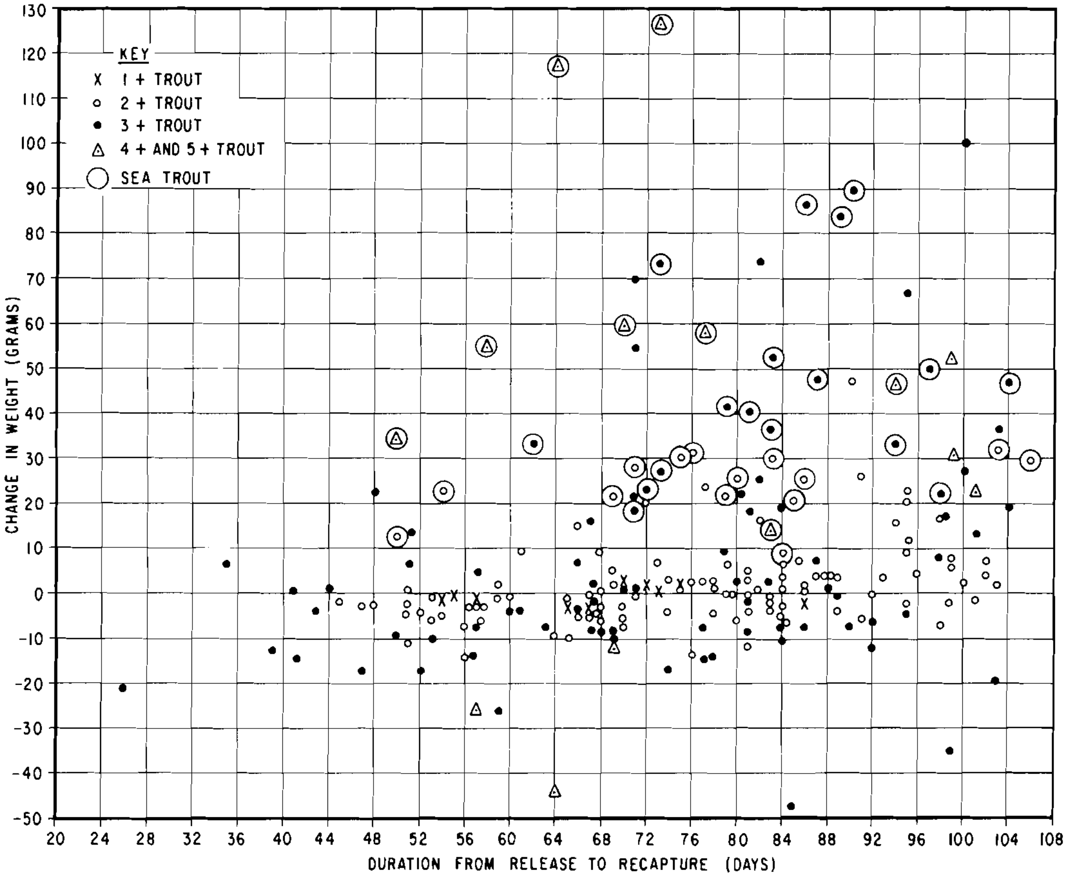

Figure 2. Change in weight of trout released into the estuary from between the first and second falls. Fish were considered to be sea trout if K was 1.0 or greater and the flesh was coloured. Some still retained the silvery sides typical of sea trout colouration, and a few had marine organisms in their stomachs.

into the sea, or remain in the restricted brackish water environment, or remain entirely in freshwater.

Another possibility for the apparent lack of accelerated growth is that the fish may have been released at an inappropriate time. The normal migration time is unknown in rivers in this area although in previous years sea trout have been caught during seining operations for smolt in June. It appears to be quite variable in Maritime rivers. White (1941) reported that sea trout in the Moser River, Nova Scotia, descended to the sea in April and May, returning in July, having remained in the sea for an average of two months. In Ellerslie Brook, Prince Edward Island, Smith and Saunders (1958), found that major movements into freshwater were in April, June-July, and November, and out in May and October to early January. Movements in spring and early summer were into preferred temperature. In the Northwest Miramichin in New Brunswick sea-run brook trout ascend the river in May and June (Saunders, 1975).

Probably late June and July would be more suitable months to harvest the fish rather than in late summer when catabolism and gonadal growth would cause a decrease in somatic tissues. June, and possibly earlier, appears to be an important feeding time in this area.

An interesting observation was that the proportion of fish with mature gonads was less than found in the river. For example in the 1+, 2+ and 3+ year classes only 0%, 6.7%, and 28.6% of the males were mature. Below the second falls for the same year classes the percentages would be 50%, 29%, and 73% (Gibson *et al.*, 1976). This might be attributed to the low condition factor of many of the fish, but Haedrich (1975) noted that none of the sea-run brook trout he examined appeared mature, despite their large size. A similar observation was made by Sutterlin *et al.* (1976) who found a 2-month delay in spawning time of brook trout reared in salt water compared to wild or hatchery reared fish, but these fish were destined to mature that season. They were unable to say whether this was attributable to the sea water or to the different temperature regime.

As the brook trout is indigenous to the East Coast of North America, sea ranching of this species may have more success there than with an exotic species. Managing an indigenous species rather than an exotic avoids the dangers of possible negative interactions with native species and of introducing diseases, and presumably the native species is already well adapted to the local environment. The anadromous brook trout does not range widely (Smith & Saunders, 1958) so would not be exploited by foreign fisheries. However, Sutterlin (pers. comm.) has pointed out some disadvantages of ranching species of the genus *Salvelinus* relative to other species. A relatively large smolt size entails high food costs and limits efficient space utilization in hatcheries. A limited time at sea means that there are small growth increments. In foraging, the *Salvelinus* species cannot make effective use of warmer offshore temperatures and marine pelagic food organisms during the winter to promote and continue high growth rate. Also production of eggs reduces tolerance to full sea water at maturity, and results in softer flesh quality upon return in the fall.

Conclusions

We would recommend releasing trout into an estuary to improve angling. Where wild trout are abundant, as in the Matamek River, it is feasible to transport wild fish. Better success could be expected with larger fish, of the 4+ and 5+ size that are found in the Matamek. There are many rivers along th North Shore of the Gulf of St. Lawrence where a natural obstruction or a dam prevents a normal run of sea trout. Hydroelectric dams are planned for other rivers in this area. Planting trout in the estuary in such a situation would improve the angling, or mitigate the loss of angling.

Selectively breeding brook trout for fast growth, ultimate large size, and the anadromous trait, may hold promise. Such work with west coast salmonids has been most successful (Hines, 1976). These fish could be released into the estuary as trout "smolt", and harvested the same year. Wilder (1952) presented evidence that sea and freshwater trout of the Moser River, Nova Scotia, constituted one taxonomic unit. and Smith and Saunders (1958) thought there was inconclusive evidence of a heritable propensity to migrate to the sea. Preliminary results from the West River in Antigonish, Nova Scotia, suggest that sea-run and river dwelling brook trout may be genetically distinct (R. Alexander, pers. comm.). However, research on the comparative behaviour of the progeny of sea and freshwater trout would shed more light on this problem. Other native salmonids might similarily be exploited. Relict arctic char *(Salvelinus alpinus)* occur in Matamek Lake and in other lakes along the North Shore of the Gulf of St. Lawrence. These char are no longer anadromous as the river is too precipitous for the species, and summer water temperatures in the river too warm. However, the sea water remains cold, and it is possible the species could exploit the local marine environment and return to its home river when water temperatures in the river were suitable. Both brook trout and arctic char are relatively fast growing in fresh-water and probably a good return could be expected by releasing these fish as large yearlings.

Further work should also be done on the optimum time of release, and of recapture, the optimum density of fish that should be stocked for the available area of brackish water, the optimum size of fish that should be released, and use of the marine environment related to salinity tolerance and to temperature effects on migratory behaviour. Also, size of preferred prey should be studied. If large trout will prey on salmon smolt, caution should be taken that such large trout are not increased in salmon rivers at the time of the salmon smolt run.

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