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Survival, Growth, and Production of Domestic and Assinica Strain Brook Trout in Four Michigan Lakes

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SURVIVAL, GROWTH, AND PRODUCTION OF DOMESTIC AND ASSINICA STRAIN BROOK TROUT IN FOUR MICHIGAN LAKES[1]

By Howard Gowing

Abstract

In fall 1973, matched plantings of domestic and Assinica strain brook trout fingerlings of the 1973 year class were stocked in three small oligotrophic lakes and one shallow flowage. Stocking rate was 125 fish per hectare for each strain or 250 fish per hectare for each lake. Populations of trout were monitored annually in fall for 4 years after stocking.

Nearly 98% of the Assinica trout were lost in the flowage during their first year after stocking from unknown causes. In a meromictic lake all trout died in the third winter as the result of a winterkill. For the remaining two lakes, domestic trout survived through age IV in both and a few are expected to survive an additional year whereas Assinica trout survived through age IV in one lake.

Growth rate of Assinica trout was superior to that of domestic trout in all lakes. From composite growth curves, Assinica trout attained 19% greater length than domestic trout in each of the 4 years after stocking. Growth in length was most rapid during the first year after stocking at age I, particularly in two lakes containing no minnows, and peaked in the third year at age III. Growth rate was sustained best in the lake containing minnows; maximum size fish was achieved in this lake, 437 mm for domestic trout and 472 mm for Assinica trout, both age III.

More than one-half of the domestic trout were sexually mature at age I; most had reached maturity at age II to age IV. For Assinica trout, only a few precocious males were mature at age II and about 62% of the females were mature at age III.

In the two lakes where trout survived best, 4-year production of Assinica trout in one lake (46.89 kg/ha) exceeded that for domestic trout (39.03 kg/ha) while domestic trout production (48.28 kg/ha) was greater than Assinica trout production (45.52 kg/ha) in the other lake.

The superior growth of Assinica trout over domestic trout provides an opportunity for improving the stocks of brook trout in the Michigan hatchery system and ultimately the catch of more desirable size trout by anglers.

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[1] Contribution from Dingell-Johnson Project F-35-R, Michigan.

Introduction

Brook trout show considerable variability in such aspects of their life history as age at maturity, and growth. In the central part of their range, they have evolved into an early maturing strain, generally reaching maturity after two growing seasons. In the more northerly portion of its range some brook trout strains most commonly mature at age III while other strains mature at age IV, approaching lake trout in this trait (Power 1975). In these late maturing populations, spawning may occur on alternate years. In river-lake systems of their northern range other strains of brook trout have evolved which, by a combination of longevity and good growth, have attained large size. In certain areas of its range some strains of brook trout spend a portion of their lives in brackish water, others migrate to salt water and otherwise exhibit anadromous characteristics.

Generally our fish cultural activities have been geared to the production of an early maturing brook trout that is particularly suited to hatchery production. In recent years efforts have been initiated to improve hatchery trout stocks, its impetus originating in northeastern United States. Flick and Webster (1976) have shown that Assinica strain brook trout obtained in Quebec, Canada, from the Broadback River-Assinica Lake watershed tributary to Hudson Bay, grew faster than New York domestic strain brook trout when stocked in Adirondack lakes and ponds.

The objective of this study is to compare survival and growth of Assinica strain brook trout with a domestic strain brook trout in Michigan lakes.

Study sites

West Lost, South Twin, and Hemlock are small, oligotrophic, landlocked lakes while Fuller Pond is a shallow flowage with an earthen dike on the site of an old beaver dam. West Lost and South Twin are typical limestone sink lakes. South Twin, West Lost, and Hemlock lakes stratify thermally but the latter is judged to be meromictic. Except for South Twin,

all are hard water environments, with average total alkalinity exceeding 130 ppm. In South Twin it averages 65 ppm. Temperature and oxygen regimes of these waters were judged suitable for salmonids. Barrett (1952), Tanner (1960), Alexander (1975), and Momot and Gowing (1977) provide additional limnological information. All the lakes were designated experimental waters closed to fishing.

Environmental conditions and fish populations in these lakes varied noticeably prior to stocking on November 5-6, 1973. On October 18, 1973, 18 days prior to stocking, Fuller Pond was treated with rotenone to remove white suckers (Catostomus commersoni) and other competing species. A complete kill was not obtained as northern redbelly dace (Phoxinus eos), brook stickleback (Culaea inconstans), fathead minnow (Pimephales promelas), and central mudminnow (Umbra limi) were observed after treatment. A remnant stock of rainbow trout (Salmo gairdneri) was removed from Hemlock Lake by netting about 1 year previous to this study. Hemlock contained a modest minnow population, consisting of bluntnose minnows (Pimephales notatus) and northern redbelly dace. For about 3 years prior to present study, West Lost Lake contained only a few naturally produced brook trout. During this period large adult crayfish, Orconectes virilis, were cropped from this lake as part of another study. Like West Lost, South Twin is without a minnow population; and for nearly 5 years prior to November 1973, it held no trout.

Methods

On November 5-6, 1973, matched plantings of Assinica strain brook trout obtained from New York and domestic strain brook trout from the Minnesota hatchery system were stocked in Fuller Pond, Hemlock, South Twin, and West Lost lakes. The stocking rate was 125 fingerling per hectare for each strain or 250 fish per hectare for each lake. The mean length of fish stocked was 86 to 89 mm (total length) and the mean weight was 7.5 to 8.2 g (Table 1). The Assinica and domestic trout were marked by excision of the left pelvic and adipose fins, respectively.

Trout were sampled annually in the fall by angling and/or electrofishing and again in winter by ice fishing for Petersen-type

mark-and-recapture population estimates. This sampling provided the means for assessing rates of growth and survival as well as measurements of standing crop and production, as outlined by Ricker (1975).

Results

Survival

Assinica trout did not survive as well as domestic trout in any of these environments, and least of all in Fuller Pond (Figs. 1 and 2). In the deeper lake basins annual survival rates (s) for domestic trout ranged from 0.641 to 0.958 during the first 3 years after stocking compared to survival rates of 0.397 to 0.823 for Assinica trout.

In Hemlock Lake domestic and Assinica trout were marked in the fall of 1976 for a population estimate. Before iceout in late March 1977, all of the brook trout in the lake had expired. An earlier study in Hemlock in 1965 showed oxygen levels as low as 2.6 ppm at 0.9 m and 1.9 ppm at 1.8 m under the ice in early winter. Fast (1973) observed this phenomenon in 1969-1970. We suspect a plankton bloom, which was observed in late March 1977, reduced the oxygen to a critical level and resulted in a complete winterkill of trout. As a consequence, no estimate of the trout population could be calculated for November 1976, and the survival rate was extrapolated.

The best measure of longevity rested on the evidence from South Twin and West Lost lakes. About 20% of the domestic trout in South Twin and 44% in West Lost survived 4 years in their respective lakes whereas none of the Assinica trout survived their fourth year in South Twin and only 8% did so in West Lost. For these lakes a few domestic trout may reach age VI and for Assinica trout, age V.

Of the four basins, survival of both strains of brook trout was lowest in the shallow water environment of Fuller Pond. A marked differential survival of domestic and Assinica trout occurred here. For domestic trout the survival rate (s) was 0.373 the first year of pond life and 0.447 the second year. On the other hand, most of the Assinica trout died during their first year in the pond, the survival rate was only 0.023. No evidence was available to explain the loss. Subsequently in 1976 the pond was drawn down.

The first-year survival of domestic trout in Hemlock in the presence of a minnow population did not differ from the survival rates in West Lost and South Twin lakes where no minnows were present. In the case of Assinica trout, survival in Hemlock was slightly inferior to domestic trout and to those in West Lost and South Twin lakes.

Female domestic and Assinica trout survived better than their male counterpart in the experimental waters. This assumed a male-to-female ratio of 1:1 at stocking. Based on this ratio in samples of domestic trout collected annually in the fall from 1975 to 1977, females dominated in all lakes and years with only one exception. The male-to-female ratios for the combined waters were as follows: 1:2.3 (age II, 1975), 1:1.5 (age III, 1976), and 1:2.6 (age IV, 1977). An even greater differential survival occurred among the Assinica trout. As only a few precocious males could be readily sexed in fall 1975, sex ratios observed in fall 1976 and 1977 were used. Again females dominated the samples from all lakes and years. The male-to-female ratio from pooled data in 1976 was 1:4.9 for age III trout and in 1977 it was 1:5.0 for age IV trout.

Maturity

Domestic trout matured earlier than Assinica trout, most commonly by 2 years. Based on 1974 fall observations in Fuller Pond, roughly 60% of the domestic trout matured at age I. In autumn 1975, most of the domestic trout at age II were mature. However, most of the Assinica trout at age II were immature, with the exception of a few precocious males. In fall 1976, nearly all of the domestic trout (age III) were again mature while only 62% of the Assinica females reached maturity for the first time. A sample of domestic trout in South Twin and West Lost in early November 1977, showed 88% of the males and 86% of the females mature. The sample of 12 Assinica trout consisted of two mature males, four mature, and six immature females.

Growth

Growth in length of Assinica trout in each of these lakes exceeded that of domestic trout. For comparative purposes growth data for all

waters were pooled for each brook trout strain (Fig. 3). For both strains of trout the greatest annual increment in length occurred during the first year and diminished progressively in the following 2 years before reaching a plateau in the fourth year. At the end of the first year after stocking Assinica trout exceeded in length the domestic trout by about 19% and this degree of disparity remained for the balance of the study. The maximum average length of Assinica trout was 406 mm, achieved after 3 years in these waters. Similarly, for domestic trout it was 347 mm, also attained in the fall of 1976.

The annual growth in length of males was greater than females in the experimental waters. The mean length of domestic males in the fall of 1975, 1976, and 1977 exceeded that of females by 5-6%. The best available sample of Assinica trout for this assessment was obtained in fall 1976. Here in a sample of 100 fish, males averaged 427 mm and females 401 mm. In a comparatively small sample of trout (12) in fall 1977, male and female averaged 432 and 399 mm, respectively.

The experimental lakes differed in their capacity to provide growth for trout. Also, no differential response in growth related to strain of trout was observed (Fig. 4). The rate of growth in length of both strains was most rapid in South Twin and West Lost the first year after stocking but then diminished progressively in the succeeding 2 years after which it leveled off. In Hemlock Lake, where comparable data were available, annual growth rate was at variance with this. While the rate of growth of both strains of trout in Hemlock Lake was slower the first year after stocking than in South Twin and West Lost lakes, it remained nearly unchanged in the second year, and diminished only slightly during the third year. Therefore, by the fall of the third year after stocking domestic and Assinica trout in Hemlock Lake had attained a greater average length than those in South Twin and West Lost lakes.

In a similar way, the pattern of growth in weight of trout in Hemlock Lake differed from that in South Twin and West Lost lakes. In the latter lakes the largest increment in weight of trout occurred the first year after stocking, diminished moderately the second year, and fell sharply in the third year

whereas in Hemlock Lake the smallest gain in weight occurred during the first year in the lake, the largest during the second year, followed by a moderate increment in weight in the third year.

Production

Collectively, domestic trout in these waters showed a small margin in production over Assinica trout. However, no consistent superiority in production was achieved by one strain of brook trout over the other in all years or in all lakes (Tables 2 and 3). Altogether, the 2-year production of domestic trout in Fuller Pond and Hemlock Lake along with the 4-year production in each of South Twin and West Lost lakes amounted to 128.36 kg/ha. Comparable Assinica trout production was 117.87 kg/ha, about 8% less than for domestic trout.

In Fuller Pond the 2-year production of domestic trout was 13.71 kg/ha, a marked contrast to 2.57 kg/ha for Assinica trout which incurred a catastrophic mortality during their first year in the pond. Two-year production was lowest in this group even when only domestic trout were considered. Similarly, 2-year production of domestic trout in Hemlock Lake amounted to 27.34 kg/ha, 20% larger than for Assinica trout which accrued 22.89 kg/ha. For comparative purposes, the 2-year production of domestic trout in South Twin was 37.48 kg/ha, about 17% less than for the 45.14 kg/ha for Assinica trout. For West Lost Lake, the 2-year production of domestic and Assinica trout was 39.82 and 43.22 kg/ha, respectively, an 8% difference. When the 4-year trout production of South Twin and West Lost was considered, Assinica trout production (46.89 kg/ha) exceeded domestic trout production (39.03 kg/ha) by about 20% whereas in West Lost Lake there was a 6% margin of domestic trout production (48.28 kg/ha) over Assinica trout production (45.52 kg/ha).

In these lakes most of the production was achieved during the 2 years following stocking, and it accrued in two patterns. For both strains of trout in Hemlock and domestic trout in Fuller Pond, the largest production was obtained during the second year after stocking. On the other hand, for both strains of trout in South Twin and West Lost, the largest annual production

accrued during the first year after stocking. Assinica trout in South Twin showed the largest production in a single year, 28.50 kg/ha, followed by Assinica trout in West Lost Lake at 25.86 kg/ha.

Discussion

This study intended to compare the performance of Michigan domestic brook trout and the Assinica strain brook trout. However, at about the time this study was scheduled to begin, difficulties were being encountered in rearing brook trout in Michigan and in meeting stocking needs. This led to the acquisition of brook trout from the Minnesota hatchery system. The selection of the Minnesota domestic brook trout for this study was fortuitous. Judging from earlier studies of Michigan domestic brook trout in three of these experimental lakes (Gowing 1974; Gowing and Momot 1978), the Minnesota domestic trout was superior in survival and growth, which would tend to minimize the differences between the two strains of trout reported here. The continued use of the term Michigan domestic, actually means Minnesota domestic trout.

Domestic trout survived unusually well in West Lost and South Twin lakes during the first 3 years after stocking, significantly better than Assinica trout. The accelerated mortality rate of trout in the fourth year, particularly among Assinica trout, was probably caused, in part, by the additional handling of fish during spawn-taking operations at the lakes to produce fertilized Assinica eggs and create hybrid eggs.

The impact of minnows, if any, on survival of trout should be evident during the first year after stocking. In Hemlock Lake, which contained minnows, the survival rate was not unlike that in West Lost and South Twin which contained no minnows.

No records of past stocking of salmonids in Fuller Pond would suggest the occurrence of a mortality as severe as shown by Assinica trout. A large share of the mortality for Assinica trout was probably caused by predators; this habitat is well suited to avian and mammalian predators. Since 37% of the domestic trout survived the first year in the pond, this suggested that perhaps some behavioral difference between the two strains of trout existed.

Hemlock Lake trout did not provide an assessment of the potential longevity, growth, and production as the populations were prematurely aborted, but they did show the survival rate of the Assinica strain was inferior to the domestic strain in the first 2 years following stocking. In the past low oxygen levels have developed in Hemlock Lake in early winter, however, a winterkill has never been reported. Nevertheless, in the winter of 1976-1977, a winterkill occurred which exterminated the trout but not the minnows.

The productiveness of these lakes differed and was reflected, in part, by the growth and production of trout. The fastest rate of growth in both length and weight occurred in South Twin and West Lost lakes during the first year after stocking, particularly the former. This rapid rate of growth in South Twin was probably related to the absence of fish in the lake for several years prior to stocking. The food resources of the lake were undoubtedly optimal. The poorest growth rate occurred in Fuller Pond and may be linked to the rotenone treatment of the pond immediately prior to stocking which decimated the invertebrates and severely reduced the minnow population.

The rate of growth in length of both strains of trout in Hemlock and Fuller Pond remained nearly undiminished during the second year and exceeded the rate of growth in South Twin and West Lost lakes. This suggests that trout in Hemlock and Fuller Pond had reached a size that enabled them to utilize the minnow resources and, in Hemlock to maintain their growth rate through the third year in the lake and thereby attain the largest fish in the four experimental lakes.

Decimation of the Assinica trout in Fuller Pond and the premature termination of the trout populations in Hemlock Lake made comparison of the production of the two strains of trout more tenuous. In South Twin and West Lost lakes, where trout populations more or less ran their course, Assinica trout production in one case (South Twin) exceeded domestic production by 25% and in the other (West Lost) domestic trout production exceeded Assinica trout production by 6%.

In review of a study of New York domestic and Assinica strain brook trout in an 87-ha Adirondack pond by Flick and Webster (1976), some

similarities and differences were evident. The major finding of both studies was that Assinica trout showed a faster rate of growth than domestic trout. After this point, however, differences in the results of the two studies became more frequent as additional comparisons between strains were made. Michigan domestic trout showed better survival and growth than New York domestic trout. Few New York domestic trout lived beyond age II whereas Michigan domestic trout survived relatively well to age III and age IV in at least two lakes; a few survived to age V. New York Assinica trout survived more poorly than Assinica trout in three of the four Michigan lakes. A few Assinica trout in New York and Michigan survived to age V, thus survivorship among New York Assinica trout was inferior to both Michigan Assinica and domestic trout.

Assinica trout stocked at a size of 86-89 mm in Michigan, grew more rapidly at age I and age II than New York Assinica trout planted at 84 mm. However, by age III the New York Assinica trout had exceeded in length age III Michigan Assinica trout in three of the four lakes. At age IV, the New York Assinica trout were larger than all comparable aged Assinica trout in three Michigan lakes. The New York pond contained a forage fish which influenced their growth according to Flick and Webster (1976).

Domestic trout in all Michigan waters showed a faster rate of growth than the New York domestic trout and, in addition, they attained a larger size in the fall at age I than the New York Assinica trout.

From the foregoing, it seems apparent that Assinica trout is an inherently faster growing strain than our present domestic trout. Also, there is considerable variability in growth and survival of various stocks of domestic trout related to genetic and/or environmental factors which in turn influence production.

As Assinica trout appear to be more vulnerable to angling than domestic trout as shown by the experimental fishing, the possible consequences of poaching on survival rates are not known. This aspect of the study could not be assessed.

The superiority in growth of Assinica trout was evident, but the potential maximum growth was not provided in the environments tested.

Nevertheless, both studies showed different inherent capacities of the various waters to produce trout flesh. There is room for improvement in the present use of hatchery brook trout. Perhaps the first step should be the identification and proper use of the best available strains of domestic trout. From here, improvement of domestic stock could be obtained by breeding with appropriate strains of wild brook trout.

Acknowledgments

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Table 1.--Domestic and Assinica strain brook trout ranging between 51 and 124 mm total length, stocked in four lakes, each strain at the rate of 125 fish per hectare, in fall 1973.

Site, and strain	Area (ha)	Number of trout stocked	Mean total length (mm)	Standard error of mean
Fuller Pond	6.1			
Domestic		762	89	0.42
Assinica		762	86	0.39
Hemlock Lake	2.4			
Domestic		300	89	0.51
Assinica		300	86	0.54
South Twin Lake	1.6			
Domestic		198	86	1.62
Assinica		198	86	0.72
West Lost Lake	1.4			
Domestic		175	89	0.67
Assinica		175	89	0.68

Table 2.--Annual production of domestic and Assinica strain brook trout in West Lost and South Twin lakes from fall 1973, when stocked at age 0, until fall 1977, at age IV.

Lake, strain, and year	Age	Number per hectare	Standing crop (kg) per hectare	Production (kg) per hectare
West Lost				
Domestic				
1973	0	125.0	1.02	
1974	I	101.4	21.60	21.99
1975	II	97.1	38.18	17.83
1976	III	79.3	24.82	7.06
1977	IV	56.4	18.85	1.40
			Total	48.28
Assinica				
1973	0	125.0	1.02	
1974	I	102.8	25.41	25.86
1975	II	50.0	24.70	17.36
1976	III	33.6	15.31	1.56
1977	IV	10.0	4.94	0.74
			Total	45.52
South Twin				
Domestic				
1973	0	123.8	0.93	
1974	I	88.1	22.03	23.36
1975	II	82.5	34.32	14.12
1976	III	76.2	30.73	1.04
1977	IV	25.0	10.35	0.51
			Total	39.03
Assinica				
1973	0	123.8	0.93	
1974	I	95.0	27.36	28.50
1975	II	66.9	33.37	16.64
1976	III	38.8	20.65	1.75
1977	IV	0.0	0.00	0.00
			Total	46.89

Table 3.--Annual production of domestic and Assinica strain brook trout in Hemlock Lake and Fuller Pond from fall 1973, when stocked at age 0, until fall 1977, at age IV.

Lake, strain, and year	Age	Number per hectare	Standing crop (kg) per hectare	Production (kg) per hectare
Hemlock Lake				
Domestic				
1973	0	125.0	1.02	
1974	I	103.3	10.75	10.51
1975	II	66.2	20.80	16.83
			Total	27.34
Assinica				
1973	0	125.0	0.94	
1974	I	76.7	8.59	9.34
1975	II	30.4	12.50	13.55
			Total	22.89
Fuller Pond				
Domestic				
1973	0	124.9	1.02	
1974	I	46.6	5.31	6.85
1975	II	20.8	7.18	6.86
			Total	13.71
Assinica				
1973	0	124.9	0.94	
1974	I	3.0	0.40	1.82
1975	II	2.1	0.94	0.75
			Total	2.57

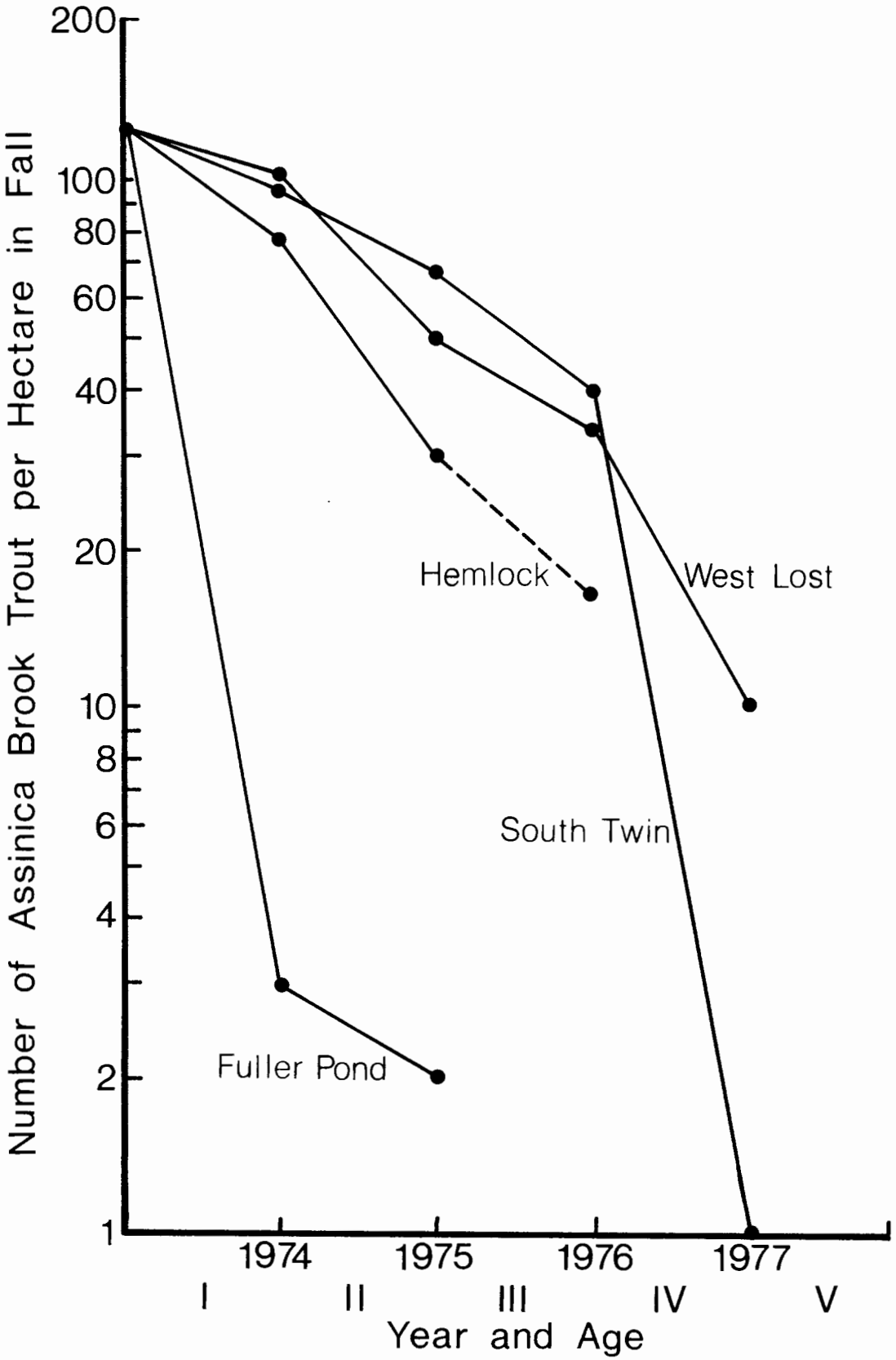

Figure 1.--Survivorship curves for Assinica brook trout in Fuller Pond, Hemlock, South Twin, and West Lost lakes from age 0, fall 1973 to age IV, fall 1977. Fall 1976 estimate for Hemlock Lake was extrapolated.

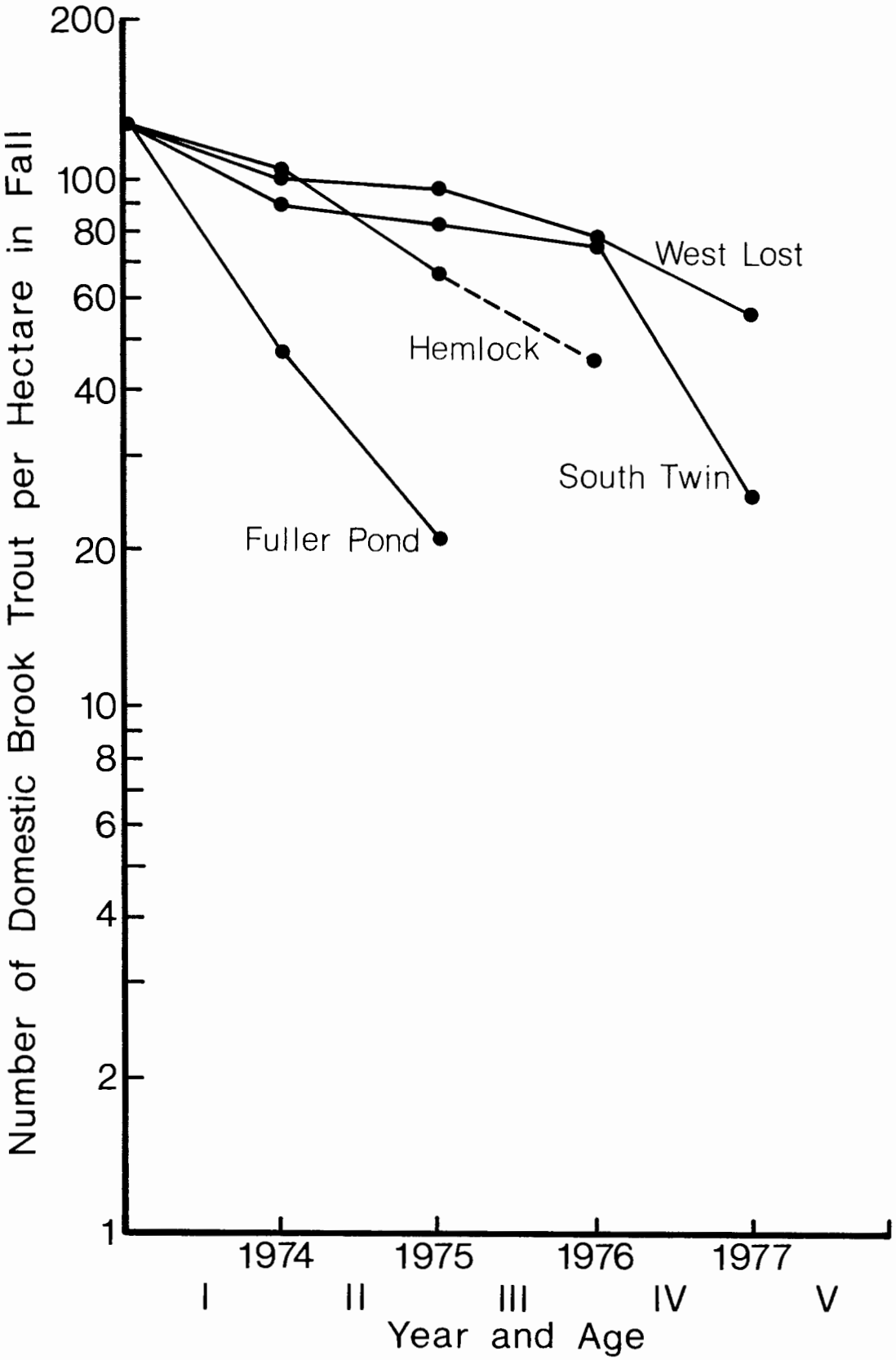

Figure 2.--Survivorship curves for domestic brook trout in Fuller Pond, Hemlock, South Twin, and West Lost lakes from age 0, fall 1973 to age IV, fall 1977. Fall 1976 estimate for Hemlock Lake was extrapolated.

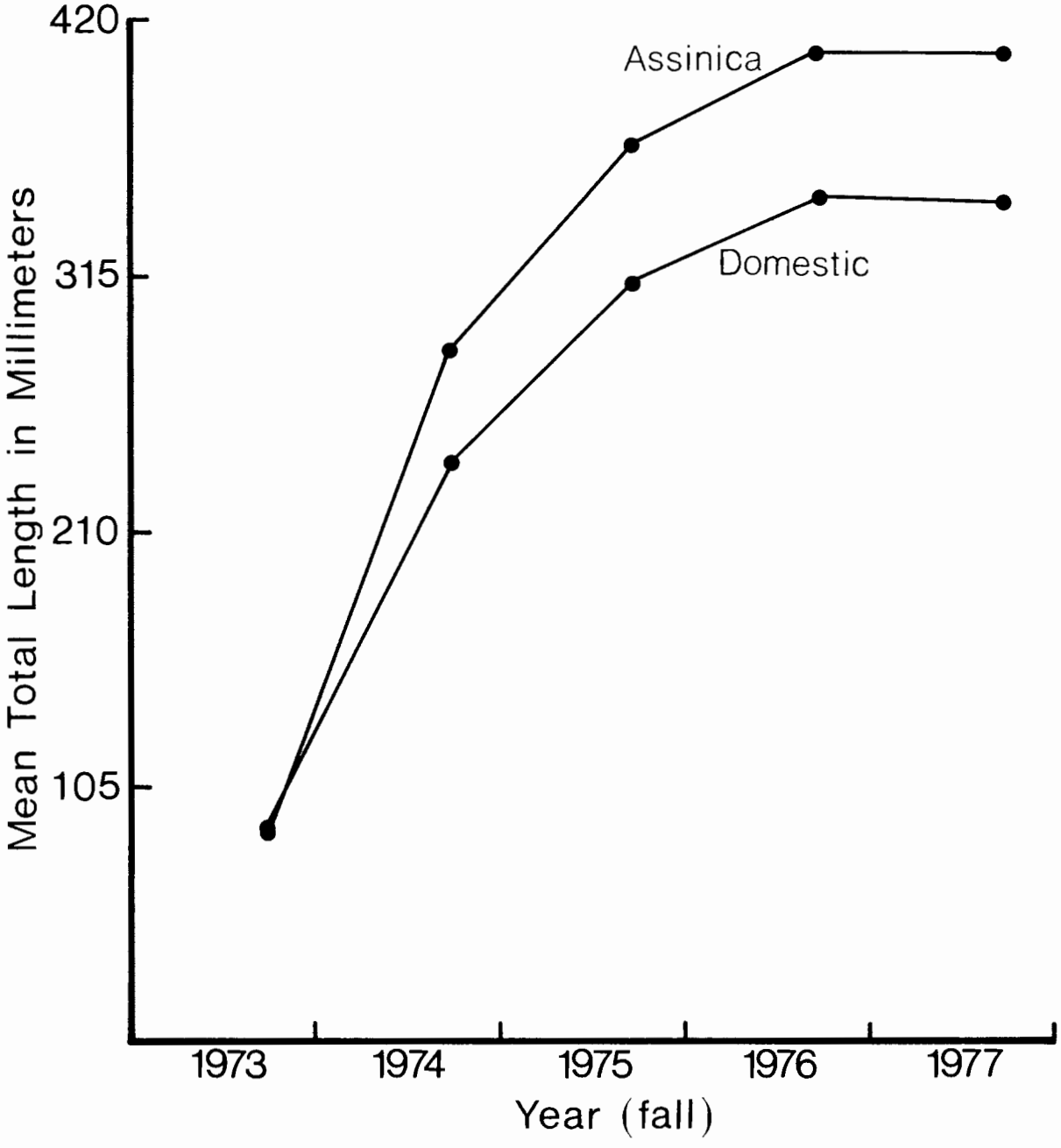

Figure 3.--Average growth (mm) of domestic and Assinica strain brook trout based on the combined data for Fuller Pond, Hemlock, South Twin, and West Lost lakes from fall 1973 to fall 1977.

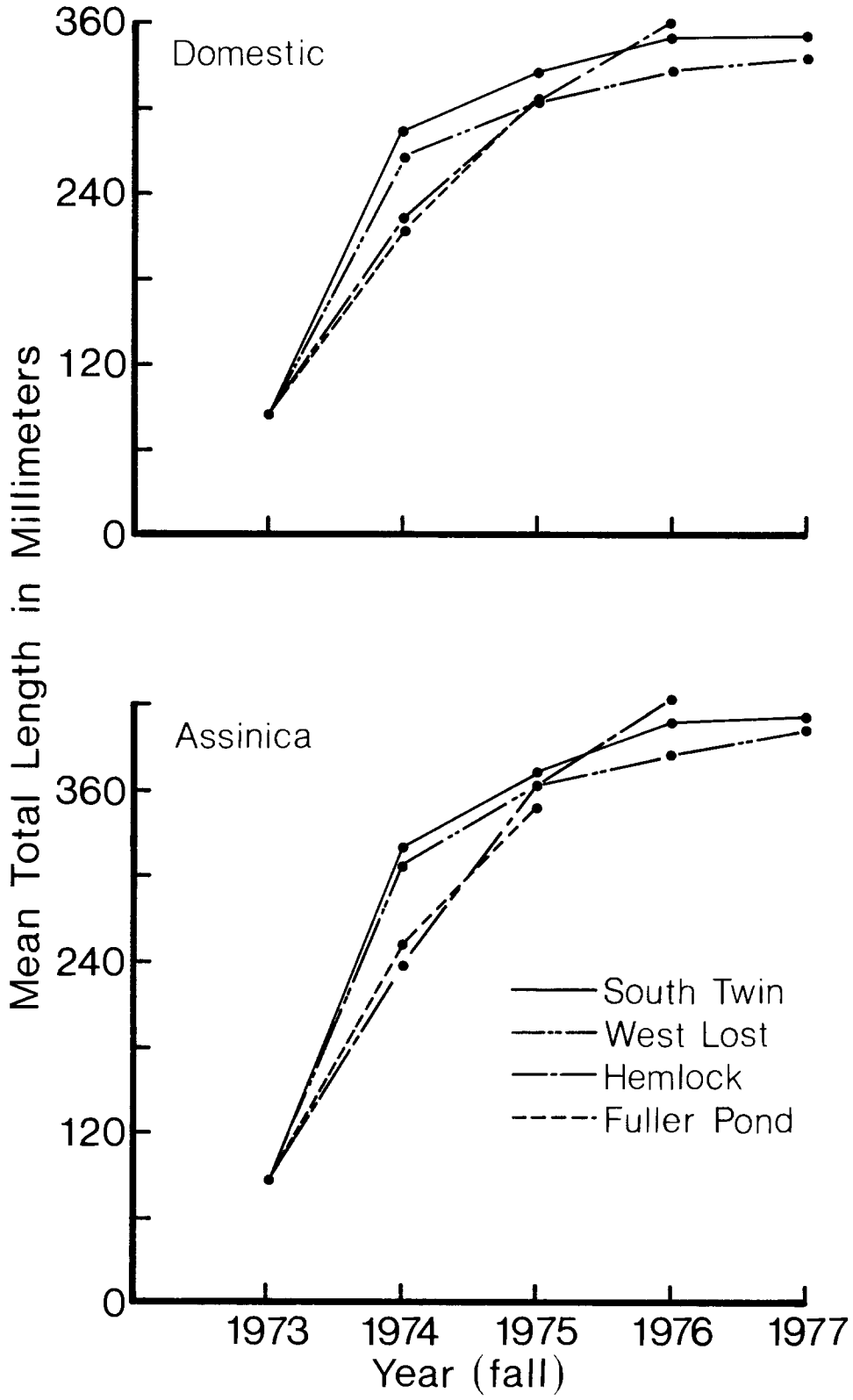

Figure 4.--Growth of domestic and Assinica strain brook trout stocked in Fuller Pond, Hemlock, South Twin, and West Lost lakes in fall 1973 at age 0.

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