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Survival and Growth of Matched Plantings of Assinica Strain Brook Trout and Hybrid Brook Trout (Assinica Male x Domestic Female) in Six Michigan Lakes

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SURVIVAL AND GROWTH OF MATCHED PLANTINGS OF ASSINICA STRAIN BROOK TROUT AND HYBRID BROOK TROUT (ASSINICA MALE X DOMESTIC FEMALE) IN SIX MICHIGAN LAKES[1]

Howard Gowing

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

Abstract

In fall 1977, matched numbers of Assinica and hybrid brook trout (Assinica male X domestic female) were planted in five lakes and a flowage each at the rate of 125 fingerlings per hectare. At the outset Assinica trout had an average length of 96 mm and a standing crop of 1.27 kg/ha compared to 86 mm and 0.94 kg/ha for hybrid trout. These populations were monitored 5 years (1977-1982) during which time some were prematurely terminated or reduced by natural (winterkill) or unnatural (poaching) causes. There were no significant differences in average annual survival rates of Assinica and hybrid trout in these waters. Maximum longevity of the two strains was judged to be age VII.

Growth and production were influenced by the inherent productivity of the receiving water and the status of the biota at the time of planting. Average annual growth in length of the two strains was similar. Rapid growth generally occurred in the first year following stocking and thereafter diminished. The margin in length and standing crop of Assinica over hybrid trout at the outset was maintained over the 5 years.

Production of Assinica and hybrid trout were comparable. Generally both strains achieved maximum production in the first year after which it decreased. For the most productive water annual production of Assinica and hybrid trout varied from 22.83 and 19.72 kg/ha, respectively, in the first year to 7.72 and 7.95 kg/ha in the fifth year. Similarly, for the least productive water annual production of Assinica and hybrid trout ranged between 11.27 and 8.07 kg/ha, respectively, in the first year and 1.75 and 0.72 kg/ha in the fifth year.

There was no evidence to support heterosis in survival and growth. However, both Assinica and interstrain hybrid brook trout were attractive alternatives to most present brood stocks of brook trout.

Introduction

In recent years hatchery brook trout (*Salvelinus fontinalis*) have played a comparatively minor role in the management of salmonids in Michigan. Characteristically they have relatively poor growth, low survival, early maturation, and are short lived compared to other salmonids. Brook trout that have evolved in the hatchery are primarily the product of selection for growth and early maturation which has not necessarily prepared them for their existence in the natural environment (Vincent 1960). A renewed interest has emerged to improve the performance of brook trout for management by identifying or developing better strains. To this end, evaluations of the performance of certain wild, domestic, and hybrid strains of brook trout have been made (Flick and Webster 1976; Webster and Flick 1981; Fraser 1981; Ihssen, Powell, and Miller 1982).

Brook trout from the northern part of their range in Canada generally mature later, live longer, and attain a larger size than brook trout in the United States apparently through different life history strategies (Power 1975). One such strain, Assinica brook trout of Quebec, Canada, and resident in the eastern drainages of James Bay, has shown superior growth over New York domestic brook trout when stocked in Adirondack lakes of New York State (Flick and Webster 1976). Also, a recent study in Michigan has demonstrated the growth advantage of Assinica trout over domestic brook trout (Gowing 1978). To pursue this matter further, F_1 hybrids (male X female domestic brook trout) and Assinica brook trout were planted in several natural lakes and a pond in Michigan to test their relative survival and growth.

Study Sites

Fuller Pond, located at the Hunt Creek Fisheries Research Station, Montmorency County, Michigan is a shallow flowage of 6.1 ha created by an earthen dike on the site of an old beaver dam. Ford, Hemlock, North Twin, South Twin, and West Lost lakes are small, thermally stratified, oligotrophic, landlocked lakes, classified as limestone sinks. These lakes, located in Otsego and Cheboygan counties, are commonly referred to as the Pigeon lakes. Ford Lake is the shallowest of the Pigeon lakes with the most extensive littoral area. Hemlock in recent years is judged to be meromictic. These waters are moderately hard water (65 to 149 mg/l) except North Twin Lake which has an alkalinity of only 29 mg/l (Table 1). All waters have a pH in excess of 7.0. Adequate temperature and oxygen conditions exist for salmonids in all lakes except Hemlock. In the case of Hemlock Lake there has not been a complete fall turnover in recent years and consequently oxygen levels going into the winter have been low resulting in a winterkill of all trout and some minnows in certain years. For additional limnological data see Barrett (1952), Tanner (1960), and Momot and Gowing (1977). These experimental waters are closed to fishing. In fall 1977, prior to the start of this study, the six experimental waters had different fish populations and environmental conditions which were potential influences on planted trout. For example, Fuller Pond and its tributaries were poisoned with rotenone in May 1977. However, the treatment did not kill all of the redbelly dace (*Phoxinus eos*), brook stickleback (*Culaea inconstans*), fathead minnow (*Pimephales promelas*), and central mudminnow (*Umbra limi*). Likewise, Ford Lake was treated with rotenone in June 1977, which killed all trout but a few mudminnows survived. Hemlock Lake contained no trout prior to the start of this study due to a winterkill in March 1977. Nevertheless, some bluntnose minnows

(*Pimephales notatus*) and northern redbelly dace survived oxygen levels that were lethal to brook trout. North Twin Lake contained a few adult rainbow trout (*Salmo gairdneri*) that survived from a planting made in September 1973. None of these fish were seen or captured after the winter of 1978-79. There are no minnows in North Twin Lake. South Twin had an estimated 40 adult domestic brook trout, survivors from a planting in 1973, when the study began but all were gone by fall 1978. No minnows are present in this lake.

At the outset of this study, West Lost Lake contained about 14 Assinica trout and 79 domestic brook trout from a planting in 1973. None of the Assinica trout were recovered after fall 1977 and no domestics after spring 1979. A small number of brook trout are recruited naturally as a result of spawning in West Lost Lake. About nine lake-spawned brook trout were present at the outset and 61 were removed during the course of the study.

Methods

On October 18-19, 1977, equal numbers of Assinica and hybrid strain brook trout were planted in each experimental water. Both strains are progeny of Assinica and domestic brook trout reared to maturity earlier in Hemlock, South Twin, and West Lost lakes. In turn, the lineage of these fish were from eggs of Assinica trout obtained from the State of New York and reared in a hatchery to fall fingerlings in Michigan and from eggs of domestic brook trout secured from Minnesota and also reared to fingerling size in Michigan. The impact of the hatchery environment and rearing on the early life of these trout is unknown.

The planting rate in the six experimental waters was 125 fingerlings/ha of Assinica and hybrid trout or 250/ha for each water (Table 2). The mean length of trout planted was 96 and 86 mm for the Assinica and hybrid trout, respectively. The standing crop of the former was 1.27 and the latter 0.94 kg/ha. A fin was excised to identify each strain.

To obtain mark-and-recapture estimates of the two strains of trout, samples of trout were captured and marked each fall by electrofishing, angling, or trapping. Samples for obtaining recapture ratios were taken in late winter by ice fishing. This sampling procedure provided the basis for assessing rates of survival, growth, and a means for measuring standing crop and production (Ricker 1975). Residual populations of trout at termination of study were captured by gill nets, except for Fuller Pond, where trout were caught in an outlet trap. Statistical significance was accepted at the 95% level.

Results

Survival

Assessment of survival of the two strains of trout in the experimental waters was influenced by: (1) winterkill, (2) illegal confiscation of trout, and (3) illegal fishing. Most of these events occurred during the latter part of the study. In March 1980, a winterkill occurred in Hemlock Lake, which decimated all trout, but did not destroy completely the minnow populations. In fall 1981, a major portion of the trout populations in South Twin Lake, which were being retained in a large holding net preparatory to marking and release, were stolen. In February 1981, two individuals were apprehended illegally fishing Fuller Pond and in possession of two Assinica and five hybrid brook trout. Lastly, populations of trout in North Twin were reduced to some extent by illegal fishing based on evidence found on the ice and by the meager sample of fish taken by intensive ice fishing and subsequent gill netting.

Assuming the foregoing influenced both strains equally, their average annual survival rates (s) in these waters from

1977 to 1982 were comparable as shown by survivorship curves in Figure 1. Perhaps the most reliable survival data rested on the earlier years of the study which also showed the survival rates of the two strains were similar. Average annual survival rates of Assinica trout in these waters for the first 3 years were rather constant. It varied only between 0.653 and 0.664 and averaged 0.660, while for hybrid trout it ranged from 0.574 to 0.734 and averaged 0.671 (Table 3). Survival rates for both strains of trout during the first year of residence were lowest in the two shallowest basins, Fuller Pond and Ford Lake. Highest survival rates occurred in North Twin and South Twin which have relatively little shoal areas. Survival rates of hybrids were lower than those of Assinica trout during the first year except for North Twin Lake. First year survival averaged 0.662 and 0.574 for Assinica and hybrid trout, respectively.

The most notable change in the second year was the marked improvement in survival of hybrid trout in Fuller Pond and the drop in survival of Assinica trout in South Twin. Neither strain in Hemlock Lake survived the 1978-79 winterkill. For the second year, average annual survival rates were 0.653 for Assinica and 0.734 for hybrids. In the third year, survival rates of both strains were reasonably high and averaged 0.664 for Assinica and 0.725 for hybrid trout. For these years, overall survival rates of both strains were highest in North Twin and most consistently lowest in Ford Lake.

Survival data for male and female trout were most complete and trends most evident in Fuller Pond and Ford Lake. At stocking each strain was assumed to be equally divided between male and female. In Fuller Pond survival rates of Assinica males and females were comparable the first year after stocking with male survivorship dropping more rapidly than female in the second year (Fig. 2). The disparity between sexes was most evident in the fourth and fifth years, when the male survival rate fell more rapidly than the female. For hybrid trout in Fuller Pond the survival rate of males was poorer than for females during the first year. Survival rates of sexes were similar in the second and third year, but dropped more rapidly for males in the fourth and were again similar in the fifth year.

A little different trend in survival rate emerged in the case of Ford Lake. Except for the first year of lake life, male and female Assinica trout showed similar survival rates (Fig. 3). Assinica males exhibited a poorer survival rate than females during the first year and it determined in large measure the subsequent disparity in population levels between the sexes. In most respects the trend in survival rates of hybrid male and female were comparable to those of Assinica male and female (Fig. 3). Hybrid males, like their Assinica male counterpart, had a lower survival rate than hybrid females in the first year which thereafter lowered their annual numerical representation in the total population.

Maximum longevity of these trout was probably age VII. Excluding Hemlock and South Twin lakes where trout populations were prematurely aborted, residual stocks of age-V trout in fall 1982, averaged 5.4 and 4.4 trout/ha for Assinica and hybrid trout, respectively. Some of these trout would have survived to age VI and a few to age VII.

Maturation

The first evidence of maturity occurred on September 28, 1978, when a sample of trout taken by electrofishing from Fuller Pond showed some males of both strains ripe and assumed capable of breeding later in the fall. Age-I Assinica and hybrid trout first attempted to leave Fuller Pond and were caught in an outlet trap on October 3, 1978, almost 1 year after planting. Males of both strains outnumbered females in the early trapping. Assinica and hybrid females containing ripe eggs were first observed on

October 13, when the first pulse in movement out of the pond occurred. At this time, 94 Assinica and 59 hybrids were captured. About 98% of the Assinica males were ripe and 3% of the females. Similarly, nearly all of the hybrid males and 11% of the females were ripe. Between October 25 and November 13, which covered the concluding day of the spawning period, females of each strain outnumbered males in the trap catch. During this period 78 Assinica females and 42 hybrid females were captured of which 81% and 78% of the respective female strains of trout contained ripe eggs. This sample included some recaptures and was obviously biased toward sexually mature individuals. The data, however, suggested that perhaps 25% of the females in the populations in Fuller Pond were potential spawners for the first time at age I.

Evidence of this degree of maturation at age I was not found in the Pigeon lakes. While most Assinica and hybrid males in samples taken by electrofishing and angling in late October and November were sexually mature, only about 4-5% of the Assinica and hybrid females attained maturity at age I.

In 1979, the first pulse in movement down out of Fuller Pond occurred on October 8, at which time none of the females of either strain showed evidence of being sexually mature. By October 18, an electrofishing sample of trout showed that about 19% of the Assinica females and 53% of the hybrid females contained ripe eggs. Late October and early November, samples of trout in the Pigeon lakes showed 43% of the Assinica and 53% of the hybrid females were potential spawners in the current year.

The proportion of sexually mature Assinica and hybrid females in samples taken in the experimental waters in 1980 varied from 80 to nearly 90%. In 1981 it amounted to 92%.

The assessment of sexual maturity of females sampled in the Pigeon lakes in late August 1982 was not made. However, all females removed from Fuller Pond between September 28 and November 3, which represented most of the residual populations, had a normal complement of eggs for deposition in the current year.

Growth

The best measure of the relative performance of brook trout strains in this study rests on growth. The general pattern of annual growth in length of both strains was similar during the 5 years of lake and/or pond life. Growth was most rapid the first year and thereafter generally diminished. Of note was the relatively large increment in growth attained equally by both strains in North Twin and South Twin lakes in the first year after planting. Also, Fuller Pond trout showed relatively large incremental growth in length in the second year which enabled them to approach and/or exceed those in North Twin and South Twin lakes in the second and succeeding years. For trout in three experimental waters with 5 years of growth data, the total increment in growth of Assinica and hybrid trout ranked by water was as follows: North Twin 337 and 333 mm, Fuller Pond 338 and 328, and Ford Lake 308 and 302. The largest trout captured during the study was a hybrid trout that measured 495 mm in total length and weighted 1.96 kg and the second largest was an Assinica trout 490 mm long and weighed 1.93 kg. Both were captured in South Twin.

Annual growth data of trout for the six waters were pooled to show the growth rate pattern of each strain (Fig. 4). The two strains showed very similar growth rates. At the outset of the study the Assinica trout had a 10 mm length advantage over hybrid trout and this margin was generally maintained over the course of the study.

Assinica trout for a given length tended to be a little heavier than hybrid trout during the first 3 years with a reversal in the weight differential in the fourth and fifth year. A length-weight relationship was derived from a sample of trout taken from the Pigeon lakes in fall 1978.

In the range of 203 to 279 mm, total lengths common to both strains, Assinica trout held a slight 2-6 g edge in weight. Similarly, for Fuller Pond the margin was about 3-7 g. This weight differential appeared to increase until 1980, when it reached about 53 g at a length of approximately 356 mm. By fall 1981, when trout began to approach a length of about 432 mm, hybrid trout began to exceed the weight of Assinica trout.

For Assinica trout, there was no consistent growth differential between the sexes over the years (Fig. 5). At stocking the average length of males and females was assumed to be similar. Assinica females attained significantly larger size than males in the first year after planting while on the average males were larger than females at the end of the third year. Both attained similar lengths in the fall of the second, fourth, and fifth years.

Male and female hybrid trout attained very similar average lengths at the end of the first and second year after planting. However, at the end of the third year males were significantly larger than females with males nearly maintaining this edge in the fourth year. Only a relatively small number of hybrid males were sampled in the fifth year.

Standing crop

The average standing crop of Assinica trout in the test waters in fall 1977 was 1.27 kg/ha versus 0.94 kg/ha for hybrid trout, significantly different levels. Standing crops subsequently increased to comparable peaks of 21.33 kg/ha for Assinica and 20.37 kg/ha for hybrid trout 3 years after planting, and thereafter fell to similar levels in the fifth year of 4.55 and 3.29 kg/ha (Table 4).

Production

Annual production of Assinica and hybrid trout among the test waters tended to be highest the first year and then diminished in succeeding years (Table 5). Notable exceptions were hybrid trout in South Twin, North Twin, and Fuller Pond which were able to sustain production through the second year, the former two at a relatively high level and the latter at a low level. Also, both strains of trout in North Twin showed a small increase in production in the fifth year as did Assinica trout in Ford Lake. Greatest 5-year production of Assinica as well as hybrid trout was achieved in North Twin by virtue of high survival and rapid growth of the populations during the first year, which amounted to 22.83 and 19.72 kg/ha for Assinica and hybrid trout, respectively. Even though a major portion of the trout populations in South Twin were removed illegally in the fourth year, it ranked second in total 5-year production. Lowest 5-year production of both strains occurred in Ford Lake. Given the larger initial standing crop of Assinica over hybrid trout, the average annual production of Assinica trout in these waters, though it exceeded that of hybrids, was not judged significant.

Discussion

Survival rates were associated with sites irrespective of strains. Overall survival rates of both strains were highest in North Twin and lowest in Ford Lake. It was only in these two lakes among the test waters that Assinica trout showed a significant differential survival rate based on the means of the first 3 years. For hybrid trout it approached statistical significance.

In Fuller Pond and Ford Lake, the two shallowest basins, Assinica and hybrid trout showed the lowest survival rates in the first year, the latter strain more than the former. Great blue herons frequent these waters, particularly Fuller Pond, and may have been a source of mortality. Alexander and Shetter (1969) reported strong circumstantial evidence of avian predation of brook trout in a lake adjacent to Fuller Pond. The comparatively high first year mortality of hybrids in Hemlock Lake, another basin suitable for this wading predator, suggested some behavioral difference between the two strains. All other Pigeon lakes have relatively small littoral area.

As Ford Lake contained no minnows, in contrast to their presence in Fuller Pond and Hemlock Lake, there was no evidence that first year survival rates of either strain was influenced by minnows.

The impact of adult trout on first-year survival of either strain was not evident. In South Twin and North Twin, where survival rates were similarly the highest, the former contained adult brook trout at a density of about 25 fish/ha and the latter had rainbow trout at a density probably no greater than 3 fish/ha. First-year survival rates of both strains in West Lost Lake were intermediate for this group of waters and it contained the largest residual population of brook trout at the outset of the study, about 66 fish/ha.

In the following 2 years, aside from the improved survival of hybrids in Fuller Pond and the increased mortality of Assinica trout in South Twin Lake in the second year, survival rates of both strains were unusually stable and similar. When averaged over the first 3 years, survival rates of the two strains were quite similar.

Typically, the survival rate of Assinica and hybrid males was poorer than females of these strains during the first year, at least in the shallowest basins, and thereafter they were generally comparable. Thus the first year after planting appeared to be critical in establishing the subsequent disparity in population levels of males and females and suggested a behavioral difference between the sexes, possibly linked to the early maturation of males.

There was no evidence of a difference between strains in maturation with respect to age. A large portion of the males of both strains were sexually mature at age I and they reached this stage in any given spawning season earlier than females. On the other hand, only about 4-5% of the Assinica and hybrid females in the Pigeon lakes reached sexual maturity at age I, while it was judged about 25% reached maturity in Fuller Pond. About 45-53% of the females of both strains were estimated to be sexually mature at age II and 80-90% at age III. There was no apparent explanation for the earlier maturation of females in Fuller Pond. Age of brook trout at first sexual maturity showed substantial plasticity based on previous experience with Assinica trout. For example, in fall 1977 matched plantings of fingerling Assinica and domestic brook trout were made in some of these same waters. More than 60% of the domestic brook trout were sexually mature at age I and nearly all at age III, whereas most Assinica trout did not attain maturity at age II, but more than 60% of the females were sexually mature at age III. In the present study Assinica trout in the Pigeon lakes reached sexual maturity earlier than the 1977 Assinica trout by almost a year on the average with a tendency for those in Fuller Pond to mature at an even earlier age. Maturation at early age, of course, influences growth as reproduction exacts high nutritional costs. Cultural and natural environmental influences on maturation in these strains were not evident.

Commonly in the fall a few fish of each strain were captured that lacked spawning color, were silvery in appearance, very slender in form, longer on the average, and of appropriate age to be sexually mature. These fish, which were not examined internally, were judge to be sterile by hatchery personnel.

The growth in length of Assinica and hybrid trout was similar and characterized by comparatively rapid growth the first year and then diminishing growth in each of the following years. Growth of both strains in the first year appeared to be related to the status of the invertebrate resources of the lake. For example, North Twin with the fewest residual fish at the time of planting ranked highest in growth. Waters with few or no fish are likely to have large invertebrate populations, particularly zooplankton which is an important food resource for trout. Poorest growth initially occurred in Fuller Pond and Ford Lake, which were treated with a fish toxicant 4-5 months prior to planting. Probably the invertebrate populations had not completely recovered. Fraser (1978, 1981) reported that wild, hybrid, and domestic brook trout fingerlings planted in the fall in precambrian shield lakes of Ontario yielded highest returns in lakes with few or no resident fish species and lowest in those containing competitive species. Best growth occurred in lakes with minnows and sticklebacks and poorest in lakes containing white suckers (Catostomus commersoni). Alexander (1975) observed a drop in growth rate and condition of rainbow trout in Fuller Pond that coincided with a reduction in food supply and an increase in white sucker and minnow populations.

Both Assinica and hybrid trout in Fuller Pond, unlike Ford Lake, were better able to sustain their growth during the second year, possibly aided by the utilization of minnows, which enabled them to approach in size, those for example, in North Twin and South Twin lakes. Similarly, this occurred in Hemlock Lake to the extent that hybrid trout were also better able to sustain their growth during the second year than those in other waters.

For the most part, growth of male and female Assinica and hybrid trout were nearly comparable. Female Assinica trout showed a small but significantly greater length at age I than males whereas the reverse occurred at age III. For hybrid trout the only difference was at age III when length of males exceeded females as was the case for Assinica trout. The common difference in length at age III might be attributed to the relatively large proportion of the female populations that are sexually mature at this age, maturation impacting adversely on growth in length.

Some perspective on angling for these trout, particularly with a restricted size and creel limit, can be gained by examining survival and growth. For this group of relatively infertile waters, a planting of 250 fingerlings per hectare resulted in an average stock density of about 109 fish per hectare having a mean length of 328 mm at age II in the fall. Even after an additional year, average stock density at age III was nearly 76 fish per hectare with a mean length of 372 mm.

Production of trout flesh differed between waters and was influenced primarily by the inherent productivity of the receiving water and the particular stage of the biota at planting. Annually, the largest production of Assinica and hybrid trout occurred in North Twin Lake, the more inherently productive of this group of waters and one that had set nearly fishless for a few years before planting. In North Twin average production for 5 years amounted to 13.26 and 12.72 kg/ha for Assinica and hybrid trout, respectively. Ford Lake is inherently the least productive of these waters. This, coupled with the adverse effect of rotenone treatment upon its invertebrate communities, resulted in the smallest 5-year average production, 5.61 and 3.92 kg/ha for Assinica and hybrid trout, respectively. For this group of waters, average annual production of Assinica trout peaked the first year at 15.89 kg/ha and dropped to 2.40 kg/ha in the fourth year while hybrid trout reached maximum production in the second year of 11.67 kg/ha, though only slightly higher than the first year, and fell to a low of 1.76 kg/ha in the fourth year. Both strains showed a slight increase of 11 to 18% in the fifth year. These values are low as recruitment, either natural or artificial (planting), were not involved. They are considerably less than annual brook trout production of 33-65 kg/ha reported by Hatch and Webster (1964) for four New York lakes where recruitment was supplied through planting. They are substantially less than Carline (1977) found in three fertile ponds in Wisconsin.

Production in the ponds varied from an average of 26 to 331 kg/ha and where production was directly related to recruitment.

Current effort in brook trout management is to identify and demonstrate strains of trout that survive and grow well in natural environments. Flick and Webster (1976) and Gowing (1978) have shown Assinica trout to be superior in growth to domestic stocks presently used in New York and Michigan. Fraser (1981) has demonstrated the advantage of hybrid brook trout over domestic stocks in some Ontario lakes. Also, Webster and Flick (1981) reported that hybrids of Assinica and Temescamie strain brook trout showed heterosis in survival and yield. While hybrid trout in this study showed no evidence of heterosis in survival and growth they did, however, perform equally as well as Assinica trout. From a management point of view, it might be more desirable to produce hybrids using brood stock of selected domestic females which are relatively easy to maintain in a hatchery and obtain sperm from males of a strain surviving in natural lakes. Development of brood stocks of wild strains is not judged desirable.

Acknowledgements

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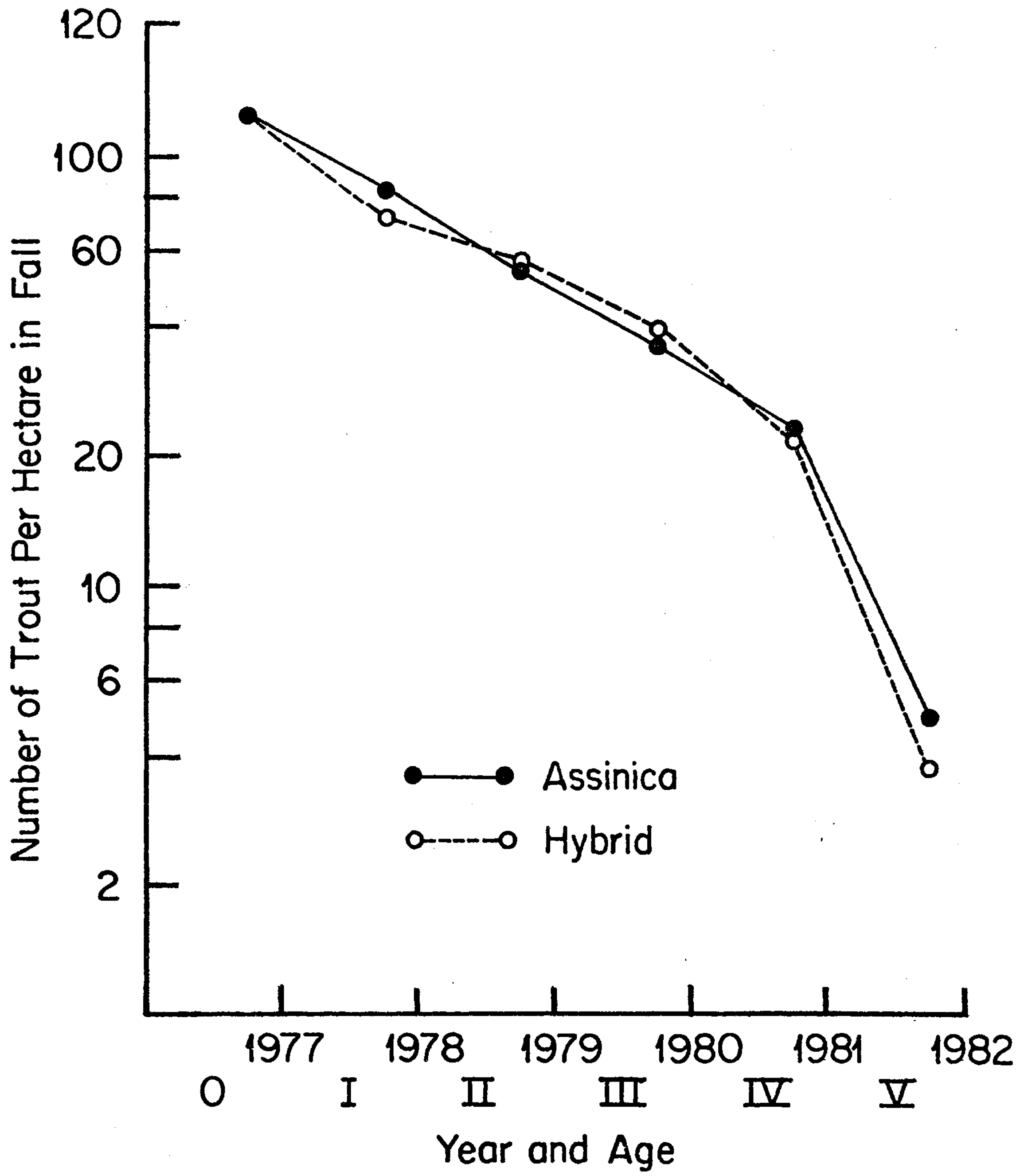

Figure 1. Survivorship curves for Assinica and hybrid strain brook trout from pooled data for six experimental waters from age 0, fall 1977, to age V, fall 1982.

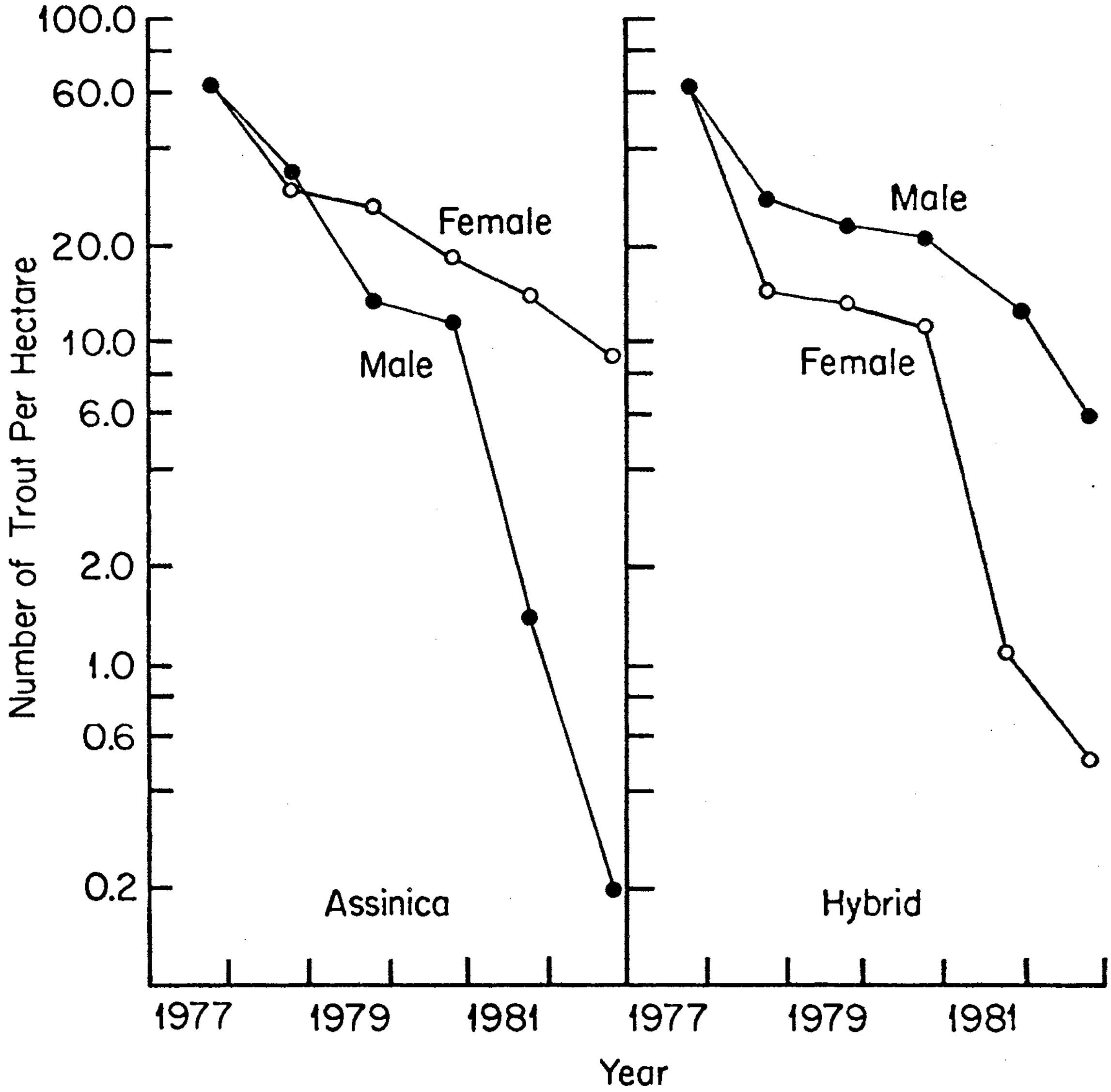

Figure 2. Survivorship curves for Assinica and hybrid strain brook trout male and female in Fuller Pond from age 0, fall 1977, to age V, fall 1982.

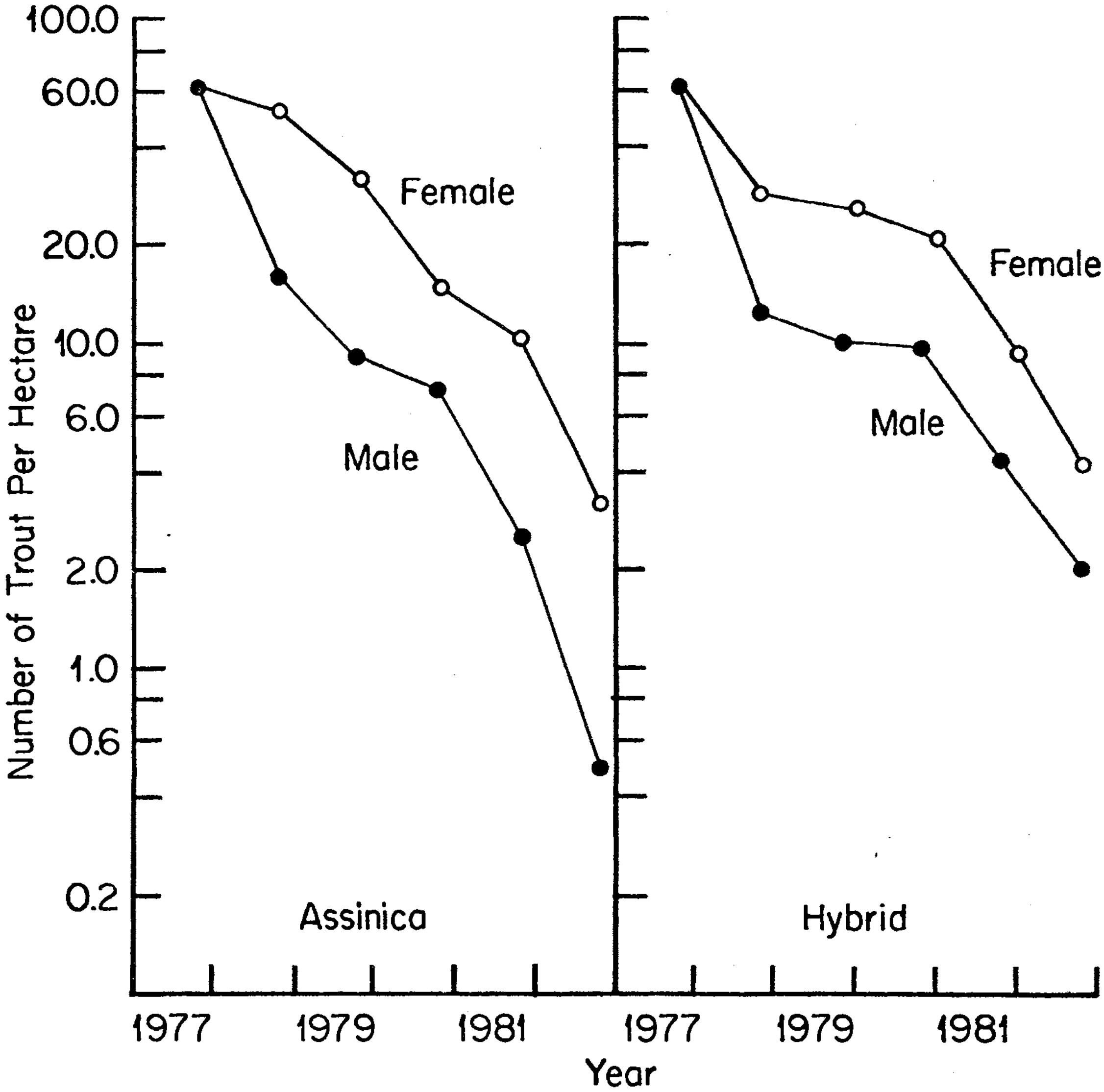

Figure 3. Survivorship curves for Assinica and hybrid strain brook trout male and female in Ford Lake from age 0, fall 1971, to age V, fall 1982.

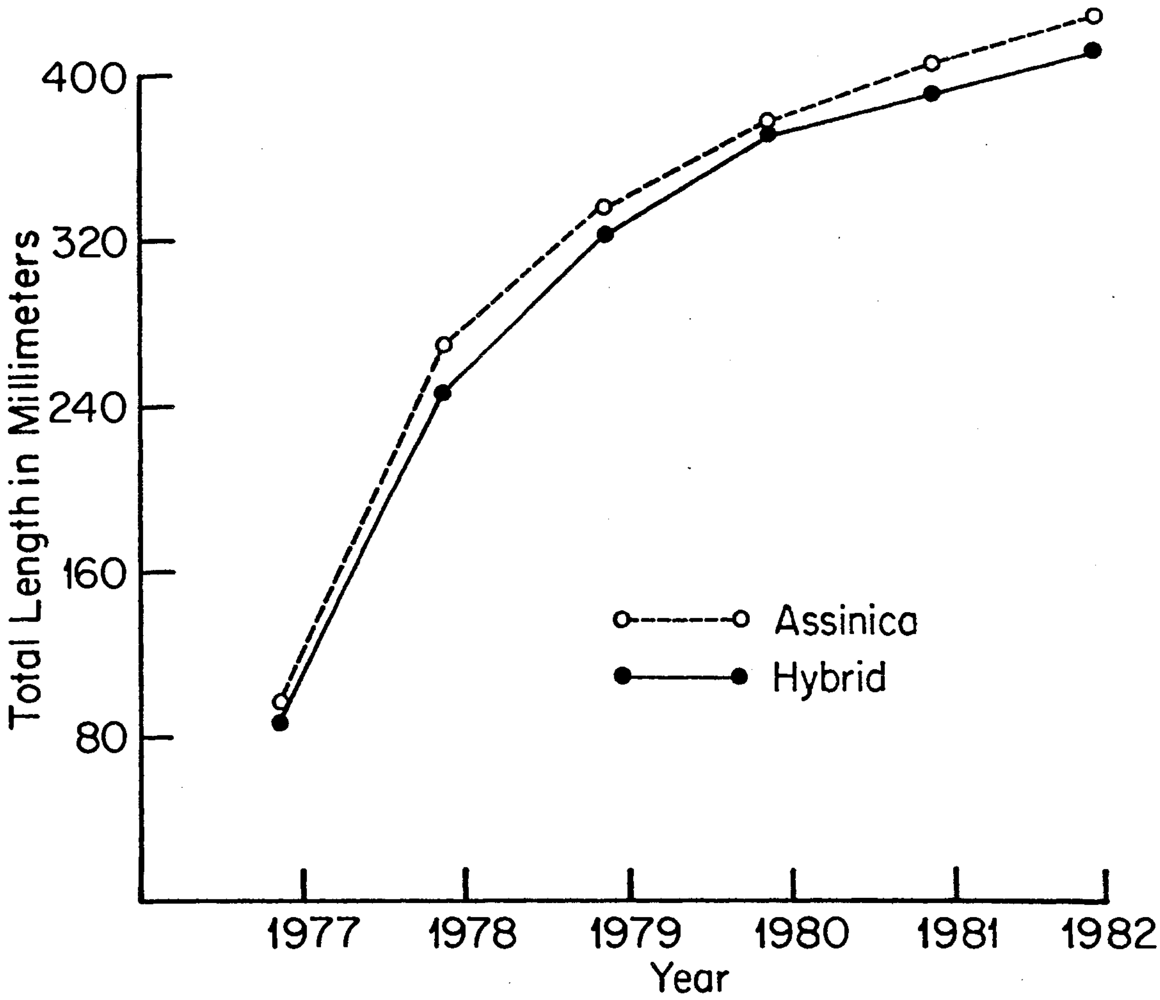

Figure 4. Growth in total length (mm) of Asssinica and hybrid stream brook trout from pooled data for six experimental waters.

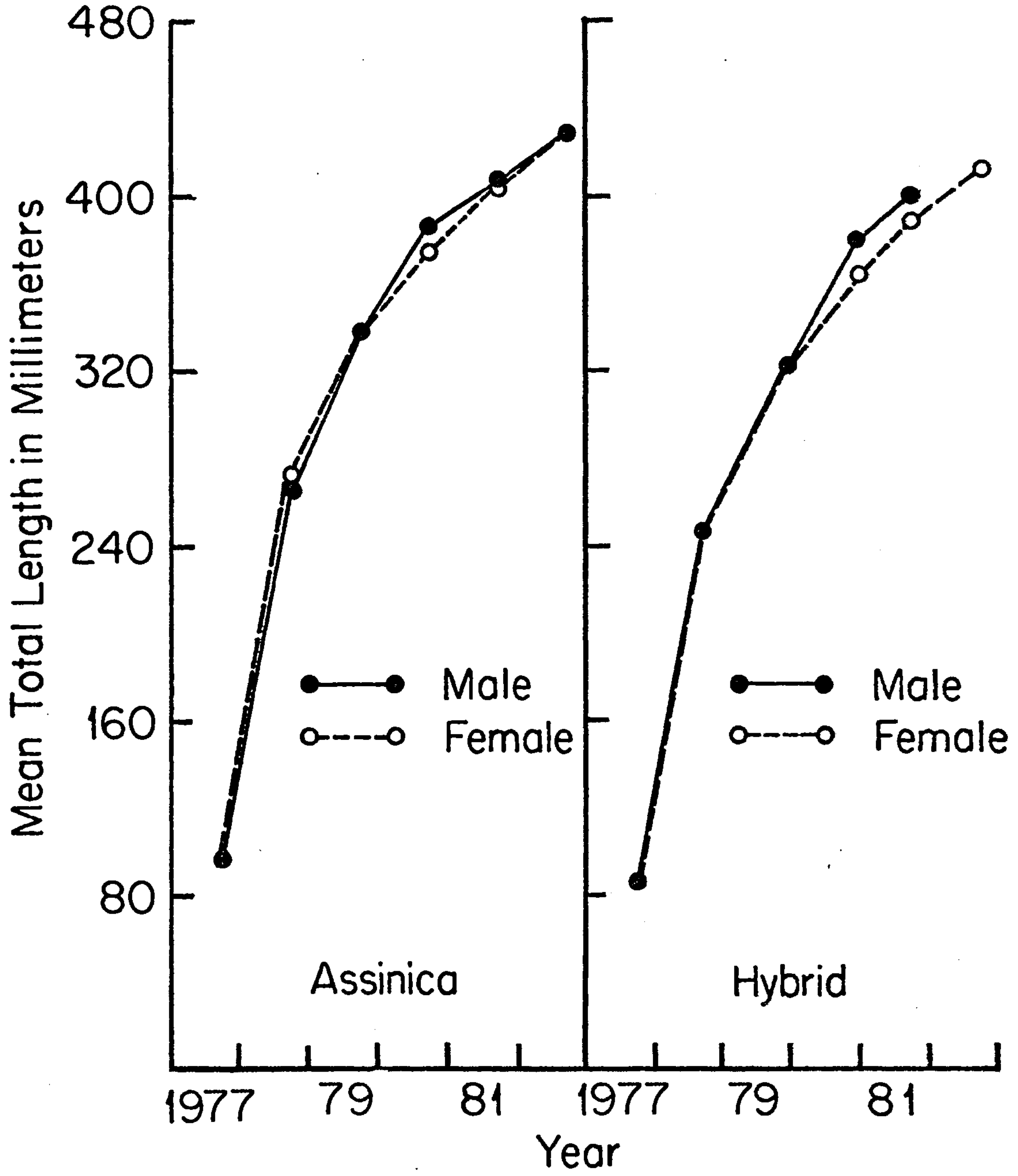

Figure 5. Growth in total length (mm) of Assinica and hybrid strain brook trout by sex from pooled data for six experimental waters.

Table 1. Description of experimental waters.

Experimental water	Area (ha)	Depth (m) Maxi-mum	Depth (m) Aver-age	Total alkal-inity	pH	Minnow popu-lation
Fuller Pond	6.1	2.4	0.6	149	8.1	present
Ford Lake	4.1	8.8	4.2	82	8.0	absent[a]
Hemlock Lake	2.4	18.0	8.4	137	8.2	present
North Twin Lake	1.9	12.5	5.9	29	7.4	absent
South Twin Lake	1.6	10.1	5.0	65	7.8	absent
West Lost Lake	1.4	13.1	5.4	134	8.0	absent

[a] Small population of _Umbra limi_ present.

Table 2. Number and length of Assinica and hybrid strain brook trout stocked in six experimental waters, at the rate of 125 fish per hectare, fall 1977.

Site and strain	Number of trout stocked	Mean total length (mm)	Standard error of mean
Fuller Pond			
Assinica	762	96	0.49
Hybrid	762	86	0.59
Ford Lake			
Assinica	512	96	0.49
Hybrid	512	86	0.59
Hemlock Lake			
Assinica	300	96	0.49
Hybrid	300	86	0.59
North Twin Lake			
Assinica	238	96	0.49
Hybrid	238	86	0.59
South Twin Lake			
Assinica	198	96	0.49
Hybrid	198	86	0.59
West Lost Lake			
Assinica	175	96	0.49
Hybrid	175	86	0.59

Table 3. Annual survival rates (s) of Assinica and hybrid brook trout for the first 3 years after planting as fingerlings in six experimental waters, fall 1977.

Site	Year: First		Year: Second		Year: Third	
	Assinica	Hybrid	Assinica	Hybrid	Assinica	Hybrid
Fuller Pond	0.517	0.333	0.614	0.898	0.772	0.886
Ford Lake	0.561	0.438	0.592	0.527	0.541	0.644
Hemlock Lake	0.647	0.477	...	...	...	...
North Twin Lake	0.786	0.861	0.813	0.863	0.783	0.621
South Twin Lake	0.818	0.742	0.531	0.728	0.523	0.785
West Lost Lake	0.640	0.594	0.714	0.654	0.700	0.691
Average	0.662	0.574	0.653	0.734	0.664	0.725

Table 4. Average annual fall standing crop (kg/ha) of Assinica and hybrid strain brook trout in six experimental waters (standard error of mean in parentheses).

	Year and age					
Strain	1977 0	1978 I	1979 II	1980 III	1981 IV	1982 V
Assinica	1.27	15.30	21.22	21.33	15.36	4.55
	(0.002)	(1.81)	(4.06)	(4.68)	(6.47)	(1.40)
Hybrid	0.94	10.36	18.78	20.37	13.29	3.29
	(0.001)	(2.28)	(4.80)	(4.43)	(6.30)	(1.38)

Table 5. Annual fall standing crop (S.C.) and production (P.) of Assinica and hybrid strain brook trout in kg/ha for six experimental waters.

Site and strain	1977 O		1978 I		1979 II		1980 III		1981 IV		1982 IV
Fuller Pond											
Assinica											
S.C.	1.27		13.31		16.91		19.16		11.10		7.85
P.		13.06		12.38		6.93		2.09		1.58	
Hybrid											
S.C.	0.94		5.32		13.10		18.60		8.90		4.66
P.		7.16		8.68		7.43		1.71		0.84	
Ford Lake											
Assinica											
S.C.	1.27		10.08		11.99		11.24		7.36		2.96
P.		11.27		7.67		6.41		0.97		1.75	
Hybrid											
S.C.	0.94		6.61		7.63		7.94		4.54		2.00
P.		8.07		5.57		3.75		1.48		0.72	
Hemlock Lake											
Assinica											
S.C.	1.27		13.90		...		...		...		...
P.		14.93		...		...		...		...	
Hybrid											
S.C.	0.94		6.20		...		...		...		...
P.		7.32		...		...		...		...	
North Twin Lake											
Assinica											
S.C.	1.27		22.34		36.16		38.94		34.62		7.72
P.		22.83		19.76		11.98		4.76		6.96	
Hybrid											
S.C.	0.94		19.74		35.42		33.00		32.00		7.95
P.		19.72		19.60		13.87		3.76		6.77	
South Twin Lake											
Assinica											
S.C.	1.26		18.72		21.20		16.75		...		3.52
P.		18.76		15.07		7.82		...		...	
Hybrid											
S.C.	0.93		13.60		22.54		27.25		...		1.84
P.		14.08		14.56		10.72		...		...	
West Lost Lake											
Assinica											
S.C.	1.28		13.44		19.81		20.56		8.36		0.72
P.		14.47		11.91		7.91		1.76		0.40	
Hybrid											
S.C.	0.94		10.70		15.21		15.05		7.73		0.00
P.		11.85		9.96		5.42		0.10		0.00	

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