MICHIGAN DEPARTMENT OF CONSERVATION
Research and Development Report No. 153*

October 21, 1968

THE EFFECTS OF CERTAIN ANGLING REGULATIONS ON STREAM TROUT POPULATIONS**

By David S. Shetter

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Annual fall brook trout population estimates, yearly angler catches, and a large series of scale samples from 1.75 miles of Hunt Creek, Montmorency County, Michigan, for 1950-1965, provided data for assessment of the effects of a fly fishing only restriction (instead of any lure) on the brook trout population. The restriction (in effect during 1955-1959) did not affect the total mortality rate or the population structure of the brook trout.

Similar but less precise information was collected from 19.8 miles of the North Branch of the Au Sable River for brook trout and brown trout during 1960-1967. Here comparative restrictions included "flies-only," higher minimum size limit (9 inches instead of 7 inches), lower daily creel limit (5 fish instead of 10 fish). Total mortality and angling mortality rates for brook trout were significantly higher in the less restricted stream area; the restrictions had little effect on the brown trout populations.

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* Institute for Fisheries Research Report No. 1752.

** Contribution from Dingell-Johnson Project F-27-R and F-30-R, Michigan.

The effects of certain angling regulations on stream trout populations[1]

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Abstract

Annual fall brook trout population estimates, yearly angler catches, and a large series of scale samples from 1.75 miles of Hunt Creek, Montmorency County, Michigan, for 1950-1965, provided data for assessment of the effects of a fly fishing only restriction (instead of any lure) on the brook trout population. The restriction (in effect during 1955-1959) did not affect the total mortality rate or the population structure of the brook trout.

Similar but less precise information was collected from 19.8 miles of the North Branch of the Au Sable River for brook trout and brown trout during 1960-1967. Here comparative restrictions included "flies-only," higher minimum size limit (9 inches instead of 7 inches), lower daily creel limit (5 fish instead of 10 fish). Total mortality and angling mortality rates for brook trout were significantly higher in the less restricted stream area; the restrictions had little effect on the brown trout populations.

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Introduction

I will consider how trout populations in two trout streams in Michigan were affected by restrictive angling regulations. Lures were restricted to flies only, the size limit was raised, and the daily creel limit was lowered; all on the assumption that this would lower the mortality rate on trout, that more trout would be protected to spawning size, and that more trout would be produced for the anglers' creel. Such restrictive regulations on trout waters are becoming common, in some instances going to the extreme of permitting no creel harvest, in a situation referred to as "fishing for fun." Most frequently there has been a dearth of information on the fish and angling which are involved.

My information is on populations and angling for brook trout (Salvelinus fontinalis) in 1.75 miles of Hunt Creek, Michigan, during 1950-1965; and for both brook trout and brown trout (Salmo trutta) in 19.8 miles of the North Branch Au Sable River during 1960-1967. I will explore how the restrictive regulations affected total mortality and angling mortality rates. The effects which the angling restrictions had on angling pressure, on total catch, and on numbers of trout remaining in the stream in the fall, have already been published (Shetter and Alexander, 1962, 1966).

For the sake of clarity "flies-only" means restricting the angler to the use of the artificial wet or dry fly as a lure; "any lure" means angling can be conducted with any legal natural or artificial lure. "Normal" regulations mean the angling rules applied to Michigan trout waters not subject to experimental or special restrictions (any lure, 7-inch minimum

length, 10-fish-daily creel limit); "Special" regulations mean, in the case of the North Branch, restricting the angler to the use of flies only, a 9-inch minimum size limit, and a 5-fish-daily creel limit.

Location of streams

Hunt Creek is located in south-central Montmorency County of Michigan's lower peninsula; it is a tributary of the Thunder Bay River, which enters Lake Huron along its northwest shore. Descriptions of the stream and environs are given in Shetter and Leonard (1943) and Shetter (1950).

The North Branch Au Sable River lies approximately 20 miles west of Hunt Creek in Otsego and Crawford counties. It is one of three major tributaries of the Main Au Sable River, which also flows into Lake Huron. The physical characteristics of the North Branch drainage are described by Hendrickson (1966), Miller (1964), and Shetter (1937). For locations of these streams, see Figure 1.

Methods

Yearly angler catches on Hunt Creek were obtained from a complete creel census as described by Shetter and Alexander (1962). On the North Branch Au Sable River, the anglers' catch was estimated by stratified random sampling (Alexander and Shetter, 1967). The North Branch was divided into three experimental sections, the upper (4.2 miles), the middle (6.9 miles) and the lower (8.7 miles),

the boundaries and the stream areas within each were posted with the angling regulations applying to that particular experimental section.

Population estimates for experimental sections of Hunt Creek (ZA, BC) were made by the Petersen mark-and-recapture method; both marking and recovery trips were made over the entire stream. Estimates were made for each inch group in each section, and these were summed to obtain the total population.

Two different methods were used to obtain population estimates on the North Branch. Time did not permit electrofishing 19.8 miles of stream, so estimates of the complete populations of trout were made from sample population study areas within each experimental stream section. For the lower and middle experimental sections the estimates given in the tables are averages of either two (1960, 1961) or three (1962-1967) sample population study areas 750 to 1,300 feet in length. In the upper section, population estimates were based on averages derived from two sample population study areas (1960, 1961), and three sample population study areas in 1962-1965 of sizes already described. In 1966 and 1967 the entire 4.2 miles of the upper section was electrofished to obtain the necessary data from which to derive the population estimates. The population estimates were expanded to a fish per mile basis to facilitate comparison between experimental stream sections.

Ages of most trout taken by anglers from Hunt Creek were determined from scale samples. Age from scales was also determined for trout taken by electrofishing gear in the fall population estimates.

Some 30 to 50 fish from each inch group between 4 and 8 inches were sampled. Earlier samples showed that most fish under 4.0 inches belonged to age-group 0. Scales were collected from most fish over 8 inches.

On the North Branch, the age distribution of trout caught by anglers was approximated by sampling. Here we started with total trout caught by anglers, estimated from the random creel census for 1961-1967. This total catch was segmented into catch by species, by experimental stream section, by quarter of the fishing season, and by inch groups in size of fish. Scales from a sample of fish in anglers' creels gave information on age distribution within each inch group, and this was applied to the total anglers' catch.

Age distribution among the fall population of trout in the North Branch was obtained, for each of the three ~~areas~~ experimental stream sections, by sampling up to 50 fish in each inch group larger than 4.0 inches (brook trout) or 5.0 inches (brown trout), and applying this age distribution to the total.

Thus we have for a series of years, the estimated anglers' catch and the age distribution of the fish, and fall population estimates by age group. It is then possible to follow the fate of each year class, and determine both total and fishing mortality from age 0 to extinction.

In an experiment testing "flies-only" at Hunt Creek, the fly regulation was in effect in ZA for 5 years, which was preceded and followed by 4- and 6-year periods respectively with normal regulations; at the same time section BC had normal regulations and served as a control.

Average annual total mortality and average fishing mortality were determined from the data on populations and angler catches for experimental and control waters and for two time periods, as shown by the dividing lines in Tables 3 and 4. These mortalities, which can be calculated from the catch and survival data shown in the tables, were determined for three age-group intervals, namely: 0 to I, I to II, and II to III. In associating annual mortality for an age group with the flies-only regulation, I selected, for treatment under the flies-only category, only the age groups in which the terminal (fall) populations had been subjected to the flies-only regulation. Fish in age-group 0 were not affected by angling. No mortality calculations were made from fall population estimates which did not result within the period of the particular regulation.

The North Branch data were less complicated than for Hunt Creek because angling regulations were constant during 1961-1967. As with the Hunt Creek data, it was assumed that fish in age-group 0 were not affected by the particular angling regulation.

Total mortality and angling mortality were calculated for each experimental time period and stream section. Differences in average mortality rates between sections or time periods were subjected to the t test (Snedecor, 1956) after reducing the calculations to i and p values (Ricker, 1958). Statistical significance was set at the 95% level.

Results

Hunt Creek brook trout

Only the native brook trout population is discussed here.[1]

In the two experimental areas of Hunt Creek with which we are concerned, fall brook trout populations have varied during 1950 to 1965 as follows:

ZA (0.91 mile, 2.56 acres) 3,030-5,263 fish (average 4,029);

BC (0.84 mile, 1.35 acres) 2,228-3,719 fish (average 3,032).

Average fall populations for ZA and BC are shown in some detail in Table 1. Angling pressure varied in ZA during the same period between 300 and 1,275 hours, in BC between 378 and 604 hours. This effort yielded annual catches ranging from 192 to 845 legal brook trout in ZA and between 134 and 296 creel-size fish from BC. Average angling pressures and catch are given in Table 2 for ZA and BC during the various time periods involved.

Fall trout population data and anglers' catches for Hunt Creek are shown in Tables 3 and 4 by age groups. The question to be examined here is: What effect did the flies-only regulation in ZA have on the population structure of ZA? I have compared the average total mortality rates (Table 5) for ages 0-I, I-II, and II-III, for the two areas and the experimental time periods, from the data in Tables 3 and 4. Total mortalities for

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[1] In the period 1952-1957, survivors of a release of 3,000 rainbow trout (Salmo gairdneri) fingerlings were present and appeared in anglers' creels. Shetter (1967) presented evidence that their presence affected neither the brook trout angling nor the brook trout populations during that time.

experimental time periods and areas ranged as follows: 0-I, 54-61%; I-II, 78-84%; II-III, 90-93%. Computations were not carried past age III, because in a majority of years there were very few survivors to age IV or V among Hunt Creek brook trout. The data for years of fly fishing only (1955-1959) were compared with data for ten other years when angling with any lure was permitted.

The Hunt Creek study provides data on mortality under the flies-only rule in ZA, under "normal" regulations in ZA, and comparative data for the control section BC over the same time period. For the two younger ages (0-I, I-II), the differences were not significant between years when the flies-only law applied and years when fishing with any lure was permitted. Among trout in age II-III there was a statistically significant difference ($.01 < P < .025$) between time periods in the control section of stream; there was a small (but non-significant) difference in the same direction in the experimental section. Finally, if one were to make an adjustment for the change in the control, and applied this to the results in the experimental waters, it would not lead to a significant difference in the experimental waters.

The estimates of angler catches equal angling mortality. Total mortality minus angling mortality leaves natural mortality (Fig. 2).

Empirically determined average fishing mortalities in the Hunt Creek test waters and periods were observed as follows: 0-I, 1-2%; I-II, 20-32%; II-III, 15-41%.

There were no statistically significant ($P > 0.05$) differences in fishing mortalities for ages 0-I and I-II between years or between areas (Fig. 2). Only for the fishing mortality from age II to age III were significant differences observed. Fishing mortality was higher in BC than in ZA during the years when the flies-only rule applied ($.001 < P < .005$), and was significantly higher in ZA during the period when normal regulations were in force than during years of flies-only fishing ($.025 < P < .05$). The latter difference is explained in part by the higher angling pressure in ZA during the 10 normal years (295 hours per acre) as compared with the fishing intensity during the years when it was fished with flies only (180 hours per acre).

In comparing fishing mortality between ZA and BC during the 5 years when ZA was fished with flies only, again noticeably higher angling pressure in BC (360 hours/acre) probably was responsible for the greater fishing mortality than in ZA (only 180 hours/acre).

Examination of the mortality data indicated that no significant differences in total mortality between age groups resulted in ZA from application of the flies-only regulation. Angling mortality was reduced slightly in ZA during years when fishing was done under a flies-only rule, but only between ages II and III.

It is concluded that restriction of the lure to flies did not significantly alter the composition of the brook trout population in area ZA of Hunt Creek. This is further borne out by inspection of the survivorship curves (Fig. 3) for the ZA and BC populations during the respective time periods.

North Branch Au Sable brook trout

During the 1961-1967 trout seasons the upper and lower ~~areas~~ were fished under a flies-only rule, a 9-inch minimum size limit, and a 5-fish-daily creel limit. The middle ~~area~~ was subjected to angling under "normal" Michigan trout stream rules (any lure, 7-inch minimum size limit, 10-fish-daily creel limit).

On this stream, populations of trout were much higher than on Hunt Creek because of the much greater stream areas over which the observations were made. The average fall populations of brook trout are shown in Table 6 in some detail along with the average annual angling pressures and catch. All data were reduced to a per mile basis.

Details of the annual fall population estimates for brook trout in the upper ~~(4.2 miles)~~, middle ~~(6.9 miles)~~ and lower ~~(8.7 miles)~~ sections of the North Branch are shown by age groups in Tables 7, 8 and 9 for the years 1960-1967, along with angler removals for the 1961-1967 trout seasons.

The average total mortality between the age groups is shown in Table 10 for the three experimental stream areas, and is derived from the information contained in Tables 7, 8 and 9. The average total mortalities for North Branch brook trout in the three test sections had the following ranges: 0-I, 75-84%; I-II, 82-95%; and II-III, 94-98% (Table 10).

The total annual mortalities of brook trout in the North Branch were generally higher and more variable than for brook trout in Hunt

Creek. Average total mortality among brook trout in the middle section was significantly higher ($P<0.05$) than in the upper section. Total mortality was also higher in the middle section than in the lower, but only for age-groups 0-I and I-II. Between the upper and lower sections mortality for age-groups 0-I and I-II did not differ significantly, but for age II-III there was significantly higher total mortality in the lower experimental section than in the upper ($0.025<P<0.05$), the reasons for which are not clear, since both sections were fished under the same special rules. The noticeable difference in angling pressures may offer an explanation (Table 6).

As before, fishing mortality between consecutive age groups was determined separately using creel census and age distribution estimates (Fig. 4).

Average fishing mortality on brook trout populations for the two flies-only sections and the one any-lure section were as follows: 0-I, flies-only, 0.01 and 0.6%, any lure, 6%; I-II, flies-only, 1 and 12%, any lure, 48%; and II-III, flies-only, 2 and 12%, any lure, 78%.

Annual fishing mortality within each age group was significantly greater in the middle experimental section than in the upper and lower experimental sections ($P<0.001$ in all instances); fishing mortality also was consistently greater for all age groups in the upper experimental section than in the lower ($P<0.001$ to 0.025).

The Hunt Creek data indicated that restriction of the lure to artificial fly is a negligible factor in altering the mortality trends of a brook trout population, and it is assumed that this also applies to the

North Branch. Hunt (1964) found, in investigations on Lawrence Creek, Wisconsin, that bag limits were not effective in altering brook trout population structures of that stream. His evidence, like that presented here, strongly indicates that the minimum legal length probably is a major factor affecting the population structure. On the middle 6.9 miles of the North Branch, the 7-inch minimum legal length permitted the harvesting of the faster-growing brook trout during their second summer of life. The 9-inch minimum size limit enforced in the upper and lower stream sections does not allow harvest of second-summer trout, and even limits harvest to the faster-growing third-summer trout, as examination of the North Branch data will demonstrate. Survivorship curves for the North Branch brook trout are shown in Figure 5.

Side effects of regulation changes, which modify long-established angling patterns, also probably are factors in changing the population structure by inducing significant changes in the angling pressure on stream areas with angling rules more restrictive as to lure, minimum legal length, and noticeably lower daily creel limits.

North Branch brown trout

On the experimental stream sections of the North Branch, brown trout population data and angler catches were collected concurrently with that concerning brook trout. Brown trout were fished under the same angling regulations as brook trout. Average fall populations of brown trout, and the average seasonal catches for the three experimental stream sections are listed in Table 11. The information concerning estimated

catches and estimated populations of brown trout sub-divided by age groups, in the experimental stream sections is given in Tables 12, 13 and 14.

From the population estimates the average total mortality between age groups, from 0 through V, was determined (Table 15), and these were observed as follows in the several sections: 0-I, fly, 63 and 77%, any lure, 63%; I-II, fly, 59 and 60%, any lure, 44%; II-III, fly 59 and 77%, any lure, 65%; III-IV, fly, 81 and 84%, any lure, 78%; and IV-V, fly 68 and 82%, any lure, 82%.

Despite pronounced differences in the angling regulations enforced on the experimental sections of the North Branch, the average total mortality of brown trout in the middle section was either the same or less than observed in the restricted upper and lower experimental sections. The only significant difference found was in mortality for age-group 0-I, where more young brown trout died in the lower section (probability = 0.05+) than in either the middle or upper section.

Total mortality for age groups did not differ between the middle and upper section (probability values for 0-I, and for II-III, III-IV and IV-V were more than 0.50; for I-II, $0.10 < P < 0.20$). Only when average total mortality was compared between the middle and lower sections were significant differences found. Among age-groups 0-I, I-II and II-III of the lower section, a larger fraction died than among their counterparts in the middle section (probability values ranged between 0.01 and 0.05).

Differences noted for mortalities from ages III-IV and IV-V were not measurably different in the upper and lower sections ($0.20 < P < 0.40$).

North Branch brown trout had the following average fishing mortalities between 1961 and 1967 for the various ages: 0-I, 0.05-7%; I-II, 20-100%; II-III, 10-34%; III-IV, 2-16%; IV-V, 0-21%. Generally, significantly greater angling mortalities were noted in the middle section than in either the lower or upper stream sections (Fig. 6). Differences between the upper and lower experimental areas were significant only for age-groups I-II and III-IV, and also are probably related to differences in average angling pressure on the two waters. Brown trout survivorship curves for the three North Branch populations are shown in Figure 7.

Discussion

The present investigations, and those of Hunt (1964) on Lawrence Creek in Wisconsin, strongly suggest that, for brook trout, restriction of the lure to artificial fly, and lowered bag limits have no significant effect on the population structure or the anglers' catch, at least under angling pressures observed to date. The North Branch Au Sable data indicate that an increased minimum size limit did lower brook trout total mortality and angling mortality by a significant amount in those sections where it was applied, the reason being that a 9-inch minimum length protected a high fraction of 7.0-8.9-inch brook trout from angling through their second and third summers of life. However, natural mortality after age II left relatively few brook trout larger than 9 inches for the anglers in later years (see tables).

The effect of the restrictions on brown trout, judging from the North Branch Au Sable investigations, was similar to that observed for brook trout. Total mortality, in the experimental stream sections where angling was conducted under special regulations, was not significantly less than in the experimental stream section fished under normal Michigan trout stream rules. Angling mortality was greatest in the middle experimental stream section for two reasons: (1) a lower (7-inch) minimum size limit which allowed anglers to harvest more age I and age II brown trout than in the upper and lower experimental sections, where a 9-inch minimum length applied; and (2) significantly higher angling pressure. Despite the creeling of significant numbers of second- and third-summer brown trout in the middle experimental section, this same section yielded more fish among the older age groups than did the upper and lower experimental sections (presumably protected by the special restrictions). The survivorship curves for the trout populations provide some visual evidence on the effect of special rules on stream trout populations (see figures).

The information discussed in this paper strongly suggests that regulations more restrictive than the normal Michigan trout stream regulations have not altered trout population structures on the test streams in such a manner as to provide more fish for any extended period of time, or larger fish, or stimulated more angling on the stream sections to which special regulations were applied.

However, it should be pointed out that almost all of the tests involving special regulations have been conducted to date in streams or stream areas with good to excellent natural reproduction, where potential differences in hooking mortality between natural and artificial lures are masked or offset by other causes of death. There is still the possibility that in submarginal trout waters, where recruitment is limited, but growth is good, an increase in trout production might be obtained, with a combination of lure restriction and minimum size limit that permitted better survival.

Future experiments should include provisions to regulate fishing pressure at equal levels under the different regulations tested. In the past, where anglers had a choice of regulations under which they might fish, angling pressure dropped significantly on those areas subjected to the more stringent set of rules. Often this difference in angling pressure has made interpretation of the results difficult.

Acknowledgments

I want to acknowledge the assistance of all Hunt Creek Fisheries Research Station staff members, past and present, who have aided in the collection of, and preliminary calculations on the data presented. Gaylord R. Alexander and Dr. G. P. Cooper reviewed the manuscript and Daniel Vokovich drafted the figures.

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Table 1.--Average fall brook trout populations, 1950-1965

Hunt Creek experimental sections, by inch classes

Stream section	Length (miles)	Area (acres)	Numbers in various inch-classes				Total brook trout all sizes
			2.0-4.9	5.0-6.9	7.0-8.9	9.0-13.9	
BC	0.84	1.35	2,445	513	67	7	3,032
ZA	0.91	2.56	2,916	918	177	18	4,029

Table 2.--Average angling pressure and catch, Hunt Creek experimental sections, during years of flies only fishing in ZA, and all other years between 1951-1965

Stream section	Time period	Average hours per season	Average catch of legal brook trout [1]
ZA	1955-1959	561	289
BC	1955-1959	598	229
ZA	All other years	755	377
BC	All other years	460	177

[1] Larger than 7 inches, total length.

Table 3.--Annual fall brook trout population estimates 1950-1964, area ZA, Hunt Creek, and annual angler catches, 1951-1965

Brood year	Year of catch	Age distribution in population and catch								Totals	
		0	I		II		III		IV		
		Population	Catch	Population	Catch	Population	Catch	Population	Catch	Population	Catch
1949		2,077		1,438		218		6		0	3,739
	1951		13		167		27		0		207
1950		2,348		1,318		200		5		0	3,871
	1952		8		249		92		4		353
1951		2,741		1,087		165		11			4,004
	1953		16		215		74		4		309
1952		3,572		1,041		118		8			4,739
	1954		33		160		94		6		293
1953		3,449		1,298		144		7			4,898
	1955		7		265		83		2		357
1954		2,676		1,324		232		13			4,245
	1956		43		291		37		0		371
1955		2,644		913		268		36		2	3,863
	1957		53		200		29		0		282
1956		4,157		918		167		20		1	5,263
	1958		5		180		7		0		192

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Table 3.--concluded

Brood year	Year of catch	Age distribution in population and catch								Totals	
		0	I		II		III		IV		
		Population	Catch	Population	Catch	Population	Catch	Population	Catch	Population	Catch
1957		2,738		1,462		199		14		1	4,414
	1959		4		203		34		0		241
1958		1,983		1,521		502		47			4,053
	1960		70		565		198		11		845[a]
1959		2,908		1,201		284		33		2	4,428
	1961		12		270		68		3		353
1960		1,561		1,189		267		13			3,030
	1962		67		446		80		5		598
1961		2,670		911		284		37		1	3,903
	1963		23		246		16		0		285
1962		2,060		1,115		203		8			3,386
	1964		4		235		33		2		274
1963		2,124		943		196		25		1	3,289
	1965		7		194		54		1		257[a]
1964		2,137		978		200		19		2	3,336
	1966		0		0		0		0		0[b]

[a] Includes one age-V brook trout in indicated years.

[b] Stream closed to angling 1966-1970 by Michigan Conservation Commission order.

Table 4.--Annual fall brook trout population estimates, 1950-1964, area BC, Hunt Creek, and annual angler catches, 1951-1965

Brood year	Year of catch	Age distribution in population and catch								Totals	
		0	I		II		III		IV		
		Population	Catch	Population	Catch	Population	Catch	Population	Catch	Population	Catch
1949		1,864		596		147		13		1	2,621
	1951		5		103		34		0		142
1950		1,940		621		93		8		1	2,663
	1952		15		129		18		0		162
1951		2,294		675		95		5		0	3,069
	1953		4		66		39		0		109
1952		1,817		596		56		4		0	2,473
	1954		8		99		27		0		134
1953		2,875		738		90		4		2	3,709
	1955		9		139		49		2		199
1954		1,559		1,004		149		9		1	2,722
	1956		12		239		43		2		296
1955		2,307		699		126		10		0	3,142
	1957		26		124		46		4		200
1956		2,548		880		138		13		0	3,579
	1958		3		194		28		1		226

(Continued, next page)

Table 4.--concluded

Brood year	Year of catch	Age distribution in population and catch								Totals	
		0	I		II		III		IV		
		Population	Catch	Population	Catch	Population	Catch	Population	Catch	Population	Catch
1957		2,361		1,191		154		12		3,719	
	1959		1		167		55		2		225
1958		2,055		876		180		20		3,133	
	1960		14		197		31		0		242
1959		2,149		1,016		187		14		3,367	
	1961		7		138		54		0		199
1960		1,248		828		144		7		2,228	
	1962		17		218		40		1		276
1961		2,383		680		161		14		3,240	
	1963		9		110		51		3		173
1962		2,180		988		140		8		3,317	
	1964		2		116		70		4		192
1963		1,733		829		99		8		2,670	
	1965		0		103		35		2		140
1964		1,957		785		113		6		2,861	
	1966		0		0		0		0		0[a]

[a] Stream closed to angling 1966-1970 by Michigan Conservation Commission order.

Table 5.--Average total mortality in per cent between age groups for Hunt Creek brook trout

Section:Years	Age		
	0-I	I-II	II-III
ZA: Flies only	61	78	90
ZA: Normal	54	81	91
BC: Flies only	60	84	91
BC: Normal	60	84	93

Table 6.--Average brook trout angling data, North Branch Au Sable River experimental sections, 1961-1967, and average fall brook trout populations, 1961-1967,* for the same waters. Data given on a per mile basis.

Stream section	Length (miles)	Estimated fall population of various inch-classes				Total brook trout all sizes	Hours of angling	Estimated angler catch in inch-classes		Total catch, brook trout
		2.0-4.9	5.0-6.9	7.0-8.9	9.0-13.9			7.0-8.9	9.0-13.9	
Upper	4.2	4,147	670	609	76	5,502	561	-	120	120
Middle	6.9	7,211	744	552	23	8,530	3,535	880	96	976
Lower	8.7	8,412	1,234	632	45	10,323	1,265	-	18	18

* 1960-68 data were used in lower section to gain one more sample. This section has been under special regulations since 1955, whereas 1960 population data could not be used for the middle and upper sections, because the angling regulations were reversed at the end of the 1960 season in these two waters.

Table 7.--Annual fall brook trout population estimates, upper section North Branch Au Sable River, 1960-1967, and estimated anglers' catch, 1961-1967. Data are given on a per mile basis.

Brood year	Year of catch	Age distribution in population and catch								Totals	
		0	I		II		III		IV		
		Population	Catch	Population	Catch	Population	Catch	Population	Catch	Population	Catch
1959		5,152		562		55		4		5,775	
	1961		0		32		2		0		34
1960		7,833		783		103		3		8,722	
	1962		0		68		13		0		81
1961		5,752		848		146		8		6,755	
	1963		0		94		20		0		114
1962		3,268		1,215		116		2		4,601	
	1964		4		191		32		0		227
1963		3,079		1,138		249		11		4,477	
	1965		1		103		27		0		131
1964		4,205		1,165		292		26		5,689	
	1966		0		79		15		0		94
1965		3,402		1,416		239		10		5,067	
	1967		8		131		23		0		162
1966		1,361		1,620		213		12		3,207	

Table 8.--Annual fall brook trout population estimates, middle section North Branch Au Sable River, 1960-1967, and estimated anglers' catch, 1961-1967. Data are given on a per mile basis.

Brood year	Year of catch	Age distribution in population and catch						Totals	
		0	I		II		III		
		Population	Catch	Population	Catch	Population	Catch	Population	Catch
1959		12,432		1,302		187		13,925	
	1961		313		274		17		604
1960		7,797		1,024		34		8,855	
	1962		517		268		12		797
1961		9,154		1,272		74		10,503	
	1963		705		925		69		1,699
1962		6,601		1,754		57		8,412	
	1964		208		758		62		1,028
1963		6,606		1,294		103		8,004	
	1965		245		330		25		600
1964		9,312		875		49		10,236	
	1966		455		619		42		1,116
1965		7,157		1,346		40		8,544	
	1967		321		616		49		986
1966		4,142		2,120		61		6,324	

Table 9.--Annual fall brook trout population estimates, lower section, North Branch Au Sable River, 1960-1967, and estimated anglers' catch, 1961-1967. Data are given on a per mile basis.

Brood year	Year of catch	Age distribution in population and catch						Totals	
		0	I		II		III		
		Population	Catch	Population	Catch	Population	Catch	Population	Catch
1959		10,678		2,297		340		13,332	
	1961		0		4		1		5
1960		11,033		1,952		224		13,219	
	1962		0		9		2		11
1961		8,327		2,309		230		10,869	
	1963		0		22		5		27
1962		7,504		2,423		340		10,271	
	1964		0		20		8		28
1963		8,385		1,670		322		10,386	
	1965		0		14		3		17
1964		7,630		1,310		223		9,171	
	1966		0		18		4		22
1965		6,269		1,174		191		7,637	
	1967		0		15		3		18
1966		6,253		1,191		256		7,703	

Table 10.--Average total mortality in per cent for age groups of North Branch brook trout

Section	Age		
	0-I	I-II	II-III
Lower	80	85	98
Middle	84	95	98
Upper	75	82	94

Table 11.--Average brown trout angling data, North Branch Au Sable River experimental sections, 1961-1967, and average fall brown trout populations, 1961-1967,* for the same waters. Data given on a per mile basis.

Stream section	Length (miles)	Estimated fall population of various inch-classes				Total brown trout all sizes	Hours of angling	Estimated angler catch in inch-classes		Total catch, brown trout
		2.0-4.9	5.0-6.9	7.0-8.9	9.0-25.9			7.0-8.9	9.0-25.9	
Upper	4.2	911	32	270	320	1,533	561	-	59	59
Middle	6.9	1,963	85	583	689	3,320	3,535	116	408	524
Lower	8.7	4,844	231	793	559	6,427	1,265	-	156	156

* 1960-68 data were used in lower section to gain one more sample. This section has been under special regulations since 1955, whereas 1960 population data could not be used for the middle and upper sections, because the angling regulations were reversed at the end of the 1960 season in these two waters.

Table 12.--Annual fall brown trout population estimates, upper section, North Branch Au Sable River, 1960-1967, and estimated anglers' catches, 1961-1967. Data are given on a per mile basis.

Brood year	Year of catch	Age distribution in population and catch												Totals	
		0	I		II		III		IV		V	VI	VII		
		Population	Catch	Population	Catch	Population	Catch	Population	Catch	Population	Population	Population	Population	Population	Catch
1959		1,579		258		140		52		12	3	2	1	2,047	
	1961		0		12		3		0						15
1960		1,900		332		61		14		5	1	1	0	2,314	
	1962		1		36		10		1						48
1961		1,895		615		135		71		8	1	1	0	2,726	
	1963		1		55		5		0						61
1962		573		438		137		31		4	1	1	0	1,185	
	1964		2		102		16		0						120
1963		153		275		276		136		18	5	2	1	866	
	1965		3		47		10		2						62
1964		413		260		224		107		15	4	2	0	1,025	
	1966		1		45		9		0						55
1965		1,081		364		75		26		4	1	1	0	1,552	
	1967		2		46		7		1						56
1966		399		501		135		40		6	1	1	0	1,083	

Table 13.--Annual fall brown trout population estimates, middle section, North Branch Au Sable River, 1960-1967, and estimated anglers' catch, 1961-1967. Data are given on a per mile basis.

Brood year	Year of catch	Age distribution of population and catch												Totals	
		0	I		II		III		IV		V		VI		
		Population	Catch	Population	Catch	Population	Catch	Population	Catch	Population	Catch	Population	Catch	Population	Catch
1959		2,625		497		279		136		38		7		1	3,583	
	1961		66		154		47		11		3		0			281
1960		2,342		446		100		39		15		3		0	2,945	
	1962		113		188		54		16		1		0			372
1961		1,731		808		242		78		23		4		1	2,887	
	1963		156		540		134		31		12		0			873
1962		620		943		473		100		18		4		1	2,159	
	1964		58		437		105		21		11		0			632
1963		1,555		546		695		222		32		5		1	3,056	
	1965		52		201		52		12		4		0			321
1964		2,201		694		352		169		36		6		1	3,459	
	1966		116		393		101		26		6		0			642
1965		3,623		1,005		398		148		30		5		1	5,210	
	1967		74		357		88		19		8		0			546
1966		1,791		1,058		483		142		38		7		1	3,520	

Table 14.--Annual fall brown trout population estimates, lower section, North Branch Au Sable River, 1960-1967, and estimated anglers' catch, 1961-1967. Data are given on a per mile basis.

Brood year	Year of catch	Age distribution in population and catch												Totals	
		0	I		II		III		IV		V	VII	IX		
		Population	Catch	Population	Catch	Population	Catch	Population	Catch	Population	Catch	Population	Population	Population	Catch
1959		4,484		620		340		101		35		7	3	2	5,592	
	1961		0		30		8		5		0					43
1960		5,518		704		175		175		74		15	5	5	6,671	
	1962		2		59		11		8		0					80
1961		4,249		1,450		297		78		20		5	1	1	6,101	
	1963		3		169		39		16		0					227
1962		3,195		1,129		477		58		10		2	0	0	4,871	
	1964		4		166		41		11		0					222
1963		4,358		1,415		587		101		4		3	0	0	6,468	
	1965		1		131		23		8		0					163
1964		3,889		980		543		193		30		6	1	0	5,642	
	1966		2		139		33		16		0					190
1965		7,926		997		357		107		20		4	0	0	9,411	
	1967		1		116		30		18		0					165
1966		5,224		950		361		111		22		7	1	1	6,677	

Table 15.--Average total mortality in per cent between age groups for North Branch brown trout

Section	Age				
	0-I	I-II	II-III	III-IV	IV-V
Upper	63	59	59	84	82
Middle	63	44	65	78	82
Lower	77	60	77	81	68

Legends for figures

Figure 1.--Map of Michigan's lower peninsula showing location of Hunt Creek and North Branch Au Sable River.

Figure 2.--Average per cent of angling mortality and natural mortality between age groups of brook trout, experimental sections, Hunt Creek, with and without the flies-only regulation.

Figure 3.--Survivorship curves, Hunt Creek brook trout.

Figure 4.--Average per cent of angling mortality between age groups of brook trout, experimental sections, North Branch Au Sable River.

Figure 5.--Survivorship curves, North Branch Au Sable River brook trout.

Figure 6.--Average per cent of angling mortality and natural mortality between age groups of brown trout, experimental sections, North Branch Au Sable River.[1]

Figure 7.--Survivorship curves, North Branch Au Sable River brown trout.

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[1] The data for angling mortality between ages I-II, middle section, obviously are not realistic. The averages shown result from products of (1) estimates of species composition, (2) estimates of age composition, (3) estimates of hours of fishing, and (4) estimates of rate of catch of anglers, all of which have their own variance.

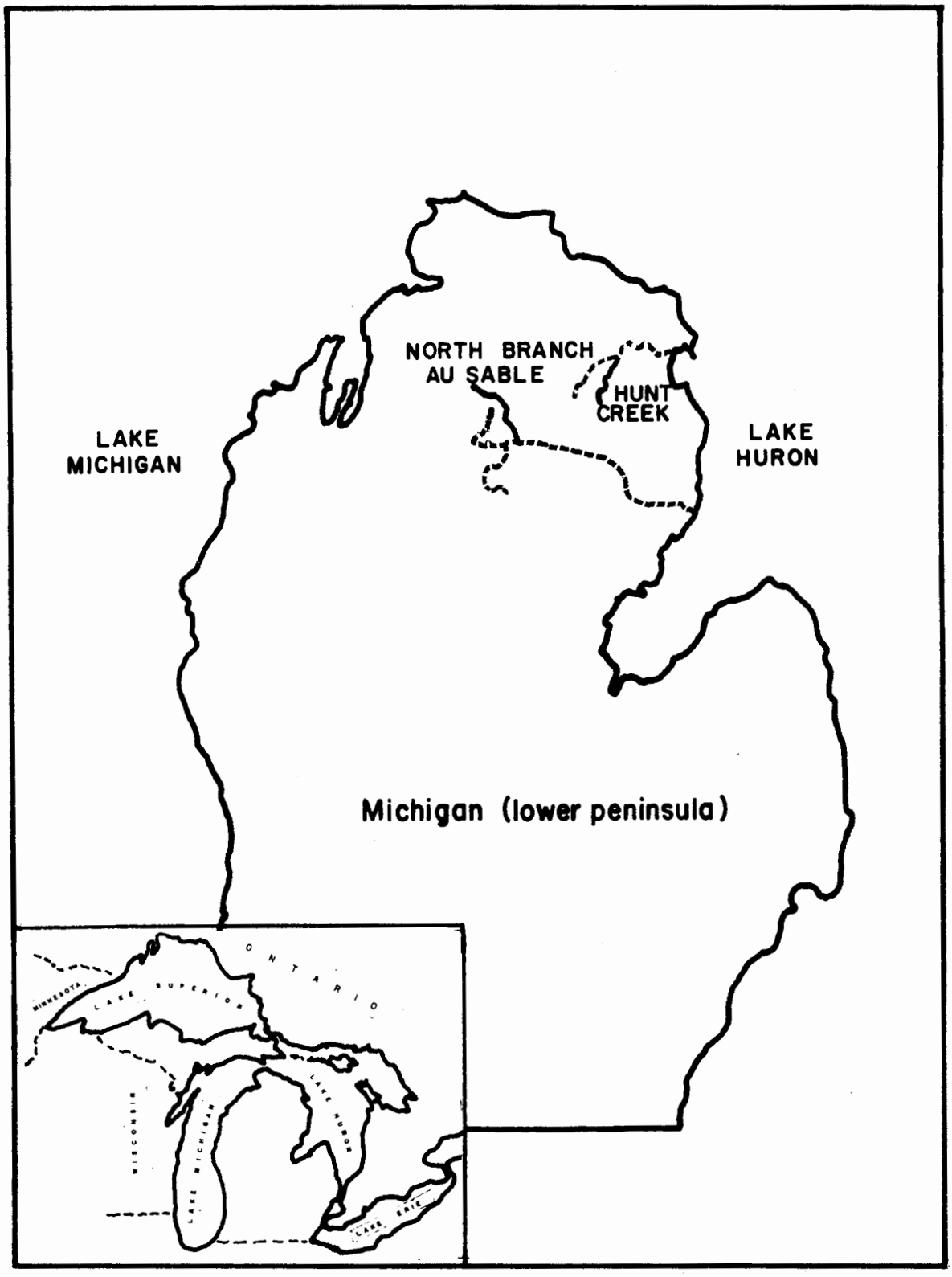

Figure 1.--Map of Michigan's lower peninsula showing location of Hunt Creek and North Branch Au Sable River.

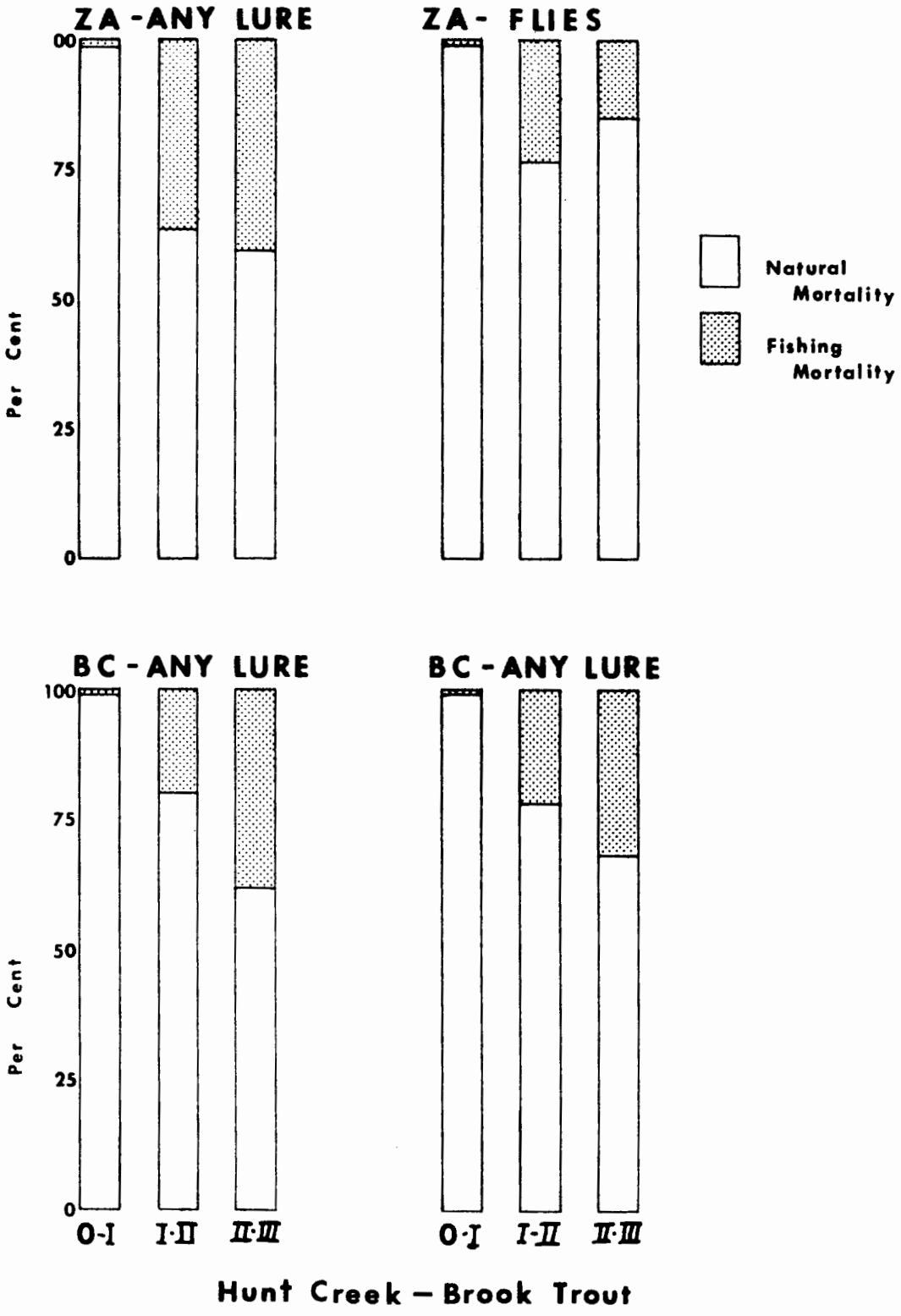

Figure 2. --Average per cent of angling mortality and natural mortality between age groups of brook trout, experimental sections, Hunt Creek, with and without the flies-only regulation.

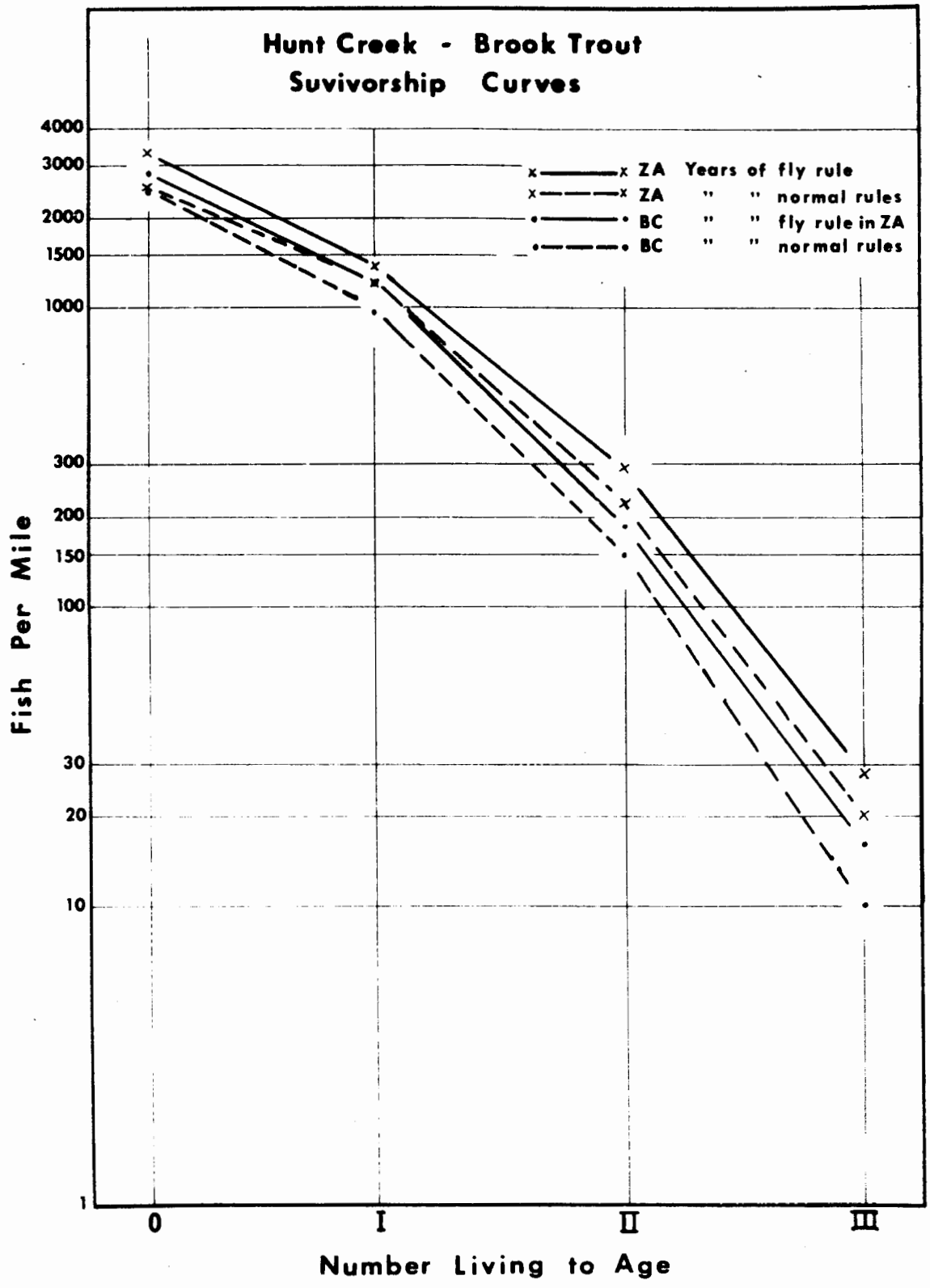

Figure 3--Survivorship curves, Hunt Creek brook trout.

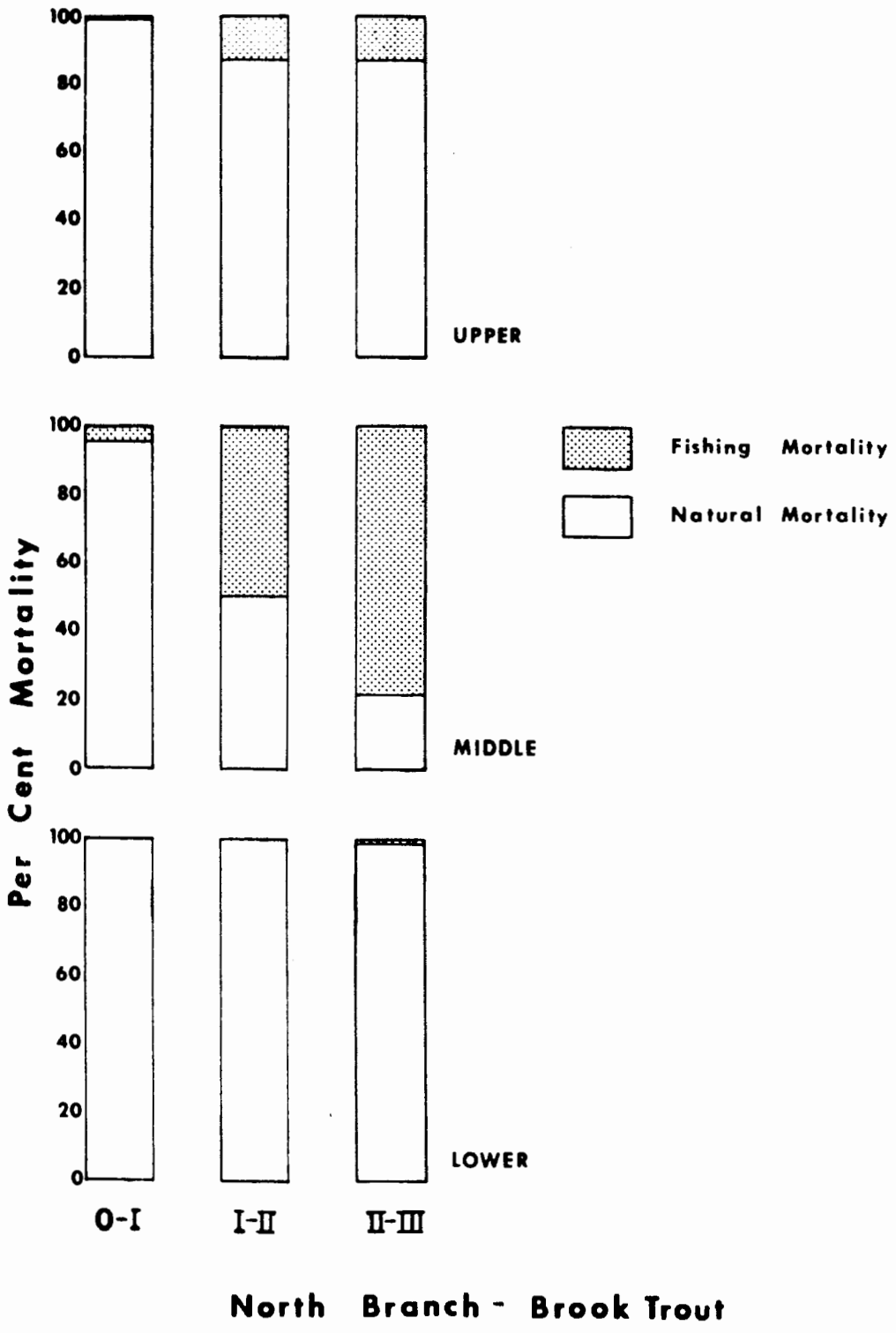

Figure 4. --Average per cent of angling mortality between age groups of brook trout, experimental sections, North Branch Au Sable River.

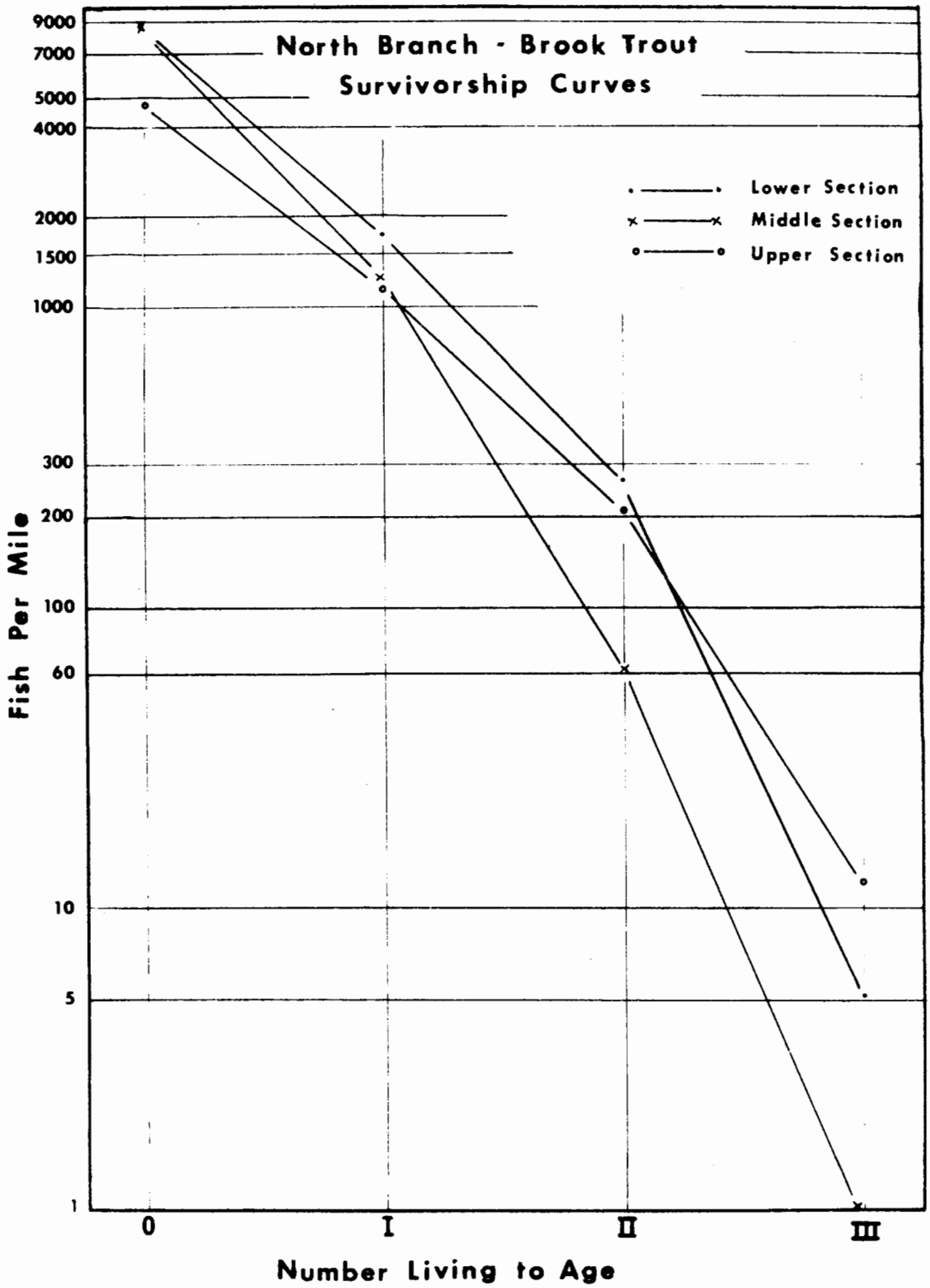

Figure 5. --Survivorship curves, North Branch Au Sable River brook trout.

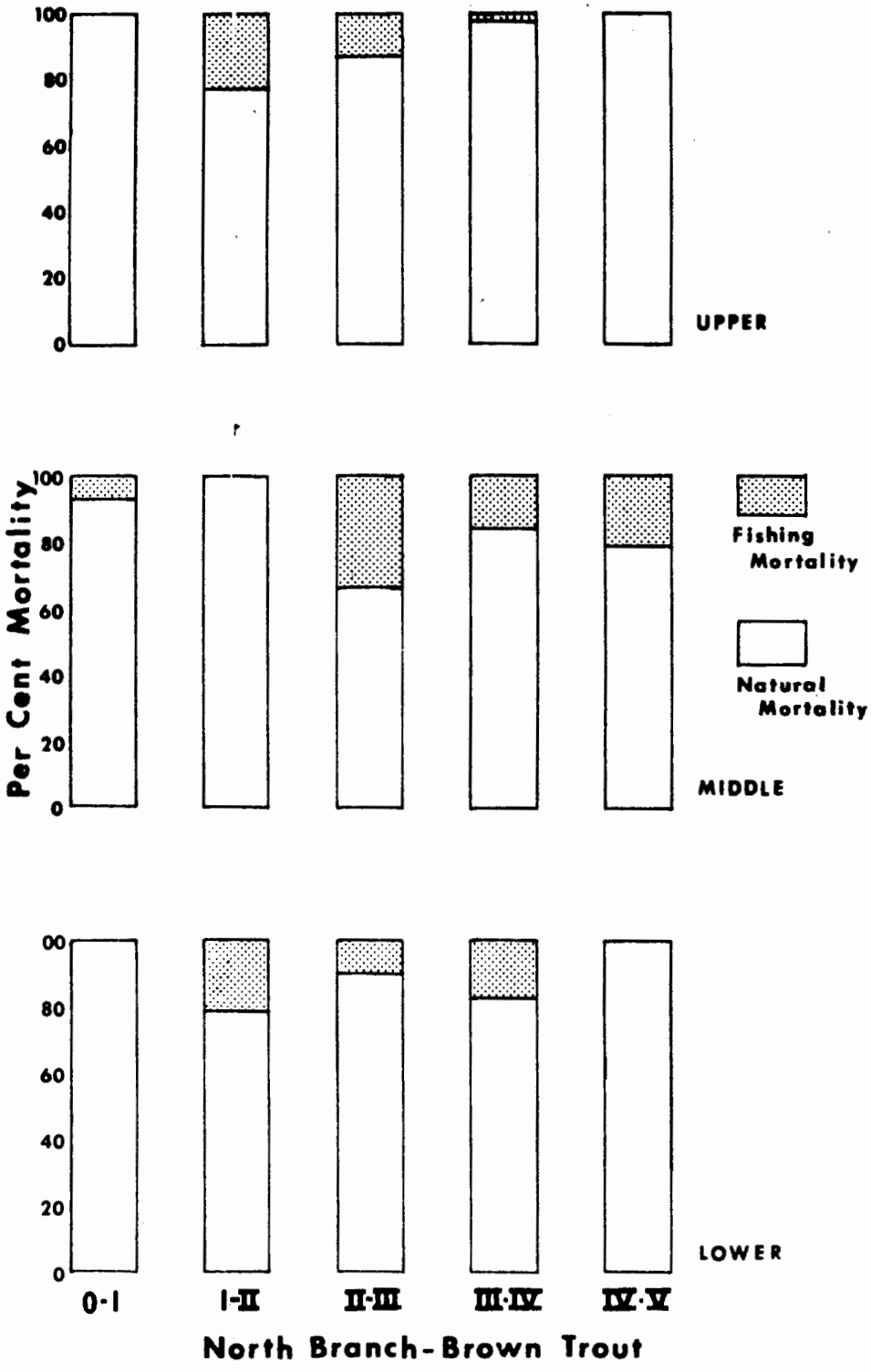

Figure 6.--Average per cent of angling mortality and natural mortality between age groups of brown trout, experimental sections, North Branch Au Sable River. (The data for angling mortality between ages I-II, middle section, obviously are not realistic. The averages shown result from products of (1) estimates of species composition, (2) estimates of age composition, (3) estimates of hours of fishing, and (4) estimates of rate of catch of anglers, all of which have their own variance.)

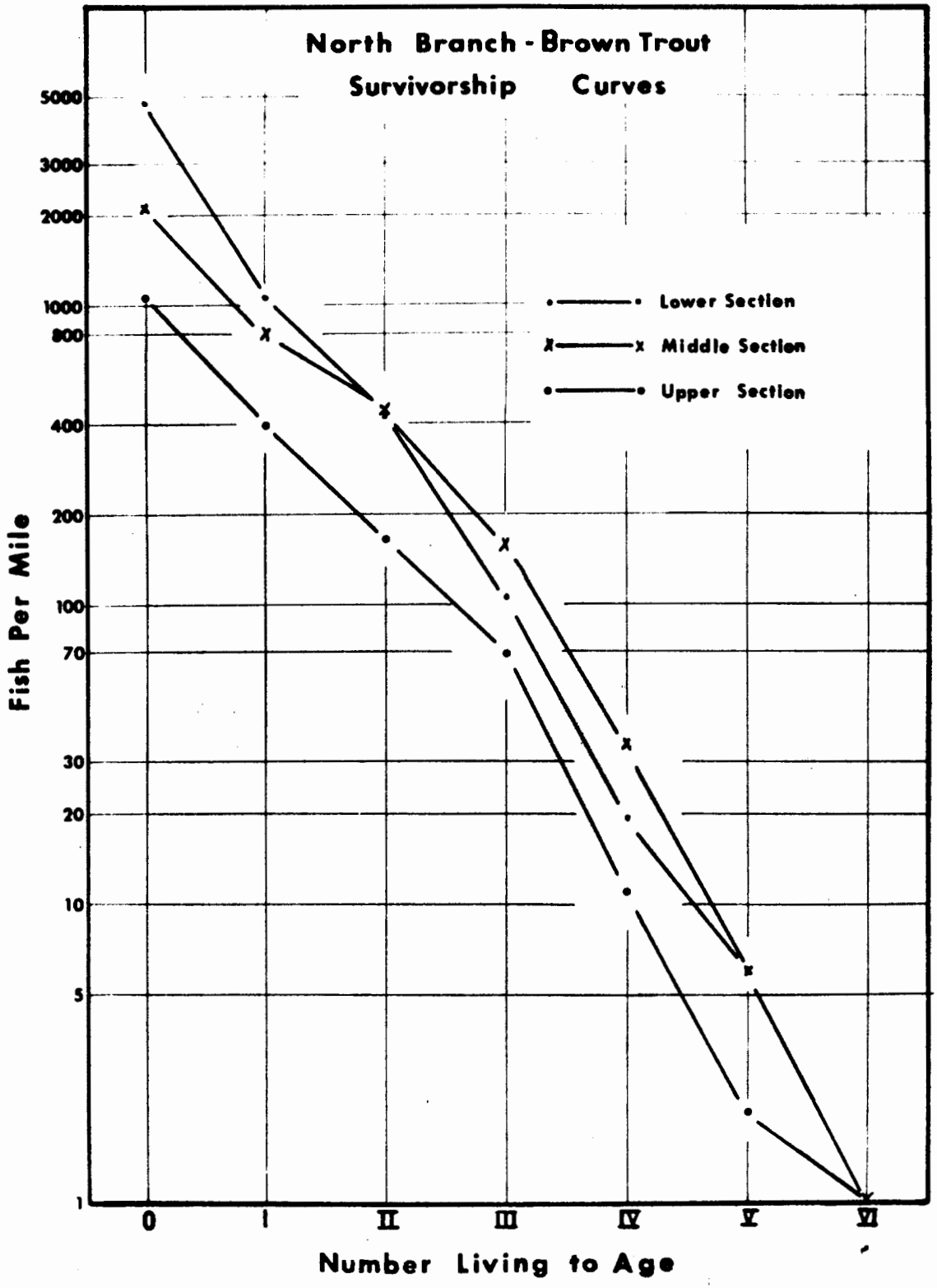

Figure 7.--Survivorship curves, North Branch Au Sable River brown trout.