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ABUNDANCE, GROWTH, BIOMASS, AND INTERRELATIONSHIP OF TROUT AND COHO SALMON IN THE PLATTE RIVER [1]

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ABSTRACT

Since 1966, large numbers of coho salmon have been planted in the states that border the Great Lakes, especially in Michigan. Soon after this species was introduced, research was begun on its relationships with trout in streams. The present study was conducted on the Platte River, a tributary of Lake Michigan in Benzie County, from April 1967 through September 1972. The main goal of the investigation was to determine whether or not the addition of coho salmon would cause a decrease in numbers and growth of trout.

Most of the field work was done in three 1-mile sections of the river, that included areas in which salmon were excluded. The number of brown trout, rainbow trout, and juvenile coho salmon that inhabited these sections was estimated annually in April and September. Scales and measurement data were obtained from trout at these times, and also in June and July.

Coho salmon exerted no detectable effect on growth or numbers of young or older brown or rainbow trout, with the exception of young brown trout in the experimental section most heavily used by spawning coho. In this section the coho salmon caused a moderate decrease in brown trout reproduction. For the years 1968 to 1972 there was a significant decrease in numbers of age-0 brown trout in comparison with 1967. But the decreases had little effect on the population of these year classes at older ages. Reduction in number of young brown trout was compensated by a better rate of survival to the older ages.

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Doris S. Greenleaf and Albert Vincent prepared the scale impressions.

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James R. Ryckman did much statistical work. Sandra Shaw transferred data to punch cards for calculations done by computer. Alan D. Sutton drafted the figures.

Thomas M. Stauffer was responsible for the administration of this study; he also contributed extensively to the editing of reports on the results. William C. Latta and Gerald P. Cooper advised on procedure and edited the report. Sandra Shaw and Barbara Lowell assisted in typing.

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INTRODUCTION

Development of the present salmon fisheries in the Great Lakes region commenced a little over 10 years ago. The work with coho salmon (Oncorhynchus kisutch) began with an allotment of eggs that the Oregon Fish Commission presented to the State of Michigan in the fall of 1964. Coho that hatched from these eggs were released in three streams[2] as yearlings in March and May 1966. Success of the releases became apparent in Lake Michigan soon thereafter [4],[*] and plans were drawn to expand the salmon rearing and planting program. Included with these plans was a proposal that relationships between coho salmon and trout be investigated. The Research and Development Division was assigned the responsibility of organizing and conducting the investigations.[3] The Platte River was chosen as one of the research sites.[4]

Biological samples and data were collected on Platte River from April 1967 through September 1972. This report deals with various aspects of the populations of brown trout (Salmo trutta), rainbow trout (Salmo gairdneri), and coho salmon that inhabited experimental sections during that time. Finally, it evaluates the effect of coho salmon on the trout, the principal objective of the study. Several preceding reports [12, 13, 21, 23, 24, 25, 26, 27, 28, 29] contain background information and describe results of auxiliary studies.

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[2] Platte River, Benzie County; Bear Creek (a tributary of the Manistee River), Manistee County; Chinks Creek (a tributary of the Big Huron River), Baraga County.

[3] Carried on under the R & D Division until 1973. When this unit of the Department of Natural Resources was dissolved that year, the work was continued under the research section of the Fisheries Division.

[4] A similar study was carried out on five tributaries of Lake Superior during 1967-1974.

[*] The bracketed No. 4, and all other bracketed numbers in this report, refer to the numbered list of literature references given at the end of the report.

THE STUDY AREAS

General description of the river and its fish fauna

The Platte River drainage system is shown in Figure 1. The main stream, which rises from Lake Ann, is approximately 25 miles long. It averages around 50 feet wide; much of it is less than 3 feet deep, with some pools exceeding 5 feet. The bottom soils are mainly gravel, sand, and a mixture of sand and silt. Natural forest covers a large portion of the flood plain of the river and tributaries, and also a considerable portion of the upland. Other features of the surrounding upland are Christmas tree plantations, abandoned farm land, and a few active farms. People now use the river almost exclusively for recreation. Cottages and homes on or near its borders are few and mostly scattered.

Cold-water fishes live the year round in the 13-mile stretch of the main stream between Burnt Mill Road and Platte Lake. Elsewhere the river is generally unsuited for salmonids in summer because of warm water that flows in from lakes. In the other seasons, however, trout and salmon (mainly migrants from Lake Michigan) inhabit the latter areas also. The three principal tributaries (Brundage and Carter creeks and the North Branch) are cold-water streams.

The grayling (*Thymallus arcticus*), that inhabited Platte River when settlers came into this region in the 1860's, disappeared sometime between 1867 and 1895. Brook trout (*Salvelinus fontinalis*) which succeeded the grayling, were plentiful until around 1937; presently the brook trout is scarce in the tributaries as well as in the main stream. Rainbow trout and brown trout, which first appeared in this drainage system in the 1920's, now are the predominant salmonid fishes.

Coho salmon have come into Platte River from Lake Michigan on spawning runs since 1966; a migration of precocious (age-group I)

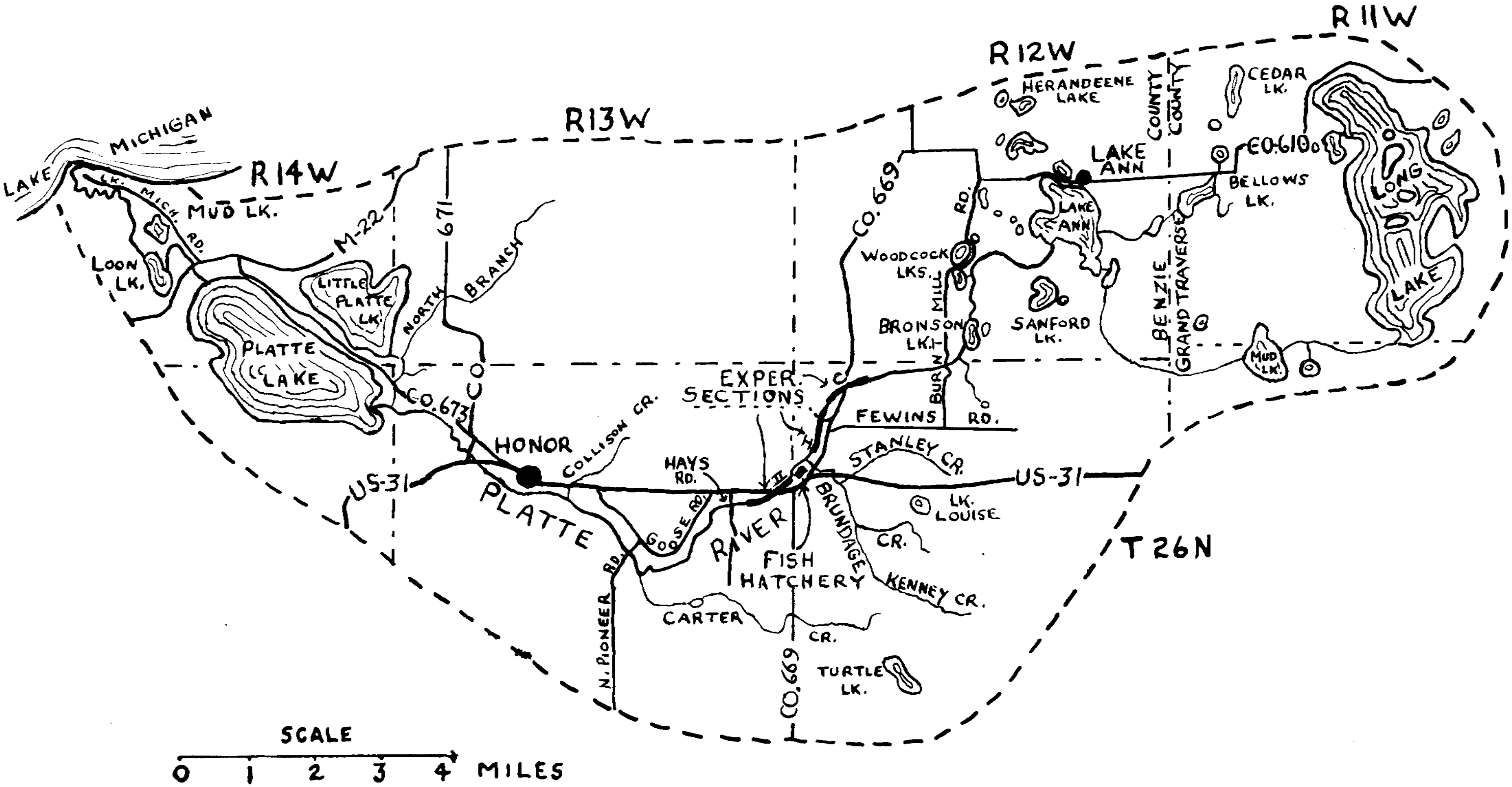

Figure 1.--The Platte River Watershed, in Benzie and Grand Traverse counties.

Copied, and modified, from "Platte River Watershed Reconnaissance Survey Report," by R. G. Wicklund and B. C. Dean, 1957.

males occurred that fall, and full-term (age-group II) coho entered the river in the fall of 1967. Naturally produced coho remain in the stream to the age of 1 year, at which time they emigrate to Lake Michigan in the spring at the size of 3-5 inches. Salmon that mature early (over 95% of which are males) return to the river the following fall. The bulk of the stock does not return until the second fall, and possibly some individuals remain in Lake Michigan a year longer.

Chinook salmon (Oncorhynchus tshawytscha) were planted in Platte River in 1971 and 1972. Small to moderate numbers of adults have appeared here in the fall each year beginning in 1969. Some of these fall-run fish quite certainly originated from plantings made in the Little Manistee River since 1967. In the population surveys, we caught only two fingerling chinook salmon, which evidently were of hatchery stock.

The cold-water stretch of the river harbors moderate numbers of sculpins (Cottus bairdi), and varying numbers of blacknose dace (Rhinichthys atratulus), creek chubs (Semotilus atromaculatus), and white suckers (Catostomus commersoni). Small numbers of several other species occur here also.

The 1-mile experimental sections

Most of the field work was done in three experimental sections, each 1 mile long. Their locations are indicated in Figure 1, and the relationship of one section to another is shown in some detail in Figure 2. Data on dimensions and bottom soils of the sections are tabulated herewith:

Section	Average width (feet)	Average depth (inches)	Area (acres)	Bottom soil (percent)		
				Gravel	Sand	Silt-sand
Control	48	10	5.8	71	8	21
I	44	12	5.3	58	25	17
II	44	15	5.3	57	31	12

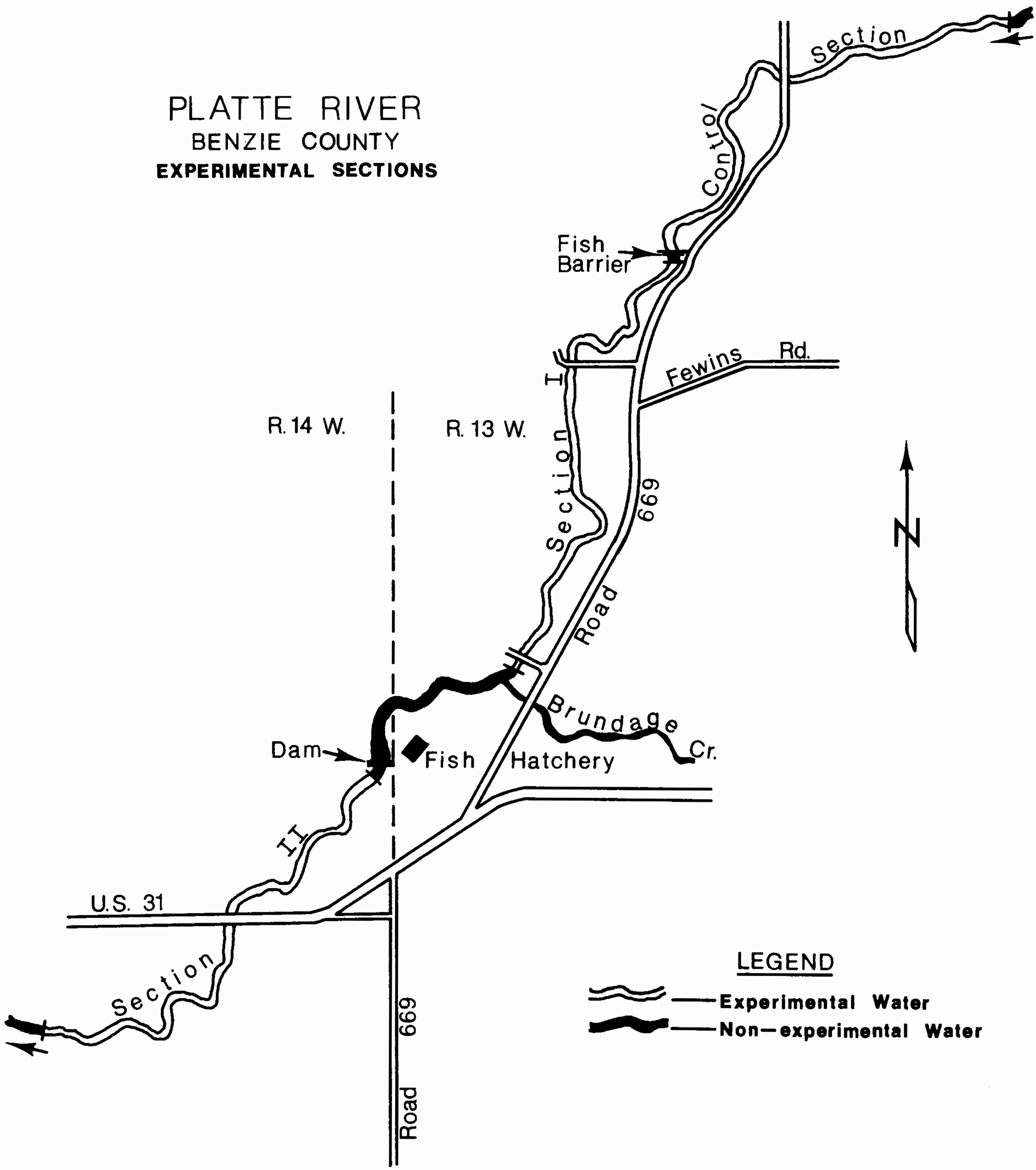

Figure 2. --Study area of the Platte River in which the 1-mile experimental sections are located.

Fish habitat improvement programs were carried out on the cold-water stretch of Platte River in 1949 and 1958. Current-control devices, and cover for fish (tree tops, logs, and stumps) were installed, banks were stabilized, and the channel was narrowed in some places. On the whole, structures and introduced cover endured quite well; by 1972, however, some of the cover had lost much of its effectiveness from deterioration or siltation.

The Control Section is divisible into two segments of almost equal length that are physically quite different. The portion below Benzie County Road 669 (Maple City Road) has the characteristics of a high quality trout stream--good pools, frequent riffle areas, and rivulets of spring inflow. The portion above the road has few good pools, much of it being broad and shallow, and there are few riffle areas. These differences are reflected in the trout populations, which are compared later on. The Control Section was kept as free of coho salmon as possible throughout the study to serve the purpose of its name. With little exception, this objective was achieved quite well. Before adult coho salmon were released in 1969 to allow them to spawn in Section I, a barricade consisting of steel piping was installed between Control Section and Section I to prevent adult salmon from passing upstream (Fig. 2). The barricade is described in detail in a preceding report [27].

Compared with the two distinctly different portions of the Control Section, Section I is intermediate in physical quality. That is, fish habitat in Section I as a whole is better than that in the upper half of the Control Section, but poorer than that in the lower half. Burial of large areas of gravel with sand is an unfavorable feature of Section I. A 200-foot riffle stretch, that commences about 200 feet below the upstream end of this section, is an especially good trout nursery area. Salmon were blocked quite effectively (by the dam of the weir at the hatchery) from entering Section I during the period from 1967 to 1969; this was done to allow study of trout before introduction of salmon. Adult coho were released in the falls of 1969, 1970, and 1971 for the purpose of populating Section I with young, followed by collection of data comparable to those obtained here through September 1969.

Section II also has much sand and silt-sand bottom, and riffle areas are even scarcer here than in Section I. Rate of flow in II is faster than in the two other sections. Outflow from the fish hatchery's water treatment ponds enters the river in the upper part of this section. Adult salmon had free access to Section II throughout the study.

Two 1480-foot sections

Population surveys were made in the falls of 1971 and 1972 in two 1480-foot sections, located several miles below Section II, to obtain information for supplementing that provided by the 1-mile sections. The first of these two sections was used by the Fisheries Division in the late 1950's and early 1960's to evaluate stream improvement work. Hence data from those years were available for comparing trout production as it was then, with production as it was in 1971 and 1972. This section is situated about 3 miles below Section II, in the west portion of township section 15, T. 26 N., R. 14 W. The upper end is approximately 100 feet above the place where a road formerly crossed the river, and where presently a foot bridge and a boulder monument (on right bank) are located, about 1/2 mile below North Pioneer Road. This section has a moderate rate of flow, a sizable number of good pools, good cover for fish, and a fair amount of exposed gravel bottom. It averages 54 feet wide. The surface area is 1.8 acres.

The second of the 1480-foot sections was selected to serve as a "control" on results obtained in the 1480-foot water in township section 15. It is located in township sections 9 and 16, T. 26 N., R. 14 W., and extends upstream from the tube under South Street in Honor. The current in this section is fast, so there is much exposed gravel, but this section has fewer pools and considerably less cover than the other. The average width is 45 feet. The area is 1.5 acres.

Fishing regulations and effort

The fishing season on brown trout and rainbow trout was quite liberal. Downstream from the US-31 bridge east of Honor, it opened on 1 April and continued through 31 December. The lower two-fifths of Section II and the two 1480-foot sections were under this regulation. Above this bridge, the general trout season was in effect, which commenced on the last Saturday in April and closed on the second Sunday in September through 1968; beginning in 1969 the season ended on 30 September.

Revised length and catch limits, which applied to the entire state, became effective with the opening of the trout season in 1969. Minimum legal length for brown and rainbow trout was increased from 7 to 10 inches, and the daily creel limit was reduced from 10 trout to 5, of each species alone, or of both combined.

During the course of this study, Platte River received the heaviest fishing pressure in early spring while adult rainbow trout were present for spawning. The spawning period was confined mostly to April, but occasionally lasted a week into May. After the large rainbows returned to Lake Michigan, fishing greatly subsided until fall, being heaviest on weekends in the remainder of spring and during summer. Beginning in October, after mature coho salmon and rainbow trout had come into the river from the big lake, interest in angling revived, but less of it was done in the fall than in the spring.

METHODS

A detailed map (showing depths, fish cover, distribution of bottom soil by type, etc.) was prepared of each mile section in 1967; copies are on file at the Fisheries Division office in Lansing, and at the Institute for Fisheries Research in Ann Arbor. Fish were collected by electrofishing with a 230-volt, 2500-watt, d-c generator driven by a gasoline engine, and with two positive electrodes. The negative electrode consisted of a strip of copper sheeting, riveted to the bottom of the shocker boat. The boat was designed especially for electrofishing. The fish population surveys were made with the mark-and-recapture method in April and September by a crew of five men.

Population estimates were calculated by the Bailey formula [2], a modified version of the Petersen formula. Estimates of brown trout are for fish of all sizes; estimates of rainbow trout cover fish to the length of 10 inches, which excludes immigrants from Lake Michigan. Estimates of coho salmon are limited to juveniles--that is, age-0 fish in September, and yearlings in April. Estimates of trout were made first by inch group; following age determinations, the figures were apportioned into estimates by age group.

Survival rates have been determined from point estimates. For example, to determine what percentage of age-I brown trout of an experimental section survived from fall to spring, the point estimate for age-II brown trout obtained in April was divided by the point estimate for age-I brown trout of the preceding September.

Trout were scale sampled during the population surveys of the 1-mile sections, and also at random locations in these sections in June and July. Scales from 30 trout per inch interval was the goal set for most 1-inch intervals. Scales were impressed on strips of cellulose acetate, and age was determined from microprojection of the impressions. Information on growth was derived entirely from empirical data.

Growth rate of trout is indicated by average length and weight. These averages were derived after the data obtained from the samples collected in April, June, July, and September were pooled.

The biomass of a population was calculated by multiplying the point estimate of fish in an inch group by the mean weight of this group, and summing the weights of all groups. Mean weights were obtained from weights taken during scale sampling; they were determined separately for each mile section and sampling period.

When this study was planned, it was thought that if presence of coho salmon in Michigan streams should prove adverse to trout, the adversity would most likely be reflected by one or both of two possible results--reduced abundance and decreased growth. Consequently, the research procedure adopted for use on the Platte River was essentially that of sampling salmonid populations quite intensively and repeatedly in designated sections where salmon were absent or scarce, and also where they were numerous. At the conclusion of sampling, abundance and growth of trout under the two situations were to be compared to assess effects of salmon.

Previously, I have sometimes referred to this study as one of competition between coho salmon and trout. In time, however, I came to realize that use of "competition" in this context probably was an unsuitable choice. Discussion of the definition and use of "competition" in the ecological sense has generated considerable controversy [1, 3, 6, 7, 19, 31]. Birch [3] contended that one species can influence the numbers of another through competition only when shortage of some resource occurs, except in some special conditions of threat. He concluded that the word might better be avoided in referring even to these relationships. Andrewartha [1, pp. 174-177] accepted only the first part of Birch's definition, and strongly disparaged use of "competition" for reference to any conflict between organisms. The arguments made by the latter two authors influenced me to avoid use of the word in this report.

ABUNDANCE OF TROUT AND COHO SALMON IN THE 1-MILE SECTIONS

Fall populations

Annual estimates of trout populations in the 1-mile experimental sections in September appear in Tables 1 and 2, and mean estimates for combined years are given in Tables 5-9. Rainbow trout outnumbered brown trout quite consistently in all the sections, and predominated most strongly in Section II. Average distribution of the two species, as determined from 5- and 6-year mean total estimates (Table 7), was as follows: Control Section, 37% brown trout and 63% rainbow trout; Section I, 38-62% respectively; Section II, 12-88%. Abundance of both species fluctuated considerably from year to year, but magnitude of the fluctuation is comparable to that in other streams. Range of rounded total estimates of brown trout in the three sections (Control, I, and II, respectively) was 1650-3350, 1450-2400, and 600-850. Range of rainbow trout estimates in the respective sections was 2600-5900, 1850-5100, and 4050-8750. Excepting brown trout in Section II, abundance of age-0 trout had the strongest effect in year-to-year oscillation.

Juvenile coho salmon have inhabited the experimental sections since 1967, when they were present also in other parts of Platte River. Even though the weir system at the hatchery was operated so that either adult or young salmon had little opportunity to pass above the weir, we always found juveniles in Section I and in the Control Section in the fall prior to 1969 when adults were first released into Section I. Some are thought to have escaped from ponds of the Platte River Rearing Station, which predated establishment of the hatchery. Others may have been produced by early maturing (age-group I) adults, some of which passed through the grating on top of the dam each fall.

In October and November 1969, we released 1,208 adult coho salmon above the dam of the hatchery weir for populating Section I with progeny for the purpose of studying salmon-trout relationships. Releases here were repeated in 1970 and 1971 (600 males and 600 females each year). The estimate of young coho present in Section I in September 1970 was 1,997 (Table 10). Salmon reproduction appreciably exceeded that estimated for brown trout (804), but was only approximately half of that of rainbow trout (4,140). Coho reproduction found here in September 1971 (point estimate, 1,220) was but 61% of that found in 1970, and in 1972 was much less (point estimate, 373).

Several conditions should be kept in mind regarding the low rate of salmon reproduction in Section I despite large releases of adults: (1) After each release, many of the salmon continuously remained in the 2100-foot stretch of river between the dam and Section I, and some coho must have hatched here. (2) Evidently some coho that hatched in Section I migrated upstream out of the section (as indicated by moderate increases in Control Section estimates), and some quite certainly must have moved downstream out of the section. (3) Success of egg deposition was poor; egg retention was high [23, 27], and many eggs lay exposed on the river bottom. (4) Spawning success of coho in 1971 was poor in other parts of the river as well as in Section I.

Reproduction of coho salmon in Section II was substantial during 1968-1972, exceeding that of rainbow trout in 3 of the 5 years (Tables 2 and 10).

Spring populations

Annual estimates of trout populations in the 1-mile sections in April are listed in Tables 3 and 4. Ratio of abundance of brown trout to rainbow trout was somewhat higher in April than in September. The brown-to-rainbow ratios, by percentage, in the sections (Control, I, II) in April were 43:57, 48:52, and 14:86. Ranges of total estimates of brown trout in April in the sections, according to the above order, were 1000-2400, 1350-1900, and 300-750 during 1967-1972; during 1968-1972, the ranges of rainbow trout estimates were 1750-2650, 1050-2250, and 3000-4650.

Considerable change occurred in numerical size and age composition of the rainbow trout populations between the end of April and the middle of June. Smolting fish migrated to Lake Michigan between these times. In the Black River, also a tributary of Lake Michigan (located in Mackinac County, and about 100 miles north of Platte River), Stauffer [22] observed that rainbow trout smolts began to leave the stream late in April, with emigration continuing into late July. As determined over a period of 9 years, the greater numbers descended from late May through June. Older fish commenced their downstream movement sooner than did younger fish. In the Platte River experimental sections, emigration of age-II smolts had evidently ended by mid-June, as the few age-II rainbows caught at this time closely corresponded with the number caught in July and September. Difference in latitude of the locations may well result in some difference of time that smolts depart from the two streams (Black and Platte).

According to an unweighted average determined from weir collections taken in 9 successive years, 68% of the migrating rainbow trout in the Black River were age I, 31% were age II, and 1% were age III. However, examination of scales from adults that came into Black River to spawn suggested that more of these fish had gone into Lake Michigan at age II than at age I. Stauffer [22] reasoned that the discrepancy between this observation and preponderance of age-I juveniles in his weir collections was probably caused by more extensive mortality in the lake among the younger migrants, and also by some age-I weir-caught trout not entering the lake until the next year.

While collecting done on Platte River provided a fairly good conception of the number of age-II rainbow trout that left the test sections to enter Lake Michigan (nearly all enumerated in April were gone by mid-June),[5] there is no evidence from which to estimate the number of age-I fish that emigrated. However, the results of Stauffer's study and of other investigations suggest that the number probably was substantial.

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[5] Some of these fish would of course be lost in the river before they reached the lake, through natural mortality and angling. Loss from angling may have been significantly reduced beginning in 1969, when the minimum legal length for rainbow trout was increased from 7 to 10 inches.

Kwain [14] sampled the lakeward run of rainbow trout smolts in a tributary of Lake Superior and found that 39% of the fish were of age-group I, 55.9% were of age-group II, and 5.1% were of age-group III. Scales of immigrating adults revealed data that were closely similar to those for the time of smolt emigration; 37.9% of these fish had lived in a stream for 1 year, 58.8% for 2 years, and 3.3% for 3 years. In two other tributaries of Lake Superior, emigration of rainbow smolts of age-groups I, II, and III over a period of 3 years averaged 31, 57, and 12%, respectively [11].

Fall-to-spring survival

Rate of survival between the September and April population surveys was calculated for trout of ages 0 and I, and for age-0 coho salmon. Some ambiguous figures (which are underlined) appear among the results in Tables 11, 12, and 13. These figures arose from situations in which the April point estimate was larger than the corresponding point estimate of the preceding September, occurring most frequently in Section II. I suppose that at least the smaller of these percentages are indicative of actual high survival. As for the reasonable annual values, considerable year-to-year variation is evident, which is to be expected. In the Control Section, for example, range for 0-I [6] brown trout was 40-83%, and for 0-I rainbow trout it was 37-74%. There is some indication (and especially in the Control Section) that survival rate of trout from age 0 to age I was influenced by the size of the population in September--that is, if this age class was very numerous, survival from fall to spring was relatively low, and vice versa. It may be that the Control Section is more subject to this compensatory effect than the other sections because of its unevenly distributed trout population, which is described farther on.

[6] This designation (and also I-II, II-III, etc.) is a convenience in referring to fish of a year class that have passed from one age class into the next older age class within a span of time (in this particular instance, September to April) that is significantly related to discussion of the year class. January 1 is the arbitrarily established date on which fish become 1 year older.

As for variation of survival between sections, significantly different 5-year mean values show the following results: (1) survival was lower in the Control Section than in sections I and II for brown trout from age I to age II; and (2) all three sections differed from each other in survival of I-II rainbow trout.

Rate of survival in the two younger age classes of brown trout and rainbow trout was quite similar between the Control Section and Section I. Appreciably more 0-I rainbow trout were alive in the spring as they had been appreciably more numerous also in the fall.

Survival of 0-I coho salmon apparently averaged lower than survival of 0-I trout. Since progeny of introduced coho inhabited Section I in 1970-71 and 1971-72, the more significant and comparable figures in Table 13 are the following: (1) the mean (24 ± 11) of survival rate in 1970-71 and 1971-72 (25 ± 16 and 23 ± 16) in Section I; (2) the mean (30 ± 11) for the same two 7-month periods in Section II; and (3) the mean (33 ± 8) for these periods plus those for 1967-68 and 1968-69 in Section II. The confidence limits show that any difference between these means is not significant statistically.

Spring-to-fall survival

May-to-September (spring-to-fall) survival was analyzed for brown trout of age I, and of ages II-IV+ combined, and for age-I rainbow trout (Tables 14 and 15). I compared these 6-year averages for spring-to-fall survival with the 5-year averages for fall-to-spring survival. There was not a significant difference between the rates for 0-I and age-I brown trout in the Control Section; but there was a difference in Section I where survival over winter was higher than from spring to fall. It will be seen also that spring-to-fall survival in the II-IV+ group differed significantly among the three sections. The survival values were quite high, even though a sizable segment of this group was subject to removal by anglers. Extent of loss from fishing is not known. In a New York stream over a period of 3 years [20], angling accounted for 15% of the annual losses of legal-size brown trout.

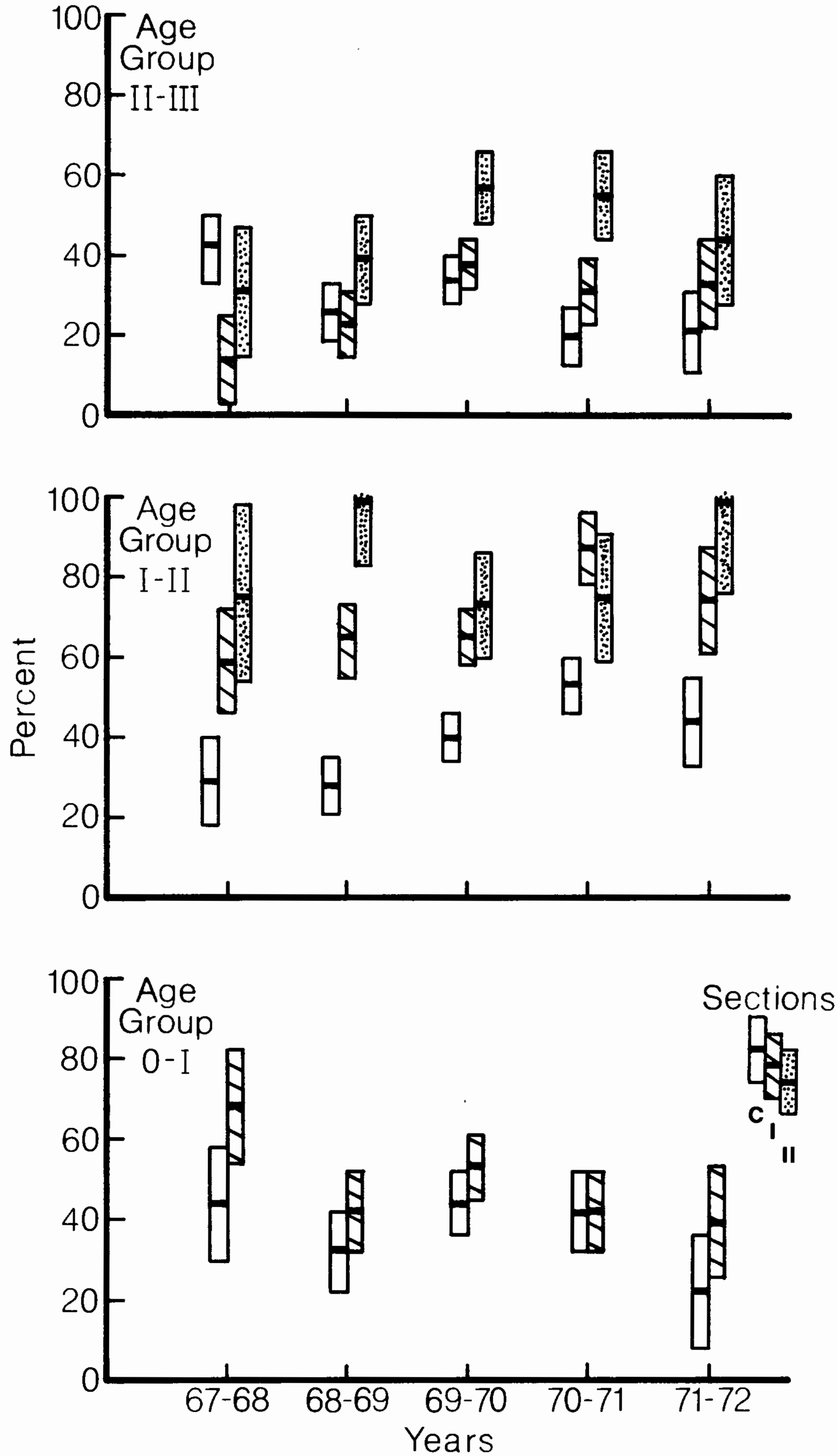

Figure 3.--Twelve-month (September-to-September) survival of three age groups of brown trout, with 95% confidence limits, in the 1-mile experimental sections during 1967-1972. Coho salmon spawned in Section I the first time in 1969.

In contrast to the results shown for brown trout, May-to-September survival of age-I rainbow trout was considerably lower than the rate for October-to-April survival of 0-I rainbows. Migration of some age-I fish to Lake Michigan quite likely was responsible for a portion of the reduction that occurred following inventory in April.

September-to-September survival

Survival of trout in the 1-mile experimental sections has been evaluated also on the basis of a 12-month interval--from one September to the next. For brown trout, three age groups of fish were involved in this assessment. The results are shown graphically in Figures 3 and 4. Data are not included for 0-I brown trout of Section II because the values obtained on this group are unrealistically high, as they are in the two assessments of survival that have just been discussed.

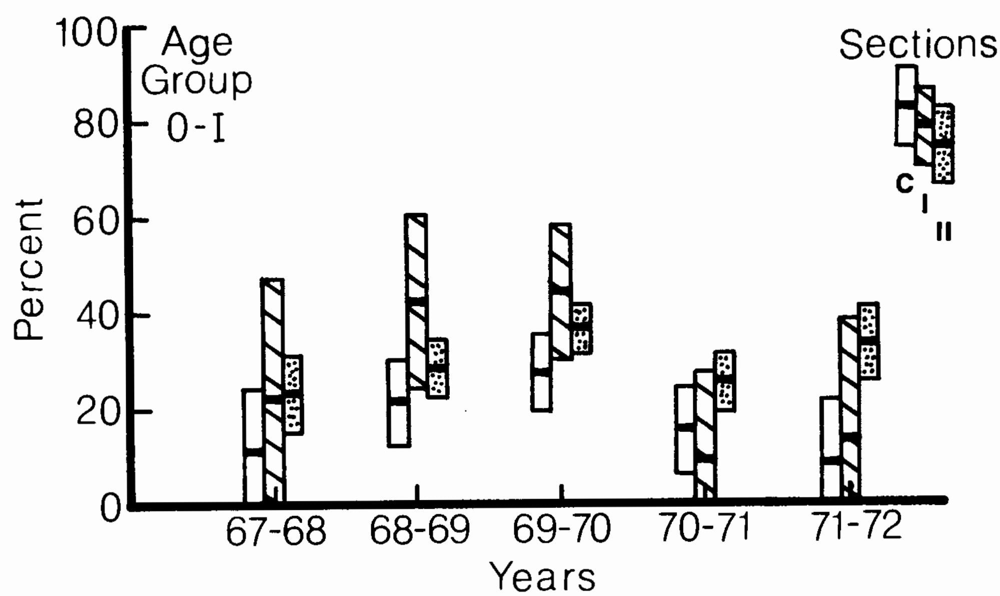

Figure 4.--Twelve-month (September-to- September) survival of age-group 0-I rainbow trout, with 95% confidence limits, in the 1-mile experimental sections during 1967-1972.

Apparent features of this evaluation are the following: (1) Although survival of brown trout among groups 0-I and II-III shows little significant difference between sections (Fig. 3), a trend is indicated for increase of survival in downstream sequence. (2) Among brown trout of group I-II, survival was definitely poorest in the Control Section.

Mean annual percentage survival of brown trout from September to September for the 5 years covered in Figure 3 (with 95% confidence limits) is summarized below:

Section	Age group			Mean of means
	0-I	I-II	II-III	
Control	37 ± 12	39 ± 13	29 ± 12	35 ± 7
Section I	49 ± 15	70 ± 14	28 ± 12	49 ± 8
Section II	...	84 ± 16	45 ± 14	64 ± 11

Rates similar to those above have been recorded for other streams. Cooper [5] found that fall-to-fall survival of brown trout in the Pigeon River over a period of several years averaged 30%. Survival of four age classes of brown trout from one year to the next in six streams of Pennsylvania [17] averaged 36% (range, 20-55%).

Mean annual percentage survival of 0-I rainbow trout from one September to the next was as follows: Control Section, 16 ± 10; Section I, 26 ± 20; Section II, 29 ± 7.

Brown trout in Experimental Section II

Two aspects of the brown trout population in Section II deserve more than passing mention. These are (1) low reproduction, and (2) estimates of age-I fish that consistently exceeded estimates of age-0 fish of the same year class (see Tables 1 and 3).

The reason for low reproduction of brown trout in Section II is not known. Several possible explanations may be explored. Estimates of adults present here in September approximately equaled or exceeded the number estimated in Section I, and strongly exceeded the number in the Control Section. Yet reproduction was much greater in the latter two sections. Brown trout of breeding size moved upstream out of Section II shortly before the spawning season, numbering around 50-100 each fall during 1966-1971 [27]. A few were migrants from Lake Michigan, and others could have come from areas of the river located below Section II. But even if most of these fish originated from Section II, it seems there still should have been a sufficient residue of spawning stock in Section II for producing many more young than were found the succeeding year. [7]

Presence of large numbers of adult coho salmon in the fall from 1967 through 1970 could easily be suspected of affecting brown trout reproduction here. Although the data suggest some adverse effect from salmon in this regard, a small estimate of age-0 brown trout already in 1967 indicates that something else is mainly responsible for their scarcity in II as compared to Section I and Control Section.

Predation by fish might also be suspected as a cause of the low number of young. Presence of considerably more brown trout of the larger sizes (above 10 inches) in Section II than in the other sections may encourage such speculation. However, studies on the food habits of brown trout, and of fishes associated with them, have shown little evidence of cannibalism in Michigan streams [8, 9, 21]. Few fish remains were found in the stomachs of trout from the Platte River experimental sections that were examined for food content. [8]

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[7] Presumably most of these migrants that survived returned to Section II later on. This assumption is based on the fact that extremely few of the brown trout marked in this section in September 1969 were ever found in the two upstream sections [28], and also on Schuck's finding [20] that tagged brown trout which had moved out of a particular section of stream before a spawning season, were back there the following year.

[8] Results of these studies are given in Fisheries Research Report No. 1831.

Another possibility is inadequacy of spawning facilities for brown trout in Section II, resulting in poor hatching success. Is upstream movement of mature brown trout out of the section around spawning time an indication of a lack of satisfactory spawning sites? Or do adults from downstream areas move into this section as these adults move out?

As with low reproduction, I do not know why spring and fall estimates of age-I brown trout in Section II consistently outnumbered the preceding estimates of age-0 trout of corresponding year classes. A thought apt to come to mind is that young brown trout from other parts of the river enter this section. Yet the study of trout movement [28] gave no evidence the following April of age-0 brown trout immigration from the upper experimental sections. Meager invasions later on of marked fish from these sections were largely counterbalanced by fish marked here that moved out. These observations of course do not rule out Brundage Creek and downstream areas as possible sources of infiltration.

Perhaps the atypical differences between fall and spring estimated populations of young brown trout in Section II are due to low collecting efficiency. Collecting efficiency in both September and April was appreciably lower for brown trout in Section II than in the other sections; for rainbow trout, it averaged about the same among the three sections in the fall, but in the spring it was somewhat higher in Section II than in the two other sections. [9]

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[9] Judgments based on indices of collecting efficiency, calculated from point estimates and their confidence limits. Example: Point estimate of 200 has 95% confidence limit of ±36; 36 divided by 200 = 18 (index). This value is regarded as indicating fairly good efficiency; values above an index of 25 reflect low efficiency.

Distribution of trout in the Control Section

Differences between the upper and lower halves of the Control Section in respect to stream morphometry and fish abundance were previously mentioned. In the population surveys, far more trout were always seen in the lower half. In the April 1971 survey, captures in the two segments were tabulated separately to allow determination of the extent the populations differed. Separate estimates were made by size groupings. The results are tabulated below. Included are results obtained by lumping the data and calculating estimates by size group for the Control Section as an undivided unit. The latter figures may be compared with those of the segmented estimates, and the totals with the totals of the estimates made by age group (Tables 3 and 4). The segmented estimates indicate that in April 1971 the lower half of the Control Section contained approximately 82% of the trout present in the entire section.

Part of section, species of trout	Size group (inches)				Total, and 95% C.L.	Percent of total esti-mate
	1-4	5-6	7-9	10+		
Lower half						
Brown	458	170	416	89	1133±135	80
Rainbow	1675	353	243	...	2271±351	85
Upper half						
Brown	83	32	109	61	285± 48	20
Rainbow	305	61	25	...	391±148	15
Entire section						
Brown	611	201	511	185	1508±220	100
Rainbow	2034	418	191	...	2643±353	100

This situation in the Control Section exemplifies corresponding situations elsewhere in Platte River and in other trout streams. A significant aspect of many of these situations is that the quality of the water (in respect to temperature, chemical constituents, purity, etc.) is the same where trout are abundant and where they are scarce. This fact points to the importance of morphometry, bottom soil, and protective cover in determining the productivity of a stream.

AGE, GROWTH, AND SIZE OF TROUT AND SALMON IN THE 1-MILE SECTIONS

Age of brown trout

Scales taken during the population surveys provided information on the age structure of the trout populations. Average composition by age group in September, and again in April, was computed for combined years (Tables 16-19).

It is apparent in Tables 16 and 17, as it is in Tables 1 and 2, that relatively few brown trout in the experimental sections reached the age of 4 years, and extremely few lived 5 years and longer. The oldest brown trout handled in this study were in their eighth year of life (age-group VII). It seems quite likely that these age limits prevail throughout the cold-water portion of Platte River. Much collecting done throughout the state has shown that the life expectancy of brown trout in other Michigan streams is closely similar to what I found in the Platte River.

Age composition of brown trout populations differed but little between the Control Section and Section I, but varied broadly between these sections and Section II (Tables 16 and 17). Appreciable variation was reported by McFadden and Cooper [18] for brown trout in five streams in Pennsylvania; in two of their streams, composition was similar to what it was in the Control Section and Section I (of Platte River), whereas in the other three it was generally intermediate between this pattern and the one in Section II.

Age of rainbow trout

Rainbow trout that inhabited the Platte River in September and in April that were of concern in this study consisted almost 100% of two age groups both months--0 and I in September, and I and II in April. During April, and to a much smaller extent in September, adult migrants from Lake Michigan were also present in the test sections, but these fish were disregarded in the population studies because of their transient status. However, age determinations were made on 800 of them from scales taken in April (in the test sections) and in the fall months (at the weir above Section II). Ages ranged from II to VI. Approximately 75% of the migrants were of ages III and IV [24]. Kwain [14] found that rainbow trout from Batchawana Bay, Lake Superior, that were ascending streams to spawn, were mostly (67%) 3- and 4-year-old fish, the oldest being of age-group VII. In Minnesota tributaries of Lake Superior, 87% of the rainbow trout sampled during spawning migrations were at the ages of 4 and 5 years; here also the oldest one examined was 7 years old [11].

Average age composition of the juvenile rainbow trout populations differed but little between sections (Tables 18 and 19). Also, there was little change in proportion between the two strongly preponderant age classes from September to April.

Growth of trout

Growth of brown trout averaged virtually the same in the middle and upper test sections, although it tended to be slightly better in the upper (Control) section. It was considerably better in Section II (Tables 20 and 21). Rainbow trout also grew at about the same rate in the middle and upper sections, and most rapidly in Section II (Table 22). Compared with State-average lengths [16], growth rate of brown trout was average in the Control Section and Section I, and above average in Section II. Rate of growth in rainbow trout was on the border between average and sub-average in the middle and upper sections, and average in Section II.

Size of trout and coho salmon in their first year of life

Table 23 supplements information contained in Tables 20-22 in its listing of mean lengths and weights of age-0 and age-I trout and salmon sampled respectively in September and April. It will be seen that there was little significant difference in size between the three species at either time. Also, their size was in general remarkably uniform among the three 1-mile sections. Therefore, whatever factor or factors caused trout to grow best in Section II apparently took effect after the fish were a year old.

Growth rate of salmonids is discussed further in the section of this report which deals with effects of coho salmon on trout in the 1-mile experimental sections.

BIOMASS OF TROUT AND JUVENILE COHO SALMON IN THE 1-MILE EXPERIMENTAL SECTIONS

Total weight of salmonids was calculated by species from point estimates obtained for each 1-mile section in April and September. These totals were reduced to pounds per surface acre of stream (Tables 24 and 25).

Biomass of trout

As was mentioned previously, rainbow trout outnumbered brown trout in the 1-mile experimental sections established on Platte River. On the other hand, brown trout usually were of greater total weight. The latter situation resulted from large brown trout being in the river while larger rainbows were in Lake Michigan. This predominance in weight of brown trout is illustrated in Figure 5, which displays the information given by the 3-year average weights in Tables 24 and 25; and perhaps it is more strikingly demonstrated by the annual figures on weights given in these tables. The latter values are assessed in the tabulation below, on the basis of their 95% confidence limits. Meaning of the symbols is as follows: + = weight of brown trout significantly greater than weight of rainbow trout; x = weight of rainbow trout significantly greater than weight of brown trout; 0 = no significant difference between the two weights.

Year	Control		Section I		Section II	
	April	Sep	April	Sep	April	Sep
1967	x	0	+	+	...	0
1968	+	0	+	+	x	0
1969	0	+	+	+	x	0
1970	+	+	+	+	0	+
1971	+	+	+	+	0	+
1972	+	+	+	+	0	0

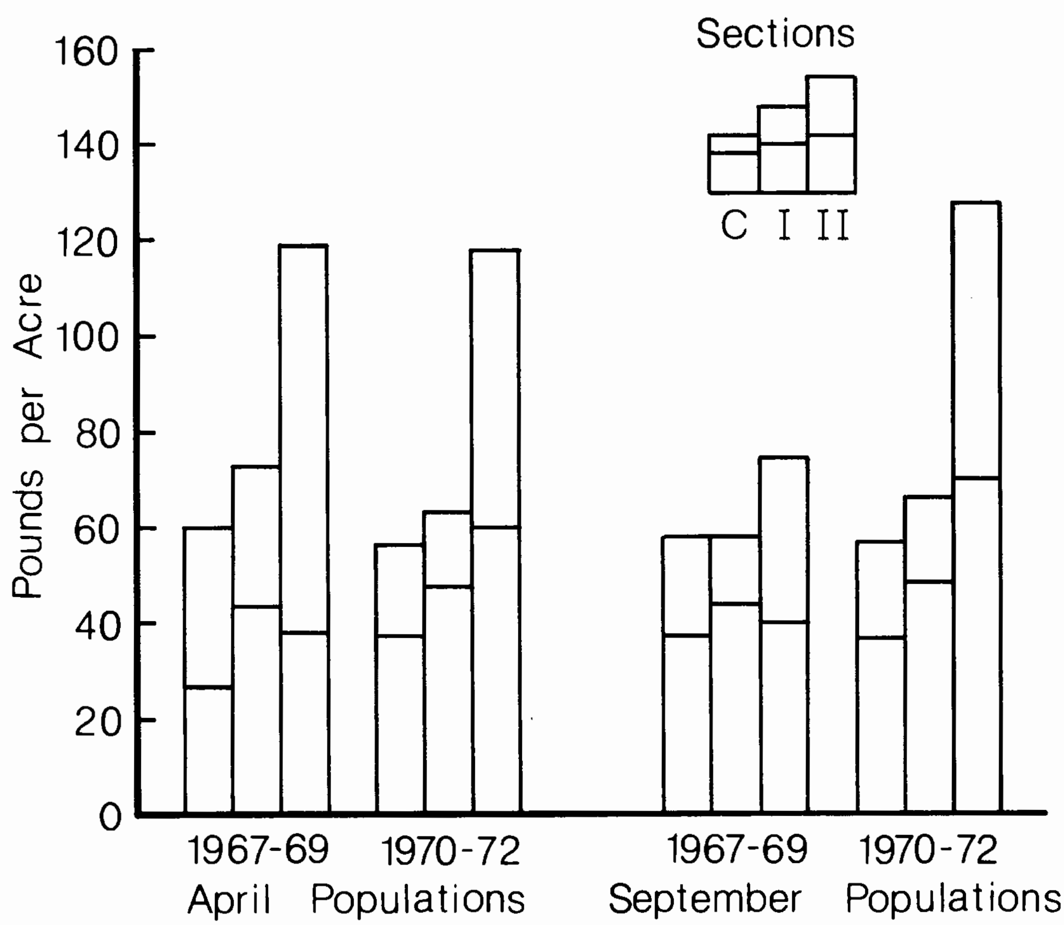

Figure 5.--Mean biomass of trout in Experimental Sections C (Control), I, and II in April and September, during 1967-1969 and 1970-1972. Lower segment of bar, brown trout; upper segment, rainbow trout. Coho salmon spawned in Section I the first time in 1969.

We see above that in the Control Section the weight of rainbow trout significantly exceeded weight of brown trout only in April 1967. Presence of a sizable number of age-II planted rainbows,[10] estimated as numbering 1,255 (±204), was mostly responsible for this result. These fish alone comprised a larger number of 2-year-old rainbows than was estimated at any other time in the test sections, except for two occasions in Section II (Table 4).

It is also evident in the above tabulation that in Section I brown trout always exceeded rainbow trout in weight. Some of the rainbow trout planted in 1966 were found here in 1967, but a separate estimate was not made for hatchery fish in Section I as was done for those in the Control Section. Their presence is reflected in the larger-than-usual estimate for age-II rainbows (Table 4).

Total weight of rainbow trout was considerably greater in Section II than in the two other 1-mile sections, but even here it definitely exceeded weight of brown trout only on two occasions--in April 1968 and April 1969.

The averages of total weights of trout in the Platte River experimental sections in September resemble the fall averages recorded for portions of 12 other streams in the Lower Peninsula in which brown trout constitute a major segment of the total trout population. In these streams fall standing crop ranged from 14 to 148 pounds per acre and averaged 68 pounds per acre.[11]

The large difference in bulk of trout between Section II and two other sections points up again the broad extent that productivity can vary between closely associated sections of water. Another illustration of such divergence is the range of standing crop of trout (14 to 148 pounds per acre) among the 12 streams mentioned above; these two extreme figures are for two sections of the same stream--the Au Sable River.

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[10] Survivors of 50,000 fin-clipped yearlings released into the Control Section (Sec. 6, T. 26 N., R. 13 W.) in March 1966.

[11] Information from productivity data compiled on 16 streams by Gaylord R. Alexander, Biologist-in-charge, Hunt Creek Fisheries Research Station, Lewiston, Michigan.

Since reproduction of brown trout in Section II was poor, and reproduction of rainbow did not greatly exceed that in the other sections, one has good cause to wonder why the total weight of trout here was so much greater. Factors contributing to this outcome included larger point estimates in Section II for brown trout of age-group III and older, and for rainbow trout of age-groups I and II. The larger estimates apparently resulted from higher survival rates.

Size of trout in the experimental sections, which age-for-age were largest in Section II, certainly was another significant factor. To gain a conception of the effect that difference in weight of individual fish had on total weight between sections, the mean individual weights of trout in another section were substituted in making total weight calculations with point estimates of populations in Section II. Weights obtained in the Control Section in 1969 were chosen at random for this purpose. The point estimates by inch group of brown trout and rainbow trout in Section II in April 1969, and also in September, were each multiplied by the mean weight of trout in the respective groups in the Control Section at these times, and the products summed. It was found that total weight calculated from mean individual weights of trout in Section II exceeded total weight calculated from mean weights in the Control Section as follows:

April	-	brown trout	30%,	rainbow trout	11%
September	-	brown trout	7%,	rainbow trout	16%

These values represent a total difference of 22 pounds of trout per acre in April 1969, and of 10 pounds per acre in September 1969.

One may also wonder what has caused growth of trout to be better in Section II than in the other experimental sections. One likely possibility is enrichment from fish-cultural waste that enters the river near the head end of this section. Undetermined natural factors may also contribute to the situation.

Biomass of juvenile coho salmon

Annual and 3-year average weights of estimated populations of juvenile coho salmon (age 0 in September, age I in April) are included in Tables 24 and 25. The more significant of these data are those for Section II. It will be seen that the weight of coho contributed a significant portion of the total weight of salmonid fishes in this section. Three-year averages of total weight of trout and salmon together were: 90 pounds per acre in September during 1967-69, 148 pounds in April during 1970-72, and 155 pounds in September during 1970-72.

Also of special interest in Tables 24 and 25 are weights of juvenile salmon in Section I after adults were introduced. The broad difference in poundage between this section and Section II is particularly noteworthy. Reasons for low reproduction of coho in Section I are discussed in the section of this report that deals with abundance of salmonids.

EXPERIMENTAL SECTION I

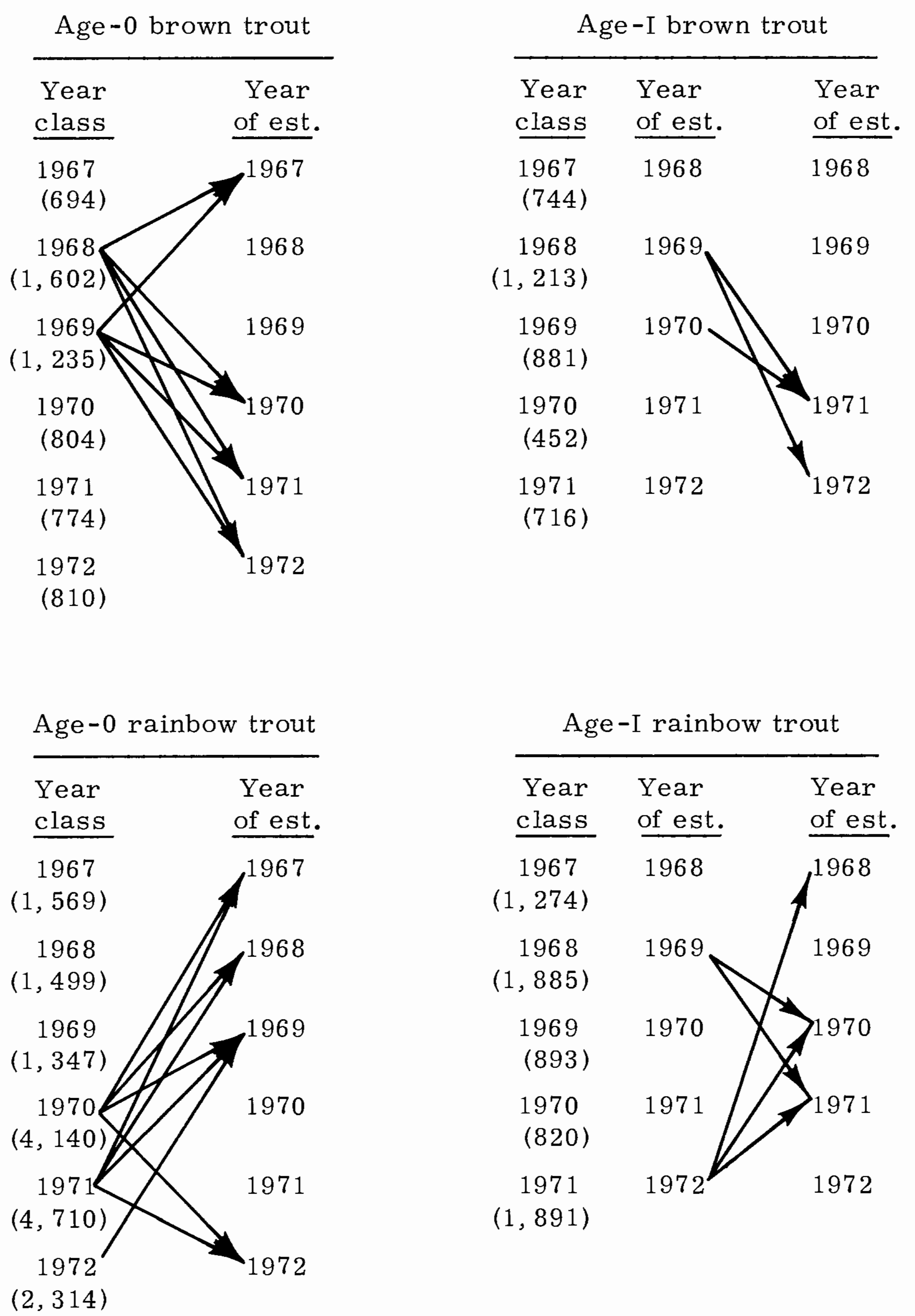

Figure 6.--Year classes of trout that significantly outnumbered other year classes in Experimental Section I, at age 0 in September, and at age I in April. Point estimates in year of estimate included in year-class column. Arrow points toward population significantly outnumbered by population at tail-end of arrow.

EFFECT OF COHO SALMON ON TROUT IN THE 1-MILE EXPERIMENTAL SECTIONS

The population estimates of trout determined biannually in the mile sections (Tables 1-4) contain the best available data for assessing effect of coho salmon on trout abundance in Platte River. The estimates most applicable for this purpose quite surely are those of age-0 fish in September and of age-I fish in April. This opinion is based on the probability that, if salmon were to cause decline in trout numbers, the effect would originate among trout less than a year old. Conceivably, decline could result from spawning coho preventing or restricting successful spawning by brown trout, as well as from age-0 coho usurping food and space required by age-0 brown trout and rainbow trout.

Comparison of estimates of trout in Section I

In examining the annual estimates of age-0 brown trout in Section I (Table 1), we find that the point estimates obtained in 1968 and 1969 are larger than those obtained in the other 4 years in the period from 1967 to 1972. Moreover, statistically they are significantly larger than the latter. This characteristic is demonstrated in the upper left diagram of Figure 6. Here we see, for example, that the point estimate of 1,602 age-0 brown trout in Section I in September 1968 was found to be significantly larger than the point estimate of 694 in September 1967, also significantly larger than the estimates of 804 in 1970, of 774 in 1971, and of 810 in 1972. Statistical significance was determined from the 95% confidence limits of the compared point estimates (Table 1). As the lower estimates of 1970-1972 followed successive introductions of adult coho into this section, presence of salmon may be suspected as having caused a reduction in numbers of brown trout in these years. However,

CONTROL SECTION

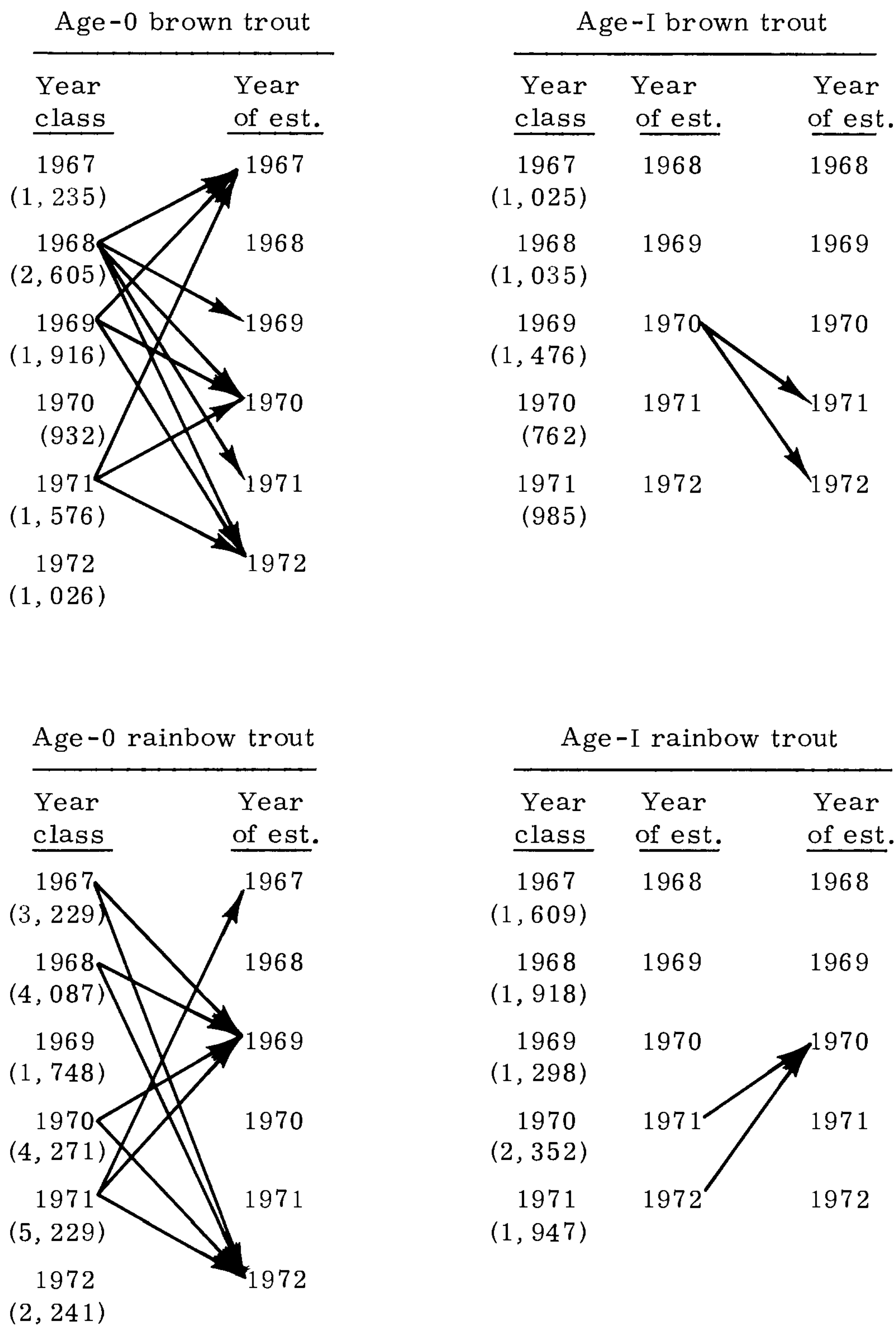

Figure 7.--Year classes of trout that significantly outnumbered other year classes in Control Section at age 0 in September, and at age I in April. Point estimates in year of estimate included in year-class column. Arrow points toward population significantly outnumbered by population at tail-end of arrow.

the smallest estimate of all (694 in 1967) preceded the introduction of mature salmon. Also, the larger estimates of age-0 rainbow trout in Section I (in 1970 and 1971) coincided with low estimates of age-0 brown trout, and are significantly larger than the rainbow estimates in the other 4 years (Table 2 and Fig. 6).

The estimates of these year classes in succeeding Aprils are considerably different from the September estimates in regard to variability (Fig. 6). Among age-I brown trout, the estimate in April 1969 for the 1968 year class (point estimate, 1,213) significantly exceeds the estimates obtained in 1971 and 1972 for the 1970 and 1971 year classes, respectively; and the 1970 estimate of the 1969 year class significantly exceeds the one of 1972 for the 1971 year class. Hence there are only three instances of significant difference among the estimates of age-I brown trout in April, as compared to eight instances of difference at age-0 in September. Like comparison of age-0 and age-I estimates of rainbow trout also shows less variability in April--nine instances of significant difference among September estimates, and five among April estimates.

The populations of age-0 trout in Section I may be evaluated also by comparing the average of the 1967-1969 ("before-salmon") estimates with the average of the 1970-1972 ("after-salmon") estimates (Tables 5 and 6). The mean estimate of age-0 brown trout for the first 3-year period (1,177 ± 151) is significantly larger than the mean for the second 3-year period (796 ± 82). This result could be suspected of being another indication of some effect from salmon. In contrast to the brown trout, age-0 rainbow trout were significantly more abundant in the second period (3,721 ± 453 versus 1,472 ± 245).

Comparison of averages of age-I estimates is not so feasible because it would have to be made between 4-year and 2-year means.

EXPERIMENTAL SECTION II

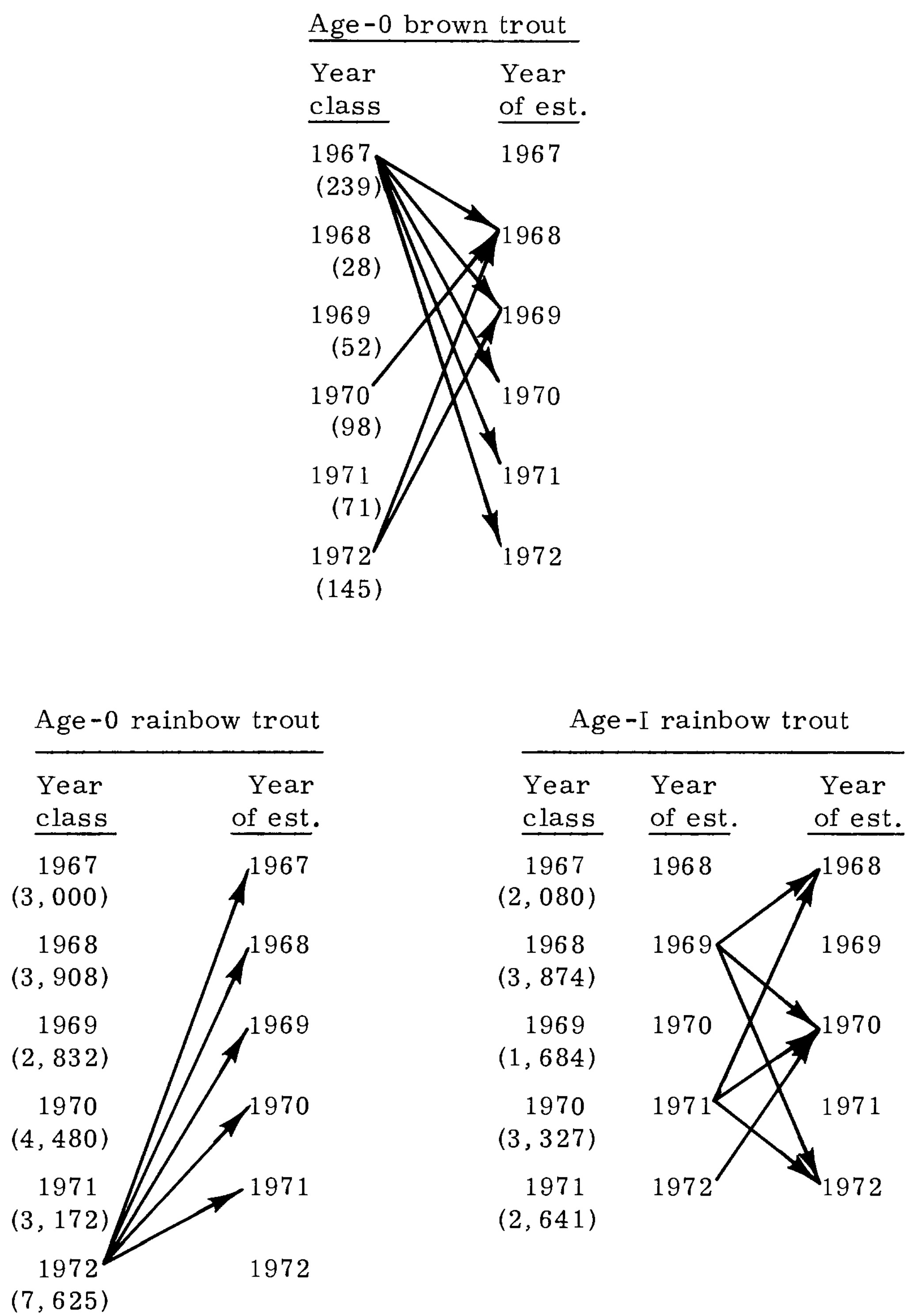

Figure 8.--Year classes of trout that significantly outnumbered other year classes in Experimental Section II, at age 0 in September, and at age I in April. Point estimates in year of estimate included in year-class column. Arrow points toward population significantly outnumbered by population at tail-end of arrow.

Comparison of estimates of trout in the Control Section

As in Section I, the larger estimates of age-0 brown trout in the Control Section are those of the 1968 and 1969 year classes, which likewise are significantly larger than the estimates for the 1967, 1970 and 1972 year classes (Fig. 7). A difference between the age-0 populations of these sections is that in the Control Section the 1971 year class also was strong. Estimates of age-0 rainbow trout in the Control Section are similar to those for this age class in Section I in that the 1970 and 1971 year classes were strong; they are different in that the 1967 and 1968 year classes in the Control Section were strong also.

Reduced variation among age-I estimates is quite similar between Section I and the Control Section.

Also, as in Section I, the mean estimate of age-0 brown trout in the Control Section for the period of 1967-1969 (1,919 ± 213) is significantly larger than the mean for 1970-1972 (1,178 ± 82). This outcome casts much doubt on the possibility of salmon having been responsible for decreased reproduction in Section I. The 3-year mean estimates of age-0 rainbow trout (3,022 ± 597 and 3,913 ± 320, respectively) are not significantly different.

Comparison of estimates of trout in Section II

Comparison of the peculiarly small estimates of age-0 brown trout in Section II shows that each of the four estimates of 1968-1971 (28, 52, 98, and 71, respectively) is significantly smaller than the estimate of 1967 (239). Since full-term (age-group II), sexually mature coho salmon first appeared here in the fall of 1967, salmon become suspect of having in some way reduced numbers of young brown trout the next 4 years. The 1972 estimate (145) is moderately larger than the preceding four estimates, but it significantly exceeds only those of 1968 and 1969 (Fig. 8). On the other hand, five of the six year classes of age-0 rainbow trout apparently are normal, as well as quite uniform, in respect to numerical size.

Comparison of April estimates (178, 130, 218, and 56) of the 1968-71 year classes of brown trout at age I (Table 3) is complicated by two of them (178 in 1969 and 218 in 1971) being significantly larger than the corresponding September estimates at age 0. None of the April estimates is significantly different from any of the others, and therefore they have not been diagramed for Figure 8. In contrast, the estimated numbers of young rainbow trout in Section II, which were so uniform in September, were quite diverse in April.

Conclusions on effects of salmon on abundance of trout in the 1-mile sections

What caused average abundance of age-0 brown trout in Section I during 1970-72 to be significantly smaller than it was during 1967-69, and the estimates in Section II during 1968-71 to be significantly smaller than the one of 1967? As both declines began right after the initial spawning of large numbers of coho salmon in these sections, it is natural to suspect salmon. The possibility of rainbow trout having influenced these effects should not be overlooked; however, examination of the population data for the three sections (Tables 1-4) shows no evidence of one species of trout having affected abundance of the other.

Influence from some undetermined factor must be considered also. This possibility has support from the following developments in the Control Section: (1) all three estimates of age-0 brown trout in 1970-72 are significantly smaller than the 1968 and 1969 estimates, and (2) the average estimate for 1970-1972 is significantly smaller than the 1967-1969 average. Hence the close similarity between fluctuations in the Control Section and in Section I indicates that something other than salmon influenced consistent occurrence of smaller populations of age-0 brown trout in Section I during 1970-1972. This possibility has been evaluated by comparing, between sections, the ratios of average annual decrease in number of age-0 brown trout from the period 1967-69 to the period 1970-72 (381 in Section I and 741 in the Control Section) to average annual production (1,177 and 1,919, respectively) of this age group in 1967-69. The results appear below:

Section I, 381:1177 = 0.3237 ± 0.1156

Control Section, 741:1919 = 0.3861 ± 0.1112

Although the extent of loss in the Control Section is apparently greater, the two values are not statistically different. Still, the fact that the two losses are relatively equal indicates that something other than salmon was responsible for the reduction in Section I.

On the other hand, decline of age-0 brown trout populations in Section II began 2 years sooner than in the other 1-mile sections, and the beginning coincided with the first appearance of large numbers of salmon. Since reproduction here in each of the 4 years succeeding 1967 (in the presence of much heavier concentrations of salmon than occurred in Section I) was significantly smaller than reproduction in 1967, it is concluded that coho salmon influenced the reduced abundance of young brown trout in Section II. The extent of this effect is considered later on in this report.

<u>Comparison of growth of trout and salmon in the 1-mile sections</u>

As with influence of coho salmon on trout abundance, it is reasonable to suppose that if the salmon have influenced growth of trout, it should be most apparent in the first year of life. Controlled laboratory experiments that Laarman [15] conducted with juvenile (age-group 0) rainbow trout and coho salmon demonstrated that, when two species of salmonids living together are dependent on a restricted supply of food, the growth rate of one species can be significantly depressed. In Laarman's experiment it was the salmon whose growth was adversely affected. Growth of salmonids in Platte River was compared primarily to learn whether coho salmon adversely affected growth of trout. As in the comparisons of abundance, average values determined from data accumulated during the periods of 1967-1969 and 1970-1972 were used. One of the comparisons involved length and weight measurements of age-0 salmonids (obtained in September) and of age-I salmonids (obtained in April). The averages are recorded in Table 23. A tabular summary of the results follows. The symbols used in this summary, and also in the one for older trout farther on, have these meanings: a plus sign (+) indicates that average length (L) or average weight (W) for 1967-69 significantly exceeded the corresponding average for 1970-72; an x means that the average for either length or weight was significantly larger in 1970-72; and a zero means there was no significant difference between the two periods.

Section, and species of trout or salmon	Age group 0		Age group I	
	L	W	L	W
Control				
Brown	0	0	+	+
Rainbow	+	+	+	+
Coho	0	0	..	..
Section I				
Brown	+	+	+	+
Rainbow	0	+	+	+
Coho	0	0	+	+
Section II				
Brown	+	0	0	0
Rainbow	0	0	0	0
Coho	0	0	+	+

It is obvious from the above tabulation that, while growth of young trout was highly uniform in Section II during 1967-1972, in Section I and the Control Section the values of average length and weight for 1967-69 in most instances significantly exceeded those for 1970-72. Yet the margins of significant difference [12] are small, usually in the range of 0.1 to 0.4 inch for length, and 2 to 4 grams for weight.

[12] "Margin of significant difference," in the sense that the term is used here, may be defined by an example: average length in 1967-69 = 4.9 ± 0.1 inches; average length in 1970-72 = 4.4 ± 0.2 inches; 4.8 – 4.6 inches = 0.2 inch ("MSD").

A comparison similar to the preceding one has been made for older trout from average lengths and weights given in Tables 20-22. For brown trout, valid comparisons could be made with age-groups I, II, and III; the IV+ group was not acceptable mainly because the size spread of fish in the samples usually was quite broad. For rainbow trout, age-groups I and II were suitable. A tabulation of the results of this comparison follows:

Section, and species of trout	Age group					
	I		II		III	
	L	W	L	W	L	W
Control						
Brown	+	+	+	+	0	+
Rainbow	+	+	+	+	..	..
Section I						
Brown	+	+	+	+	0	0
Rainbow	0	0	0	+	..	..
Section II						
Brown	0	0	0	0	+	+
Rainbow	x	x	x	x	..	..

These results are much like those obtained in the comparison made with younger trout. Here again the margins of significant difference are small (0.1-0.3 inch for length, and 5-13 grams for weight). The main difference in these results is that the older rainbow trout in Section II averaged significantly larger in 1970-72 than those present here in 1967-69; size of the younger rainbows here in these periods was not significantly different.

Conclusions on effects of salmon on growth of trout in the 1-mile sections

Inspection of data on first-year growth has shown that trout in the middle and upper experimental sections averaged significantly larger in length and weight during 1967-69 than during 1970-72, in six of eight comparisons. As the results in the Control Section were quite similar to those in Section I, it appears very unlikely that presence of considerable numbers of young salmon in Section I during 1970-72 was responsible for smaller size of trout here in this period. Other evidence which tends to indicate coho salmon had no effect on growth of young trout is that size of the three species of salmonids was remarkably uniform in September for fish of age-group 0, and in April for fish of age-group I. The 6-year averages for length and weight in September (Table 23) show no instance wherein the size of a species varied significantly between sections, and only two instances of significant size difference between species within a section (coho averaging slightly longer than rainbow trout in the Control Section and in Section II). Similarly, there are only three instances recorded in April of size difference among species in a section; these instances are as follows: brown trout significantly larger than rainbow trout and coho salmon in the Control Section and in Section I, and rainbow trout significantly larger than brown trout and coho in Section II.

In streams that served as sites for studies that Hartman [10] conducted on relationships between coho salmon and steelhead (rainbow) trout, young-of-the-year coho were appreciably larger than young-of-the-year rainbows throughout summer, but the difference decreased with the approach of fall. This pattern of growth was found to occur also in Platte River, and it applied to brown trout as well as rainbow trout. To illustrate how sizes compared here in summer, brown trout, rainbow trout, and coho salmon of age-group 0 in Section I during July in 1970-1972 averaged respectively 2.8, 2.3 and 3.3 inches in length.

Comparison of growth experienced by older trout mainly serves to corroborate findings that resulted from comparison of growth in young trout. Growth in brown trout in Section I and the Control Section was generally better in 1968 and 1969 than in the other 4 years of sampling (Tables 20 and 21), and influenced the length and weight averages of 1967-1969 to be significantly larger than those of 1970-72. Growth of rainbow trout in the Control Section apparently was slightly better in 1968 and 1969 than in the other 3 years, but not in Section I (Table 22).

The sum of the observations on growth of older trout, together with those concerning young trout, indicate that some factor or factors other than salmon influenced the small differences in growth rates that occurred between the periods of 1967-1969 and 1970-1972.

Comparison of biomass of salmonids in the 1-mile sections

Total weights of the trout populations, in pounds per acre, are given in Tables 24 and 25. Figure 5, which displays the 3-year averages graphically, indicates that biomass of trout was similar in the 2 months when the experimental sections were inventoried, and also in the two periods of combined years. Examination of the averages in Tables 24 and 25, to compare biomass in 1967-1969 with 1970-1972, reveals that there are as many instances of nonsignificant difference as there are of significant difference (six of each). The results are enumerated (and conclusions stated in the present tense) in the next two paragraphs, including the "margin of significant difference" (in pounds per acre) where weight in one period was significantly greater than what it was in the other.

Among April populations, average total weight of brown trout in Sections I and II is not significantly different between the two periods, but in the Control Section the 1970-1972 value is significantly (5 pounds) greater than the one for 1967-1969. Average total weight of rainbow trout populations is significantly greater in 1967-1969 in all three sections (Control Section, 7 pounds; Section I, 6 pounds; Section II, 8 pounds). In the Control Section, however, a considerable number (1,255 estimated) of age-II planted rainbow trout were present in April 1967. If their weight (estimated to have been approximately 35 pounds per acre) were subtracted from the weight calculated for wild and planted rainbows combined (67 pounds per acre), the average weights in the two periods would probably not be significantly different.

Among September populations, average total weight of both brown trout and rainbow trout in Section II is significantly greater in 1970-1972

(19 and 13 pounds, respectively). In the other two sections, the weights of either species do not differ significantly.

Conclusions on effects of salmon on biomass of trout in the 1-mile sections

Comparisons of biomass have shown that in Sections I and II average weight of trout populations fluctuated significantly in four of eight instances of comparison between the periods of 1967-1969 and 1970-1972. Although it is impossible to ascribe the cause of any of these fluctuations to coho salmon, neither can the cause be ascribed to anything else. What would indicate that salmon had little, if any, influence on biomass of trout is that they evidently exerted little effect on abundance of trout, and none on their growth rate.

EFFECT OF COHO SALMON ON ABUNDANCE OF TROUT IN THE 1480-FOOT SECTIONS

Two 1480-foot sections of Platte River, that also were used in this study, have been described near the beginning of this report. Estimates of salmonid populations were made here in 1971 and 1972. The lake and stream improvement section of the Fisheries Division, starting in 1958, used the upper one of these stretches (located about 1/2 mile below North Pioneer Road) to evaluate stream improvement work. In July 1958, 15 units of cover for fish, and 1 deflector, were installed in the upstream half of the section; the downstream half was left free of structures. In the following 3 years (1959-1961), fish population surveys were made annually in both segments to obtain estimates of trout numbers [30]. After the third year, the installations in the upper half of the section were removed, and like structures were built in the lower half. Population surveys were continued the next 3 years (1962-1964). The estimates of trout (brown, rainbow, and brook combined) in the entire 1480 feet of stream, for the first 5 years of the study,[13] are shown in Table 26.

Shown in Table 27 are estimates of brown trout, rainbow trout, and age-0 coho salmon obtained in 1971 and 1972 in this 1480-foot section and in the one above South Street. Not included in the table are 26 brook trout captured in the Pioneer Road section in 1971, and 12 captured here in 1972. These fish were mostly of age-groups 0 and I.

Awareness of the following procedures and conditions is desirable for comparing the estimates of 1971 and 1972 with those of 1959-1963: (1) The same type of generator (2500-watt d-c) was used for collecting fish during 1960-1963 as was used in 1971-1972; a

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[13] Data are on hand for just 5 years of the 6-year study. Those for the first 3 years appear in a progress report [30], and those for 1962 and 1963 are recorded in notations. Presumably a final report followed completion of the study, but a copy could not be found.

600-watt a-c unit was used in 1959. (2) The mark-and-recapture method was employed in both periods, but the surveys were made at somewhat different times--in late July or early August in 1959-1963, and from August 30 to September 8 in 1971-72. (3) Rainbow trout populations were at low ebb in Platte River (and in other streams as well) in the late 1950's and early 1960's, because of extensive predation by the sea lamprey (Petromyzon marinus). By 1971 (and earlier), rainbow trout in the Lake Michigan region had again attained high abundance.

Comparison of abundance of trout in the Pioneer Road section in 1971-1972 with abundance in 1959-1963

Data in Tables 26 and 28 are applicable for this comparison. The estimates made during 1959-1963 were determined with the Petersen formula; in Table 26 they have been replaced with estimates calculated with the Bailey-Petersen formula, from the same collection data, to make them more comparable to the estimates of 1971-1972. Because young fish were grouped differently in the two periods, the two variant groups (1.0-3.9 and 4.0.6.9 inches vs. 1.0-4.9 and 5.0-6.9 inches) have been combined into a single group (1.0-6.9 inches). Further, since the population estimates for 1959-1963 are of three species of trout combined,[14] they must be compared with total estimates of the 1971-1972 populations.

Other factors complicating this comparison are abnormally low abundance of rainbow trout during 1959-1963 (due to depredation by sea lampreys), and much smaller numbers of brook trout in the Pioneer Road section in 1971-1972. Although it is not clearly known how far rainbow trout in 1959-1963 had fallen below their former level of abundance, various records suggest that populations in the 1950's and early 1960's were only about 1/8 the size of those in the late 1960's and early 1970's [25]. On the basis of this observation, the average

[14] At mid-stage of the field work (through 1961), it was estimated that brown trout, rainbow trout, and brook trout respectively comprised 55, 30, and 15% of the total trout population in this part of the river [30].

point estimates of rainbow trout in 1971-1972 have been reduced by a factor of 7/8 in the tabulation which subsequently follows. As brook trout comprised approximately 15% of the total trout population in this section during the earlier years,[15] but had become so scarce by 1971 that an estimate could not be made of their number, perhaps a 15% reduction of the 1959-1963 average estimate for the 1.0-6.9 inch group would be justified. However, such adjustment has not been made in the tabulation to follow.

The last size group (fish 10 inches long and larger) may be considered to have contained only brown trout in both periods. It consisted only of this species in 1971-1972, and probably its composition in the earlier years was virtually the same. Brown trout alone are represented in this size group in those collection records of 1959-1963 that are available.

Following are average point estimates, with 95% confidence limits, of numbers of trout in the Pioneer Road section during the periods of concern:

Years	Size group (inches)			Total
	1.0-6.9	7.0-9.9	10.0+	
1959-1963 average	864±113	206±29	32± 7	1102±117
1971-1972 average	*814±265	*299±41	84±17	1197±269

* The portion of this estimate that represents rainbow trout is 1/8 the size of the original average estimate for rainbow trout.

[15] It was thought that these brook trout were produced in a small tributary which entered the river within the Pioneer Road section.

Comparison of abundance of salmonids in the 1480-foot sections with abundance in the 1-mile sections

Another pertinent evaluation can be made by comparing production of salmonids in the 1480-foot sections with concurrent production of salmonids in the 1-mile sections. To make this procedure feasible, the 1971 and 1972 estimates in each 1480-foot section were projected for 1 mile of river (Table 29). The 2-year averages of the projected estimates for the South Street section were compared with 3-year (1970-72) average estimates in the 1-mile sections (Tables 8 and 9). Direct comparison can be made with this section, because its area when projected to a mile of stream (5.4 acres) is closely similar to the areas of Sections I and II (5.3 acres for each), and because it is not greatly different from the area of the Control Section (5.8 acres). Results of comparing production of trout in the South Street section with production in the 1-mile sections follow, the symbols having these meanings: a plus sign (+) indicates that the average estimate of trout in the designated 1-mile section is significantly larger than the projected average estimate in the South Street section; an "x" indicates that the average estimate for the South Street section is significantly larger; and a zero (0) shows there is no significant difference between compared estimates.

Section and species of trout	Size group (inches)			
	1.0-4.9	5.0-6.9	7.0-9.9	10.0+
Control Section				
Brown	+	0	0	x
Rainbow	x	x	+	..
Section I				
Brown	0	0	0	0
Rainbow	x	x	x	..
Section II				
Brown	x	x	x	+
Rainbow	x	+	+	..

It is apparent in the tabulation that, on a numerical basis, production of brown trout in the South Street section was little different from what it was in the Control Section and in Section I, but was generally better than in Section II. Production of rainbow trout was significantly better in the South Street section than in the Control Section and Section I, in all instances of comparison except one, but was not quite so good as production in Section II.

Some conception of how the South Street and Pioneer Road sections compared between themselves and with the 1-mile sections in production of salmonids, on the basis of numbers of salmonids per acre of stream, is afforded by the following listing. The figures are 2- and 3-year (1971-72 and 1970-72) fall average total numbers:

Section	Brown trout	Rainbow trout	Coho salmon
South Street	295	1,766	436
Pioneer Road	452	1,562	641
Control	346	693	.....
Section I	340	589	226
Section II	137	1,174	1,241

<u>Conclusion on effect of salmon on abundance of trout in the 1480-foot sections</u>

The 1480-foot segments of Platte River under study were accessible to spawning coho salmon throughout the period of study. Considerable numbers of coho were produced here in one year (1971) of the two years that these sections were inventoried, and there is good reason to suppose that reproduction was much better during 1968-1970 than in 1972 when it was poor. Despite the presence of salmon, trout production during 1971 and 1972 in one of the sections compared favorably with production during 1959-1963. Moreover, trout production in both of these sections in 1971 and 1972 also compared quite favorably with that in the 1-mile Control section from which adult salmon were excluded during 1967-1972, in Section I which contained salmon during 1970-1972, and in Section II, to which spawning salmon had free access each year during 1967-1972. Therefore it is concluded that coho salmon had no detectable effect on abundance of trout in the 1480-foot sections.

SUMMARY OF EFFECTS OF COHO SALMON ON TROUT IN THE PLATTE RIVER

The investigations conducted on the Platte River from April 1967 through September 1972 indicated that salmon had little effect on trout except where the salmon spawners were highly concentrated, which happened in Experimental Section II. In this section I found a decrease of brown trout reproduction during 1968-72, but no reduction in older trout resulting from this decrease. Also in this section Stephen G. Hildebrand found a reduction of benthic fish-food organisms in the fall of 1967, but apparently neither growth nor survival of older trout was affected.

Reduced reproduction of brown trout in Section II followed the initial presence of spawning coho salmon which were highly numerous here fall after fall. Statistically, the 1967 estimate of age-0 brown trout significantly exceeded the estimates for the years 1968 to 1972. Both the beginning and the persistence of this decline point to salmon as having been its cause. But the decreases are interpreted (from estimates of older trout) as having had but little effect on the population of these year classes at older ages. In other words, the reduction in number of young brown trout was compensated by a better rate of survival to the older ages. This interpretation is supported by evidence from the two 1480-foot sections that had been inhabited by coho salmon as long as had Section II.

Hildebrand found that densities of twelve taxa of bottom organisms, and also the number and weight of all organisms taken in square-foot samples, decreased significantly between August and December 1967 in Section II [13]. In October and November 1967, a large concentration of spawning coho salmon extensively disturbed the bottom soils here. By the following May, three of the twelve taxa remained at low levels of abundance; at this time the total number of organisms was still significantly reduced, but the total weight was back to the pre-autumn level. Sampling was not continued beyond May 1968, so I can only speculate on what happened to the benthic populations thereafter. It seems likely that they reached their normal level of abundance during the summer, and again were reduced in succeeding autumns through 1970, when coho runs were extremely large. Probably some influence from salmon other than reduction of benthic organisms was responsible for the reduced reproduction of brown trout in Section II. I judge that the reduction in benthic food was not critical, for neither the growth rate of trout nor the number of older trout was adversely affected.

Table 1.--Number of brown trout, by age group and with 95% confidence limits, in the 1-mile experimental sections during September 1967-1972

Section and year	Age group 0	I	II	III	IV+	Total
Control						
1967	1235 ± 322	474 ± 199	114 ± 98	23 ± 44	4 ± 18	1850 ± 394
1968	2605 ± 520	547 ± 238	137 ± 119	49 ± 71	3 ± 18	3341 ± 590
1969	1916 ± 182	840 ± 121	154 ± 52	36 ± 25	3 ± 7	2949 ± 226
1970	932 ± 131	670 ± 111	336 ± 78	53 ± 5	.. ..	1991 ± 191
1971	1576 ± 149	394 ± 74	355 ± 71	66 ± 30	13 ± 14	2404 ± 184
1972	1026 ± 143	340 ± 82	172 ± 59	76 ± 43	13 ± 16	1627 ± 180
Section I						
1967	694 ± 157	481 ± 130	195 ± 83	50 ± 42	14 ± 22	1434 ± 225
1968	1602 ± 367	472 ± 199	286 ± 155	28 ± 43	5 ± 21	2393 ± 449
1969	1235 ± 215	677 ± 159	307 ± 107	67 ± 50	27 ± 32	2313 ± 294
1970	804 ± 113	659 ± 103	590 ± 97	116 ± 43	20 ± 18	2189 ± 187
1971	774 ± 118	340 ± 78	413 ± 86	182 ± 57	29 ± 23	1738 ± 177
1972	810 ± 183	301 ± 111	253 ± 102	135 ± 75	28 ± 34	1527 ± 251
Section II						
1967	239 ± 82	343 ± 97	186 ± 72	58 ± 40	12 ± 18	838 ± 153
1968	28 ± 19	255 ± 58	259 ± 57	58 ± 27	10 ± 11	610 ± 89
1969	52 ± 36	379 ± 97	254 ± 79	100 ± 50	10 ± 15	795 ± 141
1970	98 ± 39	261 ± 64	278 ± 66	144 ± 48	43 ± 26	824 ± 114
1971	71 ± 32	226 ± 56	197 ± 52	152 ± 46	41 ± 24	687 ± 98
1972	145 ± 54	94 ± 43	225 ± 67	87 ± 42	42 ± 29	593 ± 109

Table 2.--Number of rainbow trout, by age group and with 95% confidence limits, in the 1-mile experimental sections during September 1967-1972

Section and year	Age group 0	I	II	III	Total
Control					
1967	3229 ± 1326	488 ± 516	3 ± 40	2 ± 33	3722 ± 1424
1968	4087 ± 1179	343 ± 342	2 ± 26	....	4432 ± 1228
1969	1748 ± 248	850 ± 172	18 ± 25	....	2616 ± 303
1970	4271 ± 622	472 ± 207	16 ± 12	....	4759 ± 657
1971	5229 ± 614	660 ± 218	6 ± 21	....	5895 ± 652
1972	2241 ± 400	445 ± 178	7 ± 22	....	2693 ± 439
Section I					
1967	1569 ± 1569	499 ± 499	8 ± 38	....	2076 ± 606
1968	1499 ± 392	340 ± 187	25 ± 51	....	1864 ± 437
1969	1347 ± 329	636 ± 226	43 ± 59	....	2026 ± 403
1970	4140 ± 990	592 ± 374	44 ± 102	....	4776 ± 1063
1971	4710 ± 683	382 ± 194	1 ± 10	2 ± 14	5095 ± 710
1972	2314 ± 632	607 ± 323	4 ± 26	....	2925 ± 516
Section II					
1967	3000 ± 1171	1051 ± 693	3 ± 37	....	4054 ± 1361
1968	3908 ± 1138	693 ± 479	16 ± 73	....	4617 ± 1237
1969	2832 ± 994	1087 ± 616	108 ± 194	....	4027 ± 1186
1970	4480 ± 1126	1029 ± 540	52 ± 121	7 ± 45	5568 ± 1256
1971	3172 ± 594	1126 ± 354	47 ± 72	3 ± 18	4348 ± 696
1972	7625 ± 208	1063 ± 78	52 ± 17	6 ± 6	8746 ± 223

Table 3.--Number of brown trout, by age group and with 95% confidence limits, in the 1-mile experimental sections during April 1967-1972

Section and year	Age group I	II	III	IV+	Total
Control					
1967	557 ± 155	301 ± 112	65 ± 52	23 ± 34	968 ± 200
1968	1025 ± 201	358 ± 119	22 ± 29	8 ± 18	1413 ± 236
1969	1035 ± 248	258 ± 124	68 ± 64	5 ± 17	1366 ± 285
1970	1476 ± 271	826 ± 202	94 ± 68	16 ± 28	2412 ± 346
1971	762 ± 133	590 ± 117	134 ± 56	3 ± 8	1489 ± 186
1972	985 ± 99	183 ± 43	210 ± 46	36 ± 19	1414 ± 119
Section I					
1967	830 ± 252	473 ± 191	193 ± 122	37 ± 53	1533 ± 343
1968	744 ± 212	570 ± 186	145 ± 94	29 ± 42	1488 ± 300
1969	1213 ± 420	306 ± 211	147 ± 146	19 ± 53	1685 ± 495
1970	881 ± 166	796 ± 158	196 ± 79	20 ± 25	1893 ± 244
1971	452 ± 93	699 ± 115	238 ± 67	22 ± 20	1411 ± 164
1972	716 ± 87	220 ± 48	316 ± 58	88 ± 30	1340 ± 119
Section II					
1968*	252 ± 119	341 ± 138	83 ± 68	.....	676 ± 195
1969	178 ± 55	239 ± 64	123 ± 46	43 ± 27	583 ± 100
1970	130 ± 87	330 ± 138	176 ± 101	46 ± 52	682 ± 199
1971	218 ± 76	259 ± 82	221 ± 76	48 ± 36	746 ± 140
1972	56 ± 133	126 ± 200	70 ± 149	64 ± 142	316 ± 46

* No estimate for Section II in April 1967 because this section was not yet established at that time.

Table 4.--Number of rainbow trout, by age group and with 95% confidence limits, in the 1-mile experimental sections during April 1967-1972

Section and year	Age group I	Age group II	Age group III	Total
Control				
1967	1025 ± 296	1611 ± 372	.....	2636 ± 476
1968	1609 ± 491	114 ± 131	11 ± 40	1734 ± 510
1969	1918 ± 655	159 ± 189	.....	2077 ± 682
1970	1298 ± 375	515 ± 237	14 ± 39	1827 ± 446
1971	2352 ± 291	283 ± 101	8 ± 17	2643 ± 309
1972	1947 ± 221	463 ± 108	8 ± 14	2418 ± 246
Section I				
1967	1091 ± 251	735 ± 206	11 ± 25	1837 ± 326
1968	1274 ± 400	468 ± 243	13 ± 40	1755 ± 470
1969	1885 ± 589	359 ± 257	25 ± 68	2269 ± 646
1970	893 ± 256	414 ± 174	5 ± 19	1312 ± 310
1971	820 ± 174	233 ± 93	5 ± 14	1058 ± 198
1972	1891 ± 199	214 ± 67	.....	2105 ± 210
Section II				
1968*	2080 ± 552	1438 ± 459	18 ± 51	3536 ± 720
1969	3874 ± 490	753 ± 216	.....	4627 ± 536
1970	1684 ± 387	1296 ± 339	27 ± 49	3007 ± 517
1971	3327 ± 341	620 ± 147	.....	3947 ± 371
1972	2641 ± 304	598 ± 145	.....	3239 ± 337

* No estimate for Section II in April 1967 because this section was not yet established at that time.

Table 5.--Average number of brown trout, by age group and with 95% confidence limits, in the 1-mile experimental sections during September and April 1967-1972. Averages are for 3-year periods.

Section and year	Age group 0	I	II	III	IV+	Total
Control						
1967-69						
Sep.	1919 ± 213	620 ± 111	135 ± 54	36 ± 29	3 ± 9	2713 ± 248
April	.....	880 ± 118	306 ± 68	52 ± 29	12 ± 14	1250 ± 140
1970-72						
Sep.	1178 ± 82	468 ± 52	288 ± 40	65 ± 18	9 ± 10	2008 ± 107
April	.....	1074 ± 106	533 ± 79	146 ± 33	18 ± 12	1771 ± 137
Section I						
1967-69						
Sep.	1177 ± 151	543 ± 95	263 ± 69	48 ± 26	15 ± 15	2046 ± 194
April	.....	929 ± 178	450 ± 113	162 ± 71	28 ± 29	1569 ± 224
1970-72						
Sep.	796 ± 82	433 ± 57	419 ± 55	144 ± 35	26 ± 15	1818 ± 120
April	.....	683 ± 70	572 ± 67	250 ± 40	43 ± 15	1548 ± 106
Section II						
1967-69						
Sep.	106 ± 31	326 ± 50	233 ± 40	72 ± 23	11 ± 9	748 ± 75
April*	.....	215 ± 65	290 ± 76	103 ± 41	22 ± 14	630 ± 110
1970-72						
Sep.	105 ± 25	194 ± 32	233 ± 36	128 ± 26	42 ± 15	702 ± 62
April	.....	135 ± 59	238 ± 85	156 ± 65	53 ± 52	582 ± 133

* No estimate for Section II in April 1967, so these means cover only 1968 and 1969. All other means are for 3-year periods.

Table 6.--Average number of rainbow trout, by age group and with 95% confidence limits, in the 1-mile experimental sections during September and April 1967-1972. Averages are for 3-year periods.

Section, period, and month	Age group 0	I	II	III	Total
Control					
1967-69					
Sep.	3022 ± 597	560 ± 214	8 ± 18	1 ± 11	3590 ± 634
April	.....	1517 ± 290	628 ± 146	4 ± 13	2149 ± 325
1970-72					
Sep.	3913 ± 320	526 ± 116	10 ± 11	0 ...	4449 ± 341
April	.....	1866 ± 174	420 ± 93	10 ± 15	2296 ± 199
Section I					
1967-69					
Sep.	1472 ± 245	492 ± 139	25 ± 29	0 ...	1989 ± 283
April	.....	1417 ± 252	521 ± 136	16 ± 28	1954 ± 288
1970-72					
Sep.	3721 ± 453	527 ± 177	16 ± 35	<1 ± 5	4265 ± 460
April	.....	1201 ± 123	287 ± 69	3 ± 8	1492 ± 141
Section II					
1967-69					
Sep.	3247 ± 637	944 ± 348	42 ± 70	0 ...	4233 ± 729
April*	.....	2977 ± 339	1096 ± 254	9 ± 26	4082 ± 449
1970-72					
Sep.	5092 ± 430	1073 ± 217	50 ± 47	5 ± 16	6221 ± 484
April	.....	2551 ± 200	838 ± 132	9 ± 16	3398 ± 240

* No estimate for Section II in April 1967, so these means cover only 1968 and 1969. All other means are for 3-year periods.

Table 7.--Average number of brown trout and rainbow trout, by age group and with 95% confidence limits, in the 1-mile experimental sections during September and April 1967-1972. Averages are for the 6-year period.

Section, species, and month	Age group 0	I	II	III	IV+	Total
Control						
Brown						
Sep.	1548 ± 114	544 ± 61	211 ± 34	50 ± 17	6 ± 7	2359 ± 134
April	.....	977 ± 79	420 ± 52	99 ± 22	15 ± 9	1511 ± 98
Rainbow						
Sep.	3469 ± 339	543 ± 121	9 ± 11	<1 ± 6	.....	4020 ± 360
April	.....	1692 ± 169	524 ± 86	7 ± 10	.....	2222 ± 191
Section I						
Brown						
Sep.	987 ± 86	488 ± 55	341 ± 44	96 ± 22	20 ± 10	1932 ± 114
April	.....	806 ± 96	511 ± 66	206 ± 41	36 ± 13	1559 ± 124
Rainbow						
Sep.	2597 ± 257	509 ± 113	21 ± 23	<1 ± 2	.....	3127 ± 270
April	.....	1309 ± 140	404 ± 77	10 ± 14	.....	1723 ± 160
Section II						
Brown						
Sep.	106 ± 20	260 ± 30	233 ± 27	100 ± 17	26 ± 9	725 ± 49
April*	.....	167 ± 44	259 ± 60	135 ± 42	40 ± 27	601 ± 91
Rainbow						
Sep.	4170 ± 384	1088 ± 205	46 ± 42	3 ± 8	.....	5227 ± 437
April*	.....	2721 ± 190	941 ± 129	14 ± 14	.....	3671 ± 230

* No estimate for Section II in 1967, so these means are for the period of 1968-1972. All other means are for 1967-1972.

Table 8.--Average number of brown trout, by size group and with 95% confidence limits, in the 1-mile experimental sections during April and September 1967-1972. Averages are for 3-year periods and the 6-year period.

Section, month, and period	Size group (inches)				Total
	1.0-4.9	5.0-6.9	7.0-9.9	10+	
Control					
April					
1967-69	354 ± 87	540 ± 100	277 ± 44	78 ± 15	1249 ± 140
1970-72	772 ± 123	315 ± 40	529 ± 54	156 ± 23	1771 ± 142
1967-72	562 ± 75	427 ± 54	403 ± 28	117 ± 13	1509 ± 98
Sep.					
1967-69	1893 ± 342	231 ± 31	478 ± 40	111 ± 21	2713 ± 346
1970-72	1167 ± 100	230 ± 22	461 ± 26	146 ± 33	2004 ± 124
1967-72	1530 ± 178	230 ± 19	469 ± 24	128 ± 34	2357 ± 184
Section I					
April					
1967-69	470 ± 119	556 ± 124	375 ± 50	168 ± 26	1569 ± 181
1970-72	532 ± 74	256 ± 43	554 ± 57	206 ± 25	1548 ± 106
1967-72	501 ± 70	406 ± 66	464 ± 38	187 ± 18	1558 ± 105
Sep.					
1967-69	1159 ± 187	299 ± 35	441 ± 34	148 ± 28	2047 ± 195
1970-72	787 ± 100	304 ± 28	524 ± 33	203 ± 18	1818 ± 110
1967-72	973 ± 106	301 ± 22	482 ± 23	175 ± 16	1931 ± 112
Section II					
*April					
1968-69	78 ± 63	153 ± 111	227 ± 47	172 ± 43	630 ± 143
1970-72	81 ± 73	69 ± 23	192 ± 43	239 ± 53	581 ± 103
1968-72	79 ± 48	111 ± 57	209 ± 32	205 ± 34	605 ± 88
Sep.					
1967-69	103 ± 41	120 ± 34	316 ± 46	209 ± 30	748 ± 76
1970-72	103 ± 39	58 ± 23	233 ± 23	308 ± 35	702 ± 62
1967-72	103 ± 28	89 ± 20	274 ± 26	258 ± 23	724 ± 49

* No estimate for Section II in April 1967.

Table 9.--Average number of rainbow trout, by size group and with 95% confidence limits, in the 1-mile experimental sections during April and September 1967-1972. Averages are for 2- or 3-year, and 5- or 6-year periods.

Section, month, and period	Size group (inches)			Total
	1.0-4.9	5.0-6.9	7.0-9.9	
Control				
*April				
1968-69	1110 ± 366	636 ± 212	158 ± 51	1904 ± 763
1970-72	1657 ± 278	359 ± 44	279 ± 43	2295 ± 94
1968-72	1438 ± 316	470 ± 69	231 ± 23	2139 ± 244
Sep.				
1967-69	2975 ± 633	383 ± 39	232 ± 36	3590 ± 635
1970-72	3855 ± 338	438 ± 45	156 ± 22	4449 ± 323
1967-72	3415 ± 358	410 ± 30	194 ± 21	4019 ± 360
Section I				
*April				
1968-69	1060 ± 60	638 ± 212	314 ± 88	2012 ± 432
1970-72	1025 ± 131	253 ± 34	214 ± 44	1492 ± 142
1968-72	1039 ± 54	407 ± 68	254 ± 33	1700 ± 147
Sep.				
1967-69	1447 ± 275	410 ± 60	131 ± 29	1988 ± 283
1970-72	3712 ± 428	405 ± 54	148 ± 34	4265 ± 431
1967-72	2579 ± 254	407 ± 40	139 ± 22	3125 ± 258
Section II				
*April				
1968-69	1341 ± 259	1589 ± 164	1151 ± 258	4081 ± 401
1970-72	1621 ± 183	904 ± 112	872 ± 105	3397 ± 239
1968-72	1509 ± 108	1178 ± 68	984 ± 91	3671 ± 157
Sep.				
1967-69	3236 ± 718	580 ± 123	417 ± 76	4233 ± 733
1970-72	4964 ± 542	431 ± 72	826 ± 89	6221 ± 554
1967-72	4100 ± 450	505 ± 71	621 ± 59	5226 ± 459

* April 1967 estimates omitted because of presence of planted rainbow trout in the Control Section and in Section I, and absence of an estimate for Section II.

Table 10.--Number of young coho salmon, with 95% confidence limits, in the 1-mile experimental sections during September (age 0) and April (age I), 1967-1972

Section and year	Age group	
	0	I
Control		
1967	96 ± 47	.....
1968	75 ± 66	9 ± 6
1969	727 ± 624	.....
1970	600 ± 168	125 ± 81
1971	267 ± 85	198 ± 154
1972	175 ± 95	163 ± 118
Section I		
1967	298 ± 144	.....
1968	286 ± 166	215 ± 128
1969	499 ± 164	115 ± 118
1970	1997 ± 357	448 ± 169
1971	1220 ± 349	494 ± 255
1972	373 ± 152	278 ± 70
Section II		
1967	1323 ± 425	.....
1968	3431 ± 666	2520 ± 578
1969	4299 ± 791	1829 ± 326
1970	8135 ± 984	8475 ± 986
1971	8056 ± 678	3573 ± 326
1972	3539 ± 490	1280 ± 162

Table 11.--Percentage survival[1] from fall to spring (October to April) of brown trout of two age groups and with 95% confidence limits, in the 1-mile experimental sections, 1967-1972

Section, and years of interval	Age 0-I	Age I-II
Control		
1967-68	83 ± 12	63 ± 5
1968-69	40 ± 12	45 ± 5
Average	62 ± 8	54 ± 4
1969-70	77 ± 12	91 ± 5
1970-71	82 ± 12	69 ± 5
1971-72	62 ± 12	52 ± 5
Average	74 ± 7	71 ± 3
1967-72 average	65 ± 5	64 ± 2
Section I		
1967-68	107 ± 12	100 ± 5
1968-69	76 ± 12	60 ± 5
Average	92 ± 8	80 ± 4
1969-70	71 ± 12	94 ± 5
1970-71	56 ± 12	69 ± 5
1971-72	92 ± 12	65 ± 5
Average	73 ± 7	76 ± 3
1967-72 average	74 ± 5	72 ± 2
Section II		
1967-68	105 ± 480	71 ± 5
1968-69	636 ± 480	70 ± 5
Average	371 ± 339	70 ± 4
1969-70	250 ± 480	92 ± 5
1970-71	222 ± 480	73 ± 5
1971-72	79 ± 480	42 ± 5
Average	184 ± 277	69 ± 3
1967-72 average	258 ± 200	69 ± 2

[1] An underlined figure indicates an unrealistic value.

Table 12.--Percentage survival[1] from fall to spring (October to April) of rainbow trout of two age groups and with 95% confidence limits, in the 1-mile experimental sections, 1967-1972

Section, and years of interval	Age 0-I	Age I-II
Control		
1967-68	50 ± 13	23 ± 15
1968-69	47 ± 13	46 ± 15
Average	48 ± 9	34 ± 11
1969-70	74 ± 13	61 ± 15
1970-71	55 ± 13	60 ± 15
1971-72	37 ± 13	70 ± 15
Average	55 ± 8	64 ± 9
1967-72 average	53 ± 6	52 ± 7
Section I		
1967-68	81 ± 13	94 ± 15
1968-69	126 ± 13	106 ± 15
Average	104 ± 9	100 ± 11
1969-70	66 ± 13	65 ± 15
1970-71	20 ± 13	39 ± 15
1971-72	40 ± 13	56 ± 15
Average	42 ± 8	53 ± 9
1967-72 average	76 ± 6	72 ± 7
Section II		
1967-68	69 ± 13	137 ± 15
1968-69	99 ± 13	109 ± 15
Average	84 ± 9	123 ± 11
1969-70	59 ± 13	119 ± 15
1970-71	74 ± 13	60 ± 15
1971-72	83 ± 13	56 ± 15
Average	72 ± 8	78 ± 9
1967-72 average	77 ± 6	96 ± 7

[1] An underlined figure indicates an unrealistic value.

Table 13.--Percentage survival[1] from fall to spring (October to April) of coho salmon of one age group and with 95% confidence limits, in the 1-mile experimental sections, 1967-1972

Section, and years of interval	Age 0-I
Control	
1967-68	9 ± 16
1968-69	0 ± 16
Average	4 ± 11
1969-70	17 ± 16
1970-71	33 ± 16
1971-72	61 ± 16
Average	37 ± 9
1968-72 average	22 ± 7
Section I	
1967-68	72 ± 16
1968-69	40 ± 16
Average	50 ± 11
1969-70	90 ± 16
1970-71	25 ± 16
1971-72	23 ± 16
Average	46 ± 9
1968-72 average	50 ± 7
Section II	
1967-68	19 ± 16
1968-69	53 ± 16
Average	36 ± 11
1969-70	197 ± 22
1970-71	44 ± 16
1971-72	16 ± 16
Average*	30 ± 11
1968-72 average*	33 ± 8

* These averages cover two and four 7-month periods, respectively, the average of 1969-70 being omitted.

[1] An underlined figure indicates an unrealistic value.

Table 14.--Percentage survival[1] from spring to fall (May to September) of brown trout by age group and with 95% confidence limits, in the 1-mile experimental sections, 1967-1972

Section, and years of interval	Age group	
	I	II to IV+
Control		
1967	82 ± 10	36 ± 5
1968	53 ± 10	49 ± 5
1969	81 ± 10	58 ± 5
Average	72 ± 6	48 ± 3
1970	45 ± 10	42 ± 5
1971	52 ± 10	60 ± 5
1972	35 ± 10	61 ± 5
Average	44 ± 6	54 ± 3
1967-72 average	58 ± 4	51 ± 2
Section I		
1967	58 ± 10	51 ± 5
1968	63 ± 10	43 ± 5
1969	56 ± 10	85 ± 5
Average	59 ± 6	60 ± 3
1970	75 ± 10	72 ± 5
1971	75 ± 10	65 ± 5
1972	42 ± 10	67 ± 5
Average	64 ± 6	68 ± 3
1967-72 average	61 ± 4	64 ± 2
Section II		
1967	.....	.....
1968	<u>101</u> ± 47	77 ± 5
1969	<u>213</u> ± 47	90 ± 5
Average	.....	84 ± 4
1970	<u>201</u> ± 47	84 ± 5
1971	<u>104</u> ± 47	74 ± 5
1972	<u>168</u> ± 47	<u>136</u> ± 5
Average	.....	<u>98</u> ± 3
1968-72 average*	.....	81 ± 2

* Average for trout of age groups II-IV+ covers four periods, 1968-71.

[1] An underlined figure indicates an unrealistic value.

Table 15.--Percentage survival from spring to fall (May to September) of rainbow trout of age I and with 95% confidence limits, in the 1-mile experimental sections, 1968-1972

Section, and years of interval	Age group I
Control	
1968	21 ± 5
1969	44 ± 5
Average	32 ± 4
1970	36 ± 5
1971	28 ± 5
1972	23 ± 5
Average	29 ± 3
1968-72 average	30 ± 2
Section I	
1968	27 ± 5
1969	34 ± 5
Average	30 ± 4
1970	66 ± 5
1971	47 ± 5
1972	32 ± 5
Average	48 ± 3
1968-72 average	41 ± 2
Section II	
1968	33 ± 5
1969	28 ± 5
Average	30 ± 4
1970	61 ± 5
1971	34 ± 5
1972	40 ± 5
Average	45 ± 3
1968-72 average	39 ± 2

Table 16.--Age distribution of brown trout in September in the 1-mile experimental sections, 1967-1972. Average annual values in percent by 3- and 6-year periods

Section, and period	Age group 0	I	II	III	IV+	Confidence limits *
Control						
1967-69	70	23	5	1	1	3
1970-72	59	24	14	3	<1	3
1967-72	66	23	9	2	<1	2
Section I						
1967-69	56	28	13	3	<1	3
1970-72	45	23	23	8	1	3
1967-72	51	25	18	5	1	2
Section II						
1967-69	13	44	32	10	1	3
1970-72	16	27	33	18	6	3
1967-72	14	36	32	14	4	2

* Confidence limits (95%) for all age groups calculated from a pooled sampling error by analysis of variance.

Table 17.--Age distribution of brown trout in April in the 1-mile experimental sections, 1967-1972. Average annual values in percent by 2- or 3-year and 5- or 6-year periods.

Section, and period	Age group I	II	III	IV+	Confidence limits *
Control					
1967-69	70	25	4	1	4
1970-72	61	29	9	1	4
1967-72	65	28	6	1	2
Section I					
1967-69	59	29	10	2	4
1970-72	44	36	17	3	4
1967-72	52	33	13	2	2
Section II					
1968-69**	34	45	17	4	11
1970-72	22	41	26	11	4
1967-72	27	43	22	8	2

* Confidence limits (95%) for all age groups calculated from a pooled sampling error by analysis of variance.

** Samples not collected here in April 1967.

Table 18.--Age distribution of rainbow trout in September in the 1-mile experimental sections, 1967-1972. Average annual values in percent by 3- and 6-year periods.

Section, and period	Age group				Confidence limits *
	0	I	II	III	
Control					
1967-69	82	18	<1	<1	3
1970-72	87	13	<1	<1	3
1967-72	85	15	<1	<1	2
Section I					
1967-69	74	25	1	0	3
1970-72	86	14	<1	<1	3
1967-72	80	19	1	<1	2
Section II					
1967-69	76	23	1	0	3
1970-72	80	19	1	<1	3
1967-72	78	21	1	<1	2

* Confidence limits (95%) for all age groups calculated from a pooled sampling error by analysis of variance.

Table 19.--Age distribution of rainbow trout in April in the 1-mile experimental sections, 1968-1972. Average annual values in percent by 2- or 3-year and 5-year periods.

Section, and period	Age group I	Age group II	Age group III	Confidence limits *
Control				
1968-69	93	7	<1	18
1970-72	80	19	<1	6
1968-72	85	14	<1	4
Section I				
1968-69	80	20	<1	18
1970-72	80	20	<1	6
1968-72	80	20	<1	4
Section II				
1968-69	72	29	<1	18
1970-72	74	26	<1	6
1968-72	74	26	<1	4

* Confidence limits (95%) for all age groups calculated from a pooled sampling error by analysis of variance.

Table 20.--Length of brown trout, by age group, in the 1-mile experimental sections, 1967-1972. Average length in inches, with 95% confidence limits, by individual years, and by 3- and 6-year periods.

Section and year	Age group I	II	III	IV+
Control				
1967	6.4 ± 0.2	9.4 ± 0.2	11.5 ± 0.3	13.6 ± 0.8
1968	6.7 ± 0.2	9.5 ± 0.2	11.8 ± 0.7	14.5 ± 2.6
1969	6.7 ± 0.2	9.6 ± 0.2	11.6 ± 0.4	13.1 ± 1.0
1967-69	6.6 ± 0.1	9.5 ± 0.1	11.6 ± 0.3	13.7 ± 1.0
1970	6.3 ± 0.2	9.4 ± 0.1	11.7 ± 0.2	14.1 ± 2.3
1971	6.0 ± 0.2	9.2 ± 0.1	11.4 ± 0.3	12.9 ± 0.7
1972	6.4 ± 0.2	8.8 ± 0.1	10.7 ± 0.2	12.6 ± 0.4
1970-72	6.2 ± 0.1	9.1 ± 0.1	11.3 ± 0.1	13.2 ± 0.8
1967-72	6.4 ± 0.1	9.3 ± 0.1	11.4 ± 0.2	13.5 ± 0.6
Section I				
1967	6.1 ± 0.2	9.2 ± 0.2	11.3 ± 0.3	14.3 ± 0.8
1968	6.4 ± 0.2	9.3 ± 0.2	11.4 ± 0.4	13.1 ± 1.2
1969	6.3 ± 0.1	9.5 ± 0.1	10.8 ± 0.2	13.3 ± 0.8
1967-69	6.3 ± 0.1	9.3 ± 0.1	11.1 ± 0.2	13.6 ± 0.5
1970	6.0 ± 0.1	9.1 ± 0.1	11.7 ± 0.2	14.3 ± 1.3
1971	5.9 ± 0.2	8.8 ± 0.2	11.1 ± 0.2	12.8 ± 0.7
1972	6.0 ± 0.2	8.5 ± 0.2	10.6 ± 0.2	12.3 ± 0.3
1970-72	6.0 ± 0.1	8.8 ± 0.1	11.1 ± 0.1	13.1 ± 0.5
1967-72	6.1 ± 0.1	9.1 ± 0.1	11.1 ± 0.1	13.3 ± 0.4
Section II				
1967	.....	.....	.....	.....
1968	7.0 ± 0.2	10.1 ± 0.2	13.5 ± 0.7	17.7 ± 1.0
1969	6.5 ± 0.2	9.9 ± 0.2	12.8 ± 0.4	15.0 ± 0.3
*1968-69	6.7 ± 0.1	10.0 ± 0.2	13.1 ± 0.4	16.3 ± 0.5
1970	6.9 ± 0.2	10.0 ± 0.2	13.4 ± 0.4	16.7 ± 0.9
1971	6.5 ± 0.3	9.9 ± 0.2	13.0 ± 0.3	16.4 ± 0.8
1972	6.5 ± 0.3	9.7 ± 0.2	10.2 ± 0.7	15.2 ± 0.5
1970-72	6.6 ± 0.2	9.9 ± 0.1	12.2 ± 0.3	16.1 ± 0.4
*1968-72	6.7 ± 0.1	9.9 ± 0.1	12.6 ± 0.2	16.2 ± 0.3
State average length	6.4	9.0	11.5	15.1

* Samples not collected in April 1967; therefore averages comparable to the other averages could not be determined for this period.

Table 21.--Weight of brown trout, by age group, in the 1-mile experimental sections, 1967-1972. Average weight in grams, with 95% confidence limits, by individual years, and by 3- and 6-year periods.

Section and year	Age group			
	I	II	III	IV+
Control				
1967	51 ± 4	150 ± 12	263 ± 31	411 ± 73
1968	54 ± 4	147 ± 9	292 ± 41	498 ± 206
1969	52 ± 3	147 ± 8	282 ± 37	383 ± 105
1967-69	52 ± 2	148 ± 6	279 ± 21	430 ± 81
1970	43 ± 3	136 ± 6	266 ± 20	668 ± 602
1971	39 ± 4	126 ± 6	239 ± 20	333 ± 54
1972	47 ± 4	112 ± 7	202 ± 10	320 ± 37
1970-72	43 ± 2	125 ± 4	236 ± 10	440 ± 202
1967-72	48 ± 1	136 ± 3	257 ± 12	435 ± 109
Section I				
1967	45 ± 5	146 ± 12	237 ± 24	589 ± 121
1968	46 ± 4	139 ± 9	248 ± 25	408 ± 158
1969	43 ± 2	139 ± 6	213 ± 15	391 ± 73
1967-69	45 ± 2	141 ± 5	233 ± 12	463 ± 71
1970	36 ± 2	126 ± 7	276 ± 22	576 ± 210
1971	35 ± 4	113 ± 6	216 ± 11	342 ± 58
1972	38 ± 3	102 ± 6	195 ± 10	311 ± 32
1970-72	36 ± 2	114 ± 4	229 ± 9	409 ± 73
1967-72	40 ± 1	127 ± 3	231 ± 8	436 ± 51
Section II				
1967	....	.....	.....	.....
1968	59 ± 6	195 ± 15	528 ± 692	913 ± 130
1969	47 ± 4	176 ± 10	429 ± 47	737 ± 195
*1968-69	53 ± 3	185 ± 9	474 ± 52	825 ± 117
1970	56 ± 5	189 ± 13	470 ± 39	932 ± 197
1971	53 ± 6	171 ± 10	428 ± 35	862 ± 123
1972	57 ± 7	167 ± 11	269 ± 34	662 ± 77
1970-72	55 ± 4	176 ± 7	389 ± 21	818 ± 82
*1968-72	54 ± 3	180 ± 5	423 ± 24	821 ± 68

* Samples not collected in April 1967; therefore averages comparable to the other averages could not be determined for this period.

Table 22.--Length and weight of rainbow trout, by age group, in the 1-mile experimental sections, 1967-1972. Average length in inches and average weight in grams, with 95% confidence limits, by 2- or 3-year and 5-year periods.

Section, and year	Length by age group I	Length by age group II	Weight by age group I	Weight by age group II
Control				
*1967	.....	.....	.....	.....
1968	6.1 ± 0.1	8.2 ± 0.3	39 ± 3	85 ± 8
1969	6.2 ± 0.1	8.5 ± 0.3	41 ± 2	99 ± 13
1968-69	6.1 ± 0.1	8.3 ± 0.2	40 ± 2	92 ± 8
1970	5.9 ± 0.2	8.0 ± 0.2	35 ± 3	84 ± 11
1971	5.4 ± 0.2	7.9 ± 0.3	31 ± 3	77 ± 9
1972	5.2 ± 0.2	7.7 ± 0.2	22 ± 3	67 ± 6
1970-72	5.5 ± 0.1	7.9 ± 0.1	30 ± 2	76 ± 5
1968-72	5.7 ± 0.1	8.1 ± 0.1	34 ± 1	82 ± 4
Section I				
*1967	.....	.....	.....	.....
1968	5.8 ± 0.1	7.9 ± 0.2	33 ± 2	75 ± 7
1969	5.7 ± 0.1	8.5 ± 0.3	31 ± 2	101 ± 11
1968-69	5.7 ± 0.1	8.2 ± 0.2	32 ± 2	88 ± 6
1970	6.0 ± 0.2	7.8 ± 0.2	35 ± 3	80 ± 7
1971	5.6 ± 0.2	7.6 ± 0.2	33 ± 4	70 ± 7
1972	5.9 ± 0.2	8.2 ± 0.2	35 ± 3	84 ± 9
1970-72	5.8 ± 0.1	7.9 ± 0.1	34 ± 2	78 ± 4
1968-72	5.8 ± 0.1	8.0 ± 0.1	33 ± 1	82 ± 4
Section II				
*1967	.....	.....	.....	.....
1968	6.5 ± 0.2	8.7 ± 0.3	49 ± 4	113 ± 10
1969	6.4 ± 0.1	9.2 ± 0.2	48 ± 3	140 ± 14
1968-69	6.4 ± 0.1	8.9 ± 0.2	48 ± 2	126 ± 9
1970	7.0 ± 0.2	9.1 ± 0.2	61 ± 5	134 ± 9
1971	6.6 ± 0.2	9.6 ± 0.3	56 ± 6	153 ± 14
1972	6.9 ± 0.2	9.6 ± 0.3	61 ± 4	164 ± 27
1970-72	6.8 ± 0.1	9.4 ± 0.2	59 ± 3	150 ± 10
1968-72	6.7 ± 0.1	9.2 ± 0.1	55 ± 2	141 ± 7
State average length	6.3	8.4		

* Averages not determined in 1967 because of absence of April samples; hatchery trout mixed with native trout in Control Section and Section I, and Section II not yet established in April 1967.

Table 23.--Length and weight of young trout and coho salmon in the 1-mile experimental sections, 1967-1972. Average length in inches and average weight in grams, with 95% confidence limits; age-0 fish measured in September, and age-I fish in April

Section, and years	Brown trout Age group 0	Brown trout Age group I	Rainbow trout Age group 0	Rainbow trout Age group I	Coho salmon Age group 0	Coho salmon Age group I
			LENGTH			
Control						
1967-69	4.3 ± 0.1	5.7 ± 0.2	4.1 ± 0.1	4.9 ± 0.1*	4.3 ± 0.1*	.....
1970-72	4.1 ± 0.1	4.7 ± 0.1	3.8 ± 0.1	4.3 ± 0.1	4.3 ± 0.1	4.6 ± 0.1
1967-72	4.2 ± 0.1	5.2 ± 0.1	4.0 ± 0.1	4.5 ± 0.1*	4.3 ± 0.1*	.....
Section I						
1967-69	4.1 ± 0.1	5.1 ± 0.1	4.5 ± 1.3	4.9 ± 0.1*	4.2 ± 0.1	5.2 ± 0.3
1970-72	3.8 ± 0.1	4.8 ± 0.1	3.7 ± 0.1	4.4 ± 0.2	4.1 ± 0.1*	4.6 ± 0.1
1967-72	4.0 ± 0.1	5.0 ± 0.1	4.1 ± 0.1	4.6 ± 0.1*	4.2 ± 0.1*	4.8 ± 0.1
Section II						
1967-69	4.1 ± 0.1	5.2 ± 0.2*	3.8 ± 0.1	5.4 ± 0.2*	4.2 ± 0.1	5.2 ± 0.1
1970-72	3.8 ± 0.1	4.9 ± 0.2	4.0 ± 0.1	5.2 ± 0.2	4.1 ± 0.1	4.8 ± 0.1
1967-72	4.0 ± 0.1	5.0 ± 0.1*	3.9 ± 0.1	5.3 ± 0.1*	4.2 ± 0.1	5.0 ± 0.1
			WEIGHT			
Control						
1967-69	13 ± 1	38 ± 6	12 ± 1	22 ± 2*	13 ± 1*	...
1970-72	12 ± 1	17 ± 1	9 ± 1	14 ± 2	12 ± 1	14 ± 1
1967-72	13 ± 1	28 ± 3	11 ± 1	17 ± 2*	12 ± 1*	...
Section I						
1967-69	12 ± 1	25 ± 2	12 ± 1	21 ± 2*	13 ± 1	20 ± 4
1970-72	10 ± 1	18 ± 1	9 ± 1	14 ± 2	11 ± 1*	13 ± 1
1967-72	11 ± 1	22 ± 1	11 ± 1	17 ± 1*	12 ± 1*	16 ± 2
Section II						
1967-69	12 ± 1	24 ± 3*	10 ± 1	29 ± 2*	12 ± 1*	22 ± 2
1970-72	10 ± 1	19 ± 2	12 ± 1	27 ± 2	12 ± 1	17 ± 1
1967-72	11 ± 1	21 ± 3*	11 ± 1	28 ± 2*	12 ± 1*	20 ± 1

* 2- and 5-year means; other values are 3- and 6-year means.

Table 24.--Weight of trout and juvenile salmon populations in the 1-mile experimental sections in April, 1967-1972. Weight in pounds per acre, with 95% confidence limits

Year, and section	Brown trout	Rainbow trout	Total trout	Coho salmon
1967				
Control	27 ± 6	65 ± 17*	92 ± 18	.....
Section I	44 ± 6	31 ± 4*	75 ± 7	.....
1968				
Control	28 ± 5	17 ± 4	45 ± 6	.....
Section I	46 ± 7	25 ± 7	71 ± 8	1 ± 1
Section II	31 ± 9	85 ± 15	116 ± 17	19 ± 6
1969				
Control	25 ± 6	17 ± 8	42 ± 8	.....
Section I	41 ± 7	22 ± 6	63 ± 9	.....
Section II	47 ± 8	75 ± 11	122 ± 4	14 ± 4
1967-69 average				
Control	27 ± 3	33 ± 6	60 ± 7	.....
Section I	44 ± 4	26 ± 3	70 ± 5	.....
Section II	39 ± 6	80 ± 9	119 ± 9	......
1970				
Control	50 ± 10	21 ± 4	71 ± 11	1 ± <0.5
Section I	60 ± 9	19 ± 5	79 ± 10	2 ± 1
Section II	68 ± 33	71 ± 11	139 ± 35	53 ± 7
1971				
Control	37 ± 6	16 ± 3	53 ± 7	1 ± 1
Section I	47 ± 6	9 ± 2	56 ± 6	3 ± 1
Section II	75 ± 32	59 ± 8	134 ± 33	28 ± 4
1972				
Control	30 ± 3	16 ± 2	46 ± 4	1 ± 1
Section I	41 ± 4	16 ± 2	57 ± 5	2 ± <0.5
Section II	38 ± 7	43 ± 5	81 ± 9	8 ± 1
1970-72 average				
Control	39 ± 4	18 ± 2	57 ± 5	1 ± 1
Section I	49 ± 4	15 ± 2	64 ± 4	2 ± <0.5
Section II	60 ± 16	58 ± 5	118 ± 16	30 ± 3

* Planted trout of age-group II included; appreciably more were found in the Control Section.

Table 25.--Weight of trout and juvenile salmon populations in the 1-mile experimental sections in September, 1967-1972. Weight in pounds per acre, with 95% confidence limits

Year, and section	Brown trout	Rainbow trout	Total trout	Coho salmon
1967				
Control	28 ± 4	20 ± 5	48 ± 6	.....
Section I	36 ± 3	14 ± 3	50 ± 4	<1 ± 0.1
Section II	32 ± 3	29 ± 6	61 ± 7	6 ± 2
1968				
Control	42 ± 10	21 ± 13	63 ± 18	.....
Section I	44 ± 6	14 ± 2	58 ± 6	2 ± 1
Section II	43 ± 8	32 ± 6	75 ± 10	17 ± 4
1969				
Control	41 ± 4	22 ± 3	63 ± 5	.....
Section I	51 ± 5	15 ± 4	66 ± 6	2 ± 1
Section II	46 ± 10	45 ± 9	91 ± 13	18 ± 3
1967-69 average				
Control	37 ± 4	21 ± 5	58 ± 7	.....
Section I	44 ± 3	14 ± 2	58 ± 3	2 ± 1
Section II	40 ± 4	35 ± 4	76 ± 6	14 ± 2
1970				
Control	40 ± 6	20 ± 3	60 ± 7	3 ± 1
Section I	58 ± 6	20 ± 4	78 ± 7	8 ± 1
Section II	82 ± 15	45 ± 7	127 ± 17	36 ± 3
1971				
Control	39 ± 3	25 ± 3	64 ± 4	1 ± <1
Section I	51 ± 12	13 ± 3	63 ± 12	5 ± 5
Section II	68 ± 14	45 ± 6	113 ± 15	35 ± 4
1972				
Control	33 ± 7	14 ± 2	47 ± 7	1 ± <1
Section I	38 ± 5	17 ± 2	55 ± 5	2 ± <1
Section II	62 ± 12	77 ± 9	139 ± 15	17 ± 3
1970-72 average				
Control	37 ± 3	20 ± 2	57 ± 4	2 ± <0.5
Section I	49 ± 5	17 ± 2	65 ± 5	5 ± 2
Section II	71 ± 8	56 ± 4	126 ± 9	29 ± 2

Table 26.--Number of trout by size group, in the 1480-foot experimental section below Pioneer Road, 1959-1963. Collections taken during late July and early August; numbers include 95% confidence limits.

Year	Size group (inches)				Total
	1.0-3.9	4.0-6.9	7.0-9.9	10.0+	
1959	517 ± 275	115 ± 32	292 ± 113	16 ± 9	940 ± 299
1960	546 ± 193	230 ± 54	187 ± 41	49 ± 30	1012 ± 207
1961	640 ± 282	152 ± 29	203 ± 44	38 ± 10	1033 ± 287
1962	1046 ± 262	118 ± 29	126 ± 28	20 ± 8	1310 ± 265
1963	714 ± 221	242 ± 65	220 ± 66	36 ± 13	1212 ± 240
Average	693 ± 111*	171 ± 20*	206 ± 29	32 ± 7	1102 ± 117

* The estimate for the 1.0-3.9 and 4.0-6.9 inch groups combined is 864 ± 113.

Table 27.--Number of trout and age-0 coho salmon, by size group, in the two 1480-foot experimental sections, 1971 and 1972. Collections taken during early September; numbers include 95% confidence limits.

Section, year and species	Size group (inches) 1.0-4.9	5.0-6.9	7.0-9.9	10.0+	Total
Pioneer Road Section					
1971					
Brown	308 ± 177	196 ± 47	377 ± 73	81 ± 24	962 ± 198
Rainbow	2942 ± 651	379 ± 89	95 ± 39	.....	3416 ± 658
Coho	2136 ± 368	.....	.....	.....	2136 ± 368
1972					
Brown	302 ± 109	71 ± 19	200 ± 33	88 ± 26	661 ± 118
Rainbow	2394 ± 754	295 ± 69	65 ± 23	.....	2754 ± 758
Coho	168 ± 71	.....	.....	.....	168 ± 71
South Street Section					
1971					
Brown	140 ± 92	121 ± 34	105 ± 21	72 ± 17	438 ± 102
Rainbow	2944 ± 1272	321 ± 179	79 ± 43	.....	3344 ± 1292
Coho	1226 ± 204	.....	.....	.....	1226 ± 204
1972					
Brown	197 ± 80	51 ± 13	156 ± 34	53 ± 12	457 ± 88
Rainbow	1724 ± 1102	188 ± 89	96 ± 37	.....	2008 ± 1006
Coho	97 ± 57	.....	.....	.....	97 ± 57

Table 28.--Average number of trout and age-0 coho salmon, by size group, in the two 1480-foot experimental sections for 1971 and 1972. Collections taken during early September; numbers include 95% confidence limits.

Section, and species	Size group (inches)			Total
	1.0-6.9	7.0-9.9	10.0+	
Pioneer Road Section				
Brown	438 ± 106	289 ± 40	84 ± 17	811 ± 115
Rainbow	3005 ± 501	80 ± 23	.....	3085 ± 502
Total trout	3443 ± 512	369 ± 46	84 ± 17	3896 ± 515
Coho	1152 ± 187			1152 ± 187
South Street Section				
Brown	254 ± 64	131 ± 20	62 ± 10	447 ± 68
Rainbow	2588 ± 847	88 ± 28	.....	2676 ± 847
Total trout	2842 ± 849	219 ± 34	62 ± 10	3123 ± 849
Coho	661 ± 106			661 ± 106

Table 29.--Number of trout and age-0 coho salmon, by size group, in the 1480-foot experimental sections, projected for 1 mile of stream, 1971 and 1972. Collections taken during early September; numbers include 95% confidence limits.

Section, species, and year	Size group (inches)				Total
	1.0-4.9	5.0-6.9	7.0-7.9	10.0+	
Pioneer Road					
Brown					
1971	1096 ± 630	698 ± 167	1342 ± 260	288 ± 85	3424 ± 705
1972	1078 ± 389	253 ± 68	714 ± 118	314 ± 93	2359 ± 421
Average	1087 ± 370	475 ± 90	1028 ± 143	301 ± 63	2891 ± 411
Rainbow					
1971	10473 ± 2317	1349 ± 317	338 ± 139	.....	12160 ± 2342
1972	8547 ± 2691	1053 ± 246	232 ± 82	.....	9832 ± 2706
Average	9510 ± 1776	1201 ± 201	285 ± 81	.....	10996 ± 1789
Coho					
1971	7604 ± 1314	.....	.....	.....	7604 ± 1314
1972	600 ± 253	.....	.....	.....	600 ± 253
Average	4102 ± 669	.....	.....	.....	4102 ± 669
South Street					
Brown					
1971	498 ± 328	431 ± 121	373 ± 75	256 ± 61	1558 ± 364
1972	703 ± 286	182 ± 46	557 ± 121	189 ± 43	1631 ± 314
Average	600 ± 218	306 ± 65	465 ± 71	222 ± 37	1594 ± 240
Rainbow					
1971	10481 ± 4541	1143 ± 639	281 ± 154	.....	11905 ± 4612
1972	6155 ± 3934	671 ± 318	343 ± 132	.....	7169 ± 3948
Average	8318 ± 3004	907 ± 357	312 ± 101	.....	9537 ± 3036
Coho					
1971	4368 ± 728	.....	.....	.....	4368 ± 728
1972	346 ± 203	.....	.....	.....	346 ± 203
Average	2357 ± 378	.....	.....	.....	2357 ± 378

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