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MORTALITY AND PRODUCTION OF BROOK TROUT AND RAINBOW TROUT PLANTED IN EAST FISH LAKE, MICHIGAN [1]

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Abstract

We studied survival, growth, angler exploitation, and production from five consecutive matched plantings of brook trout and rainbow trout (8.5-9.5 inches long) in East Fish Lake, Montmorency County, Michigan, 1958-1962. The 16-acre lake received 300 of each species each year.

Rainbow trout survived at nearly 100% from planting time in October to the following fishing season in April, whereas brook trout averaged only 49%. Most mortality of brook trout occurred between 15 October and the date of ice formation (approx. 15 Dec.). Brook trout stayed in shallow water along shore more than did rainbow trout. Loss of trout was attributed to various predators. Of control trout held in wire enclosures, few died.

Anglers caught 86% of the rainbow trout which were planted, but only 39% of the brook trout. For each pound of trout planted, anglers caught 3.59 lb. of rainbow trout, but only 0.76 lb. of brook trout. In addition to the five-fold better return on a poundage basis, the rainbow trout provided a fishery throughout the 4-month angling season, whereas nearly all brook trout were caught during the first 10 days.

The brook trout grew well, but the rainbow trout did better--up to 1.5 lb. per year. An even greater poundage return on rainbow trout would accrue if the beginning of the angling season were delayed somewhat, to take better advantage of the spring growing season.

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Introduction

Fish managers maintain trout in lakes mostly by stocking hatchery fish, because trout do not reproduce in most lakes. A distinct advantage in periodic stocking is that the manager has control over fish density. We can manage lake fisheries most efficiently, however, when we also understand mortality, growth and production of trout. This report deals with comparable plantings of brook trout (Salvelinus fontinalis) and rainbow trout (Salmo gairdneri) over a 5-year period (1958-62) in East Fish Lake, Montmorency County, Michigan. Special emphasis is on the causes of natural mortality.

There have been many studies on growth of trout, but few studies on population numbers (and weights) throughout a year-class cycle. Natural mortality is difficult to measure, because the investigator usually has only circumstantial evidence on cause of death, and he measures only survival to the creel.

The magnitude, seasonal occurrence, and causes of natural mortality of trout in lakes have been determined for relatively few populations. Foerster and Ricker (1941) found that fish predators, by feeding on young salmon, caused a significant reduction in salmon production in Cultus Lake, British Columbia. Smith (1956) found that control of predatory fish and birds in Crecy Lake, New Brunswick, resulted in much better brook trout survival. Elson (1962) found that control of mergansers increased the production of salmon smolt five-fold in a Canadian stream. Johnson and Hasler (1954) suggested that

predation by mergansers was an important cause of mortality of rainbow trout in dystrophic lakes in Wisconsin and Michigan. Finally, Eipper (1964) believed that ducks, herons, and kingfishers caused some mortality of trout in farm ponds in New York.

Seasonal differences in natural mortality of trout were observed in a general way by Alexander and Shetter (1961), Latta (1963), and Eipper (1964), but we need to understand the seasonal pattern more precisely. Differences in survival between strains of hatchery and wild brook trout have been reported (Flick and Webster, 1964; Vincent, 1960; Miller, 1952). Miller also stated that in some situations hatchery trout die soon after planting, from exhaustion or shock largely caused by aggressive territorial activities of resident fish. Saila (1952) and Eipper (1964) found similar survival rates for different species of trout when planted in the same pond environment.

East Fish Lake

East Fish Lake is 16 acres in area. More than half of the basin is deeper than 20 ft.; the maximum depth is 40 ft. Shallow water (5 ft. or less) occupies about 3 acres along the north shore, and a 10-yard strip around the remainder of the lake. One small tributary enters the southwest end of the lake. Numerous springs and seepage areas are scattered around the east, south, and west shores. A weir in the outlet confines the trout population to the lake. Stratification occurs in midsummer, but oxygen and temperature regimes are

satisfactory for trout from top to bottom throughout the year. The water is clear and hard (methyl orange alkalinity, 175 ppm). Aquatic vegetation is sparse and generally confined to water less than 10 ft. deep.

The fathead minnow (Pimephales promelas), brook stickleback (Eucalia inconstans), northern redbelly dace (Chrosomus eos), central mudminnow (Umbra limi), and brook trout comprise the natural fish population. Natural reproduction of brook trout, however, is of little consequence.

East Fish Lake is located approximately 1 mile from the nearest human habitation. There is little human activity there except during the trout season.

Methods

Hatchery brook and rainbow trout were planted in East Fish Lake precisely on 15 October each year from 1958 to 1962. These fish were selected for size at a mean length of 8.9 inches (range, 8.5-9.5). They were fin-clipped for later identification.

Estimates of the trout populations were made by the Petersen method, and 95% confidence limits were determined from the chart in Clopper and Pearson (1934). For the estimates, trout were captured initially by either angling or d-c electrofishing (Latta and Myers, 1961), and recoveries were from anglers' catches (Johnson and Hasler, 1954). The total catch of trout was determined by a creel census operated under a permit system (Shetter and Alexander, 1962).

Fishing seasons extended from the last Saturday in April to the second Sunday in September. There was a daily creel limit of 5 trout and a minimum size limit of 10 inches. Most of the stocked trout grew to legal length by opening day; thus, mortality from hooking sublegal fish was minimal.

Control trout for survival tests were confined in two live cages 10' x 10' x 4' in the lake during fall and winter of 1959 through 1962. These cages were of 1/2-inch mesh hardware cloth, fitted with covers, and located in water about 3 ft. deep near the inlet. Each time trout were planted in the lake, 10 brook trout and 10 rainbow trout from the same stock were put in the live cages, and these fish were checked periodically for mortality.

Over-winter survival

Survival of rainbow trout between planting in October and the fishing season in April was nearly 100% each year (Table 1). Survival of brook trout was lower; it ranged from a high of 72% for the 1960 plant to a low of 29% for the 1959 plant. For the 1959 and 1960 plants, most mortality of brook trout occurred between mid-October and mid-December, i.e., prior to ice formation on the lake. The higher fall survival of brook trout in 1960 and 1961 occurred probably because we monitored predator activity then and frightened some predators away. This better fall survival carried over to the following April.

The highest mortality of brook trout occurred during the fall spawning season. From netting, electrofishing, angling, and direct

observation we know that brook trout generally inhabit the shallow waters of the lake in the fall. Furthermore, they tend to concentrate near the inlet and other sources of spring water. This is in contrast to rainbow trout which generally tend to stay in deeper water. The brook trout, being in shallower water, apparently were more vulnerable to predators.

One objective of this study was to determine the causes of mortality. The good survival of trout in the live cages is significant. Only 2 trout died, from 80 brook and 80 rainbow trout confined during October-April in the four test years 1959-1962. These penned fish were not fed artificially, however, some natural food must have been available, because the trout grew 0.5 inch per fish during confinement. The low mortality of trout in live crates shows that disease, the physiological shock from handling, and the retention of ovarian eggs resulting from the inability of trout to spawn, were not major factors causing loss of brook trout which were free in the lake.

Mortality appeared to result mainly from predation. During the fall of 1960 and again in 1961, the lake was monitored for predator activity by spot sampling at randomly selected times after planting and prior to ice formation. The observer, as he approached the lake through the woods, flushed herons, mergansers, and kingfishers; he did not "flush" any number of otter, mink, raccoon, and snakes, undoubtedly because these are more difficult to see than birds. After this "flush count," the observer watched for predators from a blind near the lake shore, equipped with a 20X spotting scope and a pair of 7 mm x 50 mm

binoculars. Nearly all of the shoreline was visible. For individual predators, the amount of time spent on the lake was recorded, and it was frequently possible to observe just what the predator was eating.

During these fall counts, the following were observed on the lake: great blue heron, little green heron, American merganser, hooded merganser, American goldeneye, kingfisher, and watersnake. Other potential predators known to frequent the lake (but not seen during the counts) were the raccoon, otter, mink, osprey, and loon.

Some trout taken by electrofishing or by angling bore characteristic wounds made by herons and kingfishers. Great blue herons were observed both years on a number of occasions. Twice a heron landed near the inlet area of the lake at dusk, but its feeding could not be observed because of darkness. Herons that were flushed when the observer approached, always left the lake. One or two kingfishers usually were present every day but were not observed to eat trout.

Twice in 1960 an American merganser was seen on the lake. It was seen to catch three trout, but the species (brook or rainbow) could not be identified. One to five hooded mergansers were present nearly every day; they could be seen to feed on crayfish and unidentifiable small items. Goldeneyes, which occasionally visited the lake, also ate crayfish and other small items. Both the hooded mergansers and goldeneyes always fed in water less than 10 feet deep.

Some mortality, especially of brook trout, occurred after the lake acquired an ice cover (see data in Table 1). We have spent many

hours observing trout in lakes from a winter ice shanty, and in catching trout by fishing through the ice. From this we know that brook trout frequent the shallow-water areas most of the time, whereas rainbow trout stay in deeper water. Otter, mink, and raccoon tracks have been observed every winter around the open-water areas of the inlet stream and spring water seepage areas at East Fish Lake, and we judge that these predators would get brook trout more frequently than rainbow trout.

Poaching by man was a possible mortality factor. However, no evidence of poaching was detected during numerous visits to the lake. Further, the live cages holding control fish were not locked, and it is unlikely that poachers would pass up such vulnerable groups of trout.

Fuller Pond, 15 acres in area and located 0.5 mile from East Fish Lake, was planted in the same way as East Fish Lake during two falls. Contrary to results at East Fish Lake, rainbow trout survived only slightly better than did brook trout. Fuller Pond is shallow, with a maximum depth of 5 ft. Apparently when rainbow trout are forced to frequent shallow water in the fall, they are also vulnerable to predation.

Angling mortality

In East Fish Lake most of the trout which disappeared between mid-April and mid-October went into the anglers' creel. On the average, over the 5-year period, about one-half (148 out of 300 stocked) of the brook trout survived until the angling season (Table 1), and anglers

caught 79% (range 75%-85%) of these. Of those caught by anglers, 84% were taken during the first month (mid-April to 15 May)--in fact, mostly during the first two days; 6.2% were caught during the second month (16 May to 15 June); 7.3% during the third month; and few thereafter (Table 2). The brook trout fishery was of short duration; the anglers creeled an average of 116 brook trout per year, or 39% of the 300 fish stocked (Table 3).

About 95% of the rainbow trout survived to opening day each year (Table 1). Fishermen creeled an average of 78% of these trout during the first fishing season after planting. Another 10% was recovered during the next two seasons. Total recovery by anglers averaged 86% (range 78%-93%) of the initial plantings for the 5 years (Table 3).

The initial weight of trout when planted was comparable for brook and rainbow trout. The weight of trout creeled by anglers per season amounted to an average of 187 lb. of rainbow trout the first season, plus 61 lb. of carry-over rainbows in following seasons; in contrast the annual catch of brook trout was 57 lb. In other terms, for each pound of rainbow trout planted, anglers caught 3 1/2 lb.; for each pound of brook trout planted, they caught 3/4 lb.

The seasonal distribution of anglers' catch of rainbow trout was better than that of brook trout. Although, on the average, 39% of the catch of rainbow trout was made before 15 May, the monthly catch for the remaining 4 months was 8% to 20%. Another 10% was caught during the next two angling seasons, compared to only 1% for

brook trout. The total catch by anglers undoubtedly was somewhat higher than recorded, because it was reported that some people took and concealed more than their legal limit during the opening weekend of the trout season. Hook wounds and fatigue probably killed some trout which were hooked but not landed by anglers.

Natural mortality during the fishing season was light, and the causes of this mortality were not identified. Fish were creeled with wounds in the back characteristic of heron attack, and some had wedge-shaped marks on both sides of the body which were attributed to herons or kingfishers.

Fishing pressure on East Fish Lake increased each year during the study. Prior to 1958, before introduction of rainbow trout, anglers fished about 850 hours per year. In 1959, the first year rainbow trout were present, anglers fished 1, 205 hours; by 1963, angling pressure had increased to 2, 074 hours. This increase in fishing pressure resulted in a greater harvest of rainbow trout early in the season, but it had little similar effect on the brook trout which were caught out readily, early in the season, by the lighter fishing pressure during the earlier years.

Growth

In this study we measured length on trout handled in population estimates, and we measured and weighed fish in anglers' creels. Cooper (1952) and Larkin and Smith (1954) pointed out that trout caught by anglers tend to be the faster-growing individuals of a year class,

and therefore growth estimates based on such samples are biased. Such bias in our study had to be very small, for the fish were all about the same length (1.1-inch spread) when planted, and their growth was similar until caught. Growth history of fish among each of the five lots of hatchery plantings was very similar after release in East Fish Lake. Thus the growth data for the five annual planting lots are combined in the table and figures, to give a monthly analysis of growth.

A summary of average lengths and weights, with standard errors, is given in Table 4 and Figures 1 and 2.

In East Fish Lake the planted trout grew well between the planting date in October and the following April or May. Thus in April, 6 months after planting, rainbow trout averaged 10.5 inches and 0.46 lb., and brook trout averaged 10.4 inches and 0.44 lb. Further, 5 months later, in September, rainbow trout averaged 15.8 inches and 1.55 lb., whereas brook trout were 13.8 inches and 1.16 lb. Two rainbow trout recovered 35 months after stocking averaged 22.8 inches long and weighed 4.62 lb. The largest trout caught was a rainbow, 24.0 inches long and 5.50 lb. in weight. In growth and size the rainbow trout in East Fish Lake were similar to rainbows in Weber Lake, Wisconsin as reported by Burdick and Cooper (1956).

In East Fish Lake growth rates, as expected, were highest during the summer season for both species, reduced during the fall, and very low during the winter. In East Fish Lake there was one variation in that the growth rate remained high all summer, without

the usual decline after June which occurs in many trout waters. Those rainbow trout which survived over two or three seasons likewise made good growth during summer and little growth during winter.

Production

Data on mortality and growth were combined to estimate standing crop and production of rainbow trout and brook trout for various dates (Tables 5, 6, and 7). We used Ricker's (1958) method to estimate production. On the average, over the 5-year period, 30 rainbow trout survived the first angling season and 230 were creeled, which left only 40 deaths unexplained. Of these 40 trout, 5 died between planting time and 15 April. These deaths were arbitrarily assigned as one death per month, excluding the last month before angling started. Thirty-five of the non-angling mortalities occurred during the trout season and these were assigned to months in a ratio similar to the known angling mortality, as follows: 15 April-14 May (18 deaths); 15 May-14 June (9); 15 June-14 July (5); 15 July-14 August (2); and 15 August-15 September (1). We then compute monthly population figures for May to September this way: start with the mid-April population estimate, and subtract for each month the known trout mortality from angling and unknown deaths assigned to that monthly period. Population numbers were converted to total weights by applying seasonal data on length and weight from Table 4.

The standing crop in pounds (biomass) of first-summer rainbow trout reached a high of 135 lb. on 15 April just prior to the angling season (Table 5). The biomass of carryover trout, during years when they were present, also reached its high (of 51 lb.) on 15 April (Table 6). Undoubtedly the biomass would have gone considerably higher, between mid-April and late summer, if anglers had not cropped the trout. The presence of the carry-over rainbow trout (about 30) after the second planting apparently did not affect survival or growth of successive plantings.

Rainbow flesh produced per month was highest during the period 15 May-15 June (Tables 5 and 6). Rainbow production was nearly 25 lb. per month for the first 2 months after stocking (fall period) but only from 3 to 6 lb. were produced per month during the winter. Increases in water temperature and available food accelerated production after 15 April.

In contrast to rainbow trout, the biomass of brook trout reached a maximum of 96 lb. one month after planting (Table 7). High mortality rates prevented the standing crop of brook trout from exceeding the weight planted by no more than 28%, on the average. Thereafter, production varied between 0 and 7.3 lb. per month.

Considering all trout (rainbow, rainbow carry-overs, and brook trout), the maximum biomass of trout flesh present about 15 April was nearly 252 lb. In addition the lake has a few pounds of wild brook trout.

The estimated average production of trout flesh per year within the lake was about 261 lb. Brook trout contributed about 54 lb. and rainbows 207 lb. (first-year, 187 lb.; carry-overs, 20 lb.).

Discussion

One of the objectives of this study was to determine the extent and causes of trout mortality in East Fish Lake. Between 100 and 200 brook trout were taken by predators during the 6-month period after each stocking of 300 fish. Rainbow trout suffered little mortality from predators, apparently because they stay in deep water. Trout mortality during the fall and winter in this lake seems to be caused by predation, but no one species of predator can be singled out.

The American merganser can eat 1 lb. of fish per day (White, 1957). A blue heron, being a larger bird than the merganser, probably eats more per day. The daily ration of a mammal like the otter and mink could be substantial. Any one of these forms, feeding for a period of 3 months and eating only two trout per day, could account for the entire loss of trout in East Fish Lake. Anything less than 100% control of predators probably would not save many trout and would be expensive. Furthermore, predators are part of the natural fauna and have varying degrees of value among individual philosophies.

Our data suggest that the mere presence of humans can reduce mortality caused by natural predators. Experiments designed to measure survival of trout in areas with varying amounts of human activity might, therefore, yield significantly different and misleading results. Trout in remote lakes and ponds are exposed to a whole array of natural predators, whereas trout populations in the vicinity of human activity are not. Therefore, data on trout survival should be obtained in waters characteristic of those to be managed for trout.

Anglers efficiently cropped brook and rainbow trout that survived to opening day of the fishing season. Since most of the brook trout were caught in the first 2 weeks of the trout season, they did not provide a sustained fishery. Furthermore, the population level of brook trout was not high enough during most of the summer growing season to effectively utilize the food resources of the lake for fish production. Under a fishing pressure of 75 hours per acre during the first month, about one-half of the rainbow trout population survived this onslaught. These survivors attained a desirable size and provided an acceptable fishery for the remainder of the fishing season, although the catch per hour was low. After five seasons of rainbow trout stocking, the fishing pressure had increased to 130 hours per acre, with a corresponding increase in early-season cropping, and a decline in fishing success later in the season. If this trend continued, production would probably be reduced.

An orderly cropping of fish populations that have a low rate of natural mortality and rapid growth is certainly desirable. If greater production of fish flesh and greater yield in pounds to the angler are desired, this might be achieved either by rationing the catch throughout the season or prohibiting cropping until after the major summer growth period. A high size limit, theoretically would serve the purpose. However, angler-caught sublegal trout probably would suffer some mortality when returned to the water because of hooking wounds and extreme fatigue due to fighting in the warm epilimnion. Another alternative would be to plant trout as fast as they are removed by anglers to fully utilize the food resources, but at this level of intensity in management, few trout would grow to trophy sizes.

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Table 1. --Periodic estimates of rainbow and brook trout populations following October plantings in East Fish Lake, Michigan

(95% confidence limits in parentheses)

Species and year	Number planted Oct. 15	Estimated numbers					
		Nov. 15	Dec. 15	Jan. 15	Mar. 15	Apr. 15	Sept. 15
Rainbow							
1958	300	-	-	302 (213-445)	292 (200-418)	-	35 (24-56)
1959	300	-	280 (218-359)	336 (255-431)	303 (219-347)	308 (214-427)	41 (29-65)
1960	300	-	289 (231-375)	317 (235-381)	288 (206-438)	299 (193-450)	24 (13-54)
1961	300	243 (154-400)	322 (259-475)	318 (248-400)	286 (212-379)	301 (186-371)	15 (7-62)
1962	300	-	-	303 (219-460)	304 (205-410)	271 (216-333)	36 (22-66)
Averages	300	243	297	315	295	295	30
Brook							
1958	300	288 (202-396)	-	124 (90-181)	106 (85-137)	103 (79-145)	0
1959	300	-	90 (75-124)	97 (72-148)	89 (71-118)	86 (71-118)	0
1960	300	257 (193-325)	212 (165-295)	214 (168-279)	193 (141-265)	217 (163-306)	1
1961	300	344 (239-550)	299 (207-400)	267 (212-330)	199 (148-286)	177 (136-253)	2
1962	300	338 (226-650)	-	204 (156-265)	211 (156-280)	159 (117-210)	2
Averages	300	307	200	181	160	148	1

Table 2. --Percentage distribution of the anglers' catch, by various periods, in East Fish Lake, Michigan, 1959-1963

Period	Rainbow trout	Brook trout	Carry-over rainbow trout [a]
April 15-May 15	39.4	82.0	58.1
May 15-June 15	17.9	9.3	12.4
June 15-July 15	20.4	5.3	10.5
July 15-Aug. 15	14.4	2.2	12.3
Aug. 15-Sept. 15	7.9	1.2	6.7
Totals	100.0	100.0	100.0

[a] Fish that survived more than one fishing season.

Table 3. --Anglers' catch of rainbow and brook trout planted in East Fish Lake, by number and percentage recovery

Species and year	Number planted	Estimated population in mid-April	Number caught				Percentage recovery of	
			1st season	2nd season	3rd season	Total	Initial plant	Survivors to mid-April
Rainbow								
1958	300	295	197	35	2	234	78	79
1959	300	295	216	34	5	255	85	86
1960	300	295	255	22	2	279	93	95
1961	300	295	245	12	0	257	86	87
1962	300	295	236	33	0	269	90	91
Averages	300	295	230	27	2	259	86	88
Brook								
1958	300	103	88	0	0	88	29	85
1959	300	86	69	0	0	69	23	80
1960	300	217	163	0	0	163	54	75
1961	300	177	143	0	0	143	48	81
1962	300	159	117	2	0	119	40	75
Averages	300	148	116	0	0	116	39	79

Table 4. --Average length (inches) and weight (pounds) of rainbow and brook trout at various dates after planting, East Fish Lake

Date (mid-month)	Rainbow trout					Brook trout				
	Number of trout	Average total length	Standard error	Average weight	Standard error	Number of trout	Average total length	Standard error	Average weight	Standard error
First-year growth										
Oct.	1,500	8.9	-	0.23	-	1,500	8.9	-	0.25	-
Nov.	16	9.2	0.67	0.31	-	254	9.2	0.20	0.32	-
Dec.	178	9.9	0.11	0.39	-	159	9.6	0.12	0.35	-
Jan.	284	10.1	0.12	0.41	-	286	9.8	0.09	0.38	-
Mar.	234	10.3	0.11	0.44	-	213	10.1	0.05	0.41	-
Apr.	116	10.5	0.12	0.46	-	364	10.4	0.04	0.44	-
May	528	11.4	0.16	0.54	0.03	505	10.6	0.12	0.48	0.02
June	197	12.8	0.11	0.81	0.04	30	11.2	0.20	0.60	0.03
July	270	14.0	0.16	1.10	0.04	27	11.8	0.20	0.75	0.05
Aug.	114	15.2	0.25	1.42	0.03	12	13.2	0.17	1.00	0.06
Sept.	38	15.8	0.16	1.55	0.03	2	13.8	0.35	1.16	0.16
Second-year growth										
Nov.	3	16.8	0.46	1.61	-	1	13.1	-	0.95	-
Dec.	13	17.4	0.22	1.62	-	-	-	-	-	-
Jan.	16	17.3	0.17	1.63	-	-	-	-	-	-
Mar.	8	16.6	0.52	1.67	-	-	-	-	-	-
Apr.	14	17.0	0.27	1.70	0.20	1	14.3	-	0.96	-
May	84	17.0	0.21	1.90	0.09	2	14.4	0.07	0.99	0.02
June	14	18.2	0.40	2.41	0.19	-	-	-	-	-
July	25	19.0	0.24	2.84	0.16	-	-	-	-	-
Aug.	12	19.4	0.70	2.97	0.33	-	-	-	-	-
Sept.	1	20.8	-	3.50	-	-	-	-	-	-
Third-year growth										
May	3	19.9	0.35	3.07	0.41	-	-	-	-	-
June	1	20.5	-	3.37	-	-	-	-	-	-
July	3	21.9	0.56	4.23	0.56	-	-	-	-	-
Aug.	2	22.8	1.20	4.62	0.88	-	-	-	-	-

Table 5.--Estimated average annual production of rainbow trout from planting date to the following 15 October, East Fish Lake[a]

Mid-month	Estimated number	Standing crop (lb.)	$\frac{W_t}{W_{t-1}}$	$\text{Log}_e \frac{W_t}{W_{t-1}}$	s	i	g	$\bar{w}$	$g\bar{w}$
Oct.	300	69.0	-	-	-	-	-	-	-
Nov.	299	92.7	1.343	.29490	.997	.00300	.29790	80.25	23.91
Dec.	298	116.2	1.254	.22633	.997	.00300	.22933	104.03	23.86
Jan.	297	121.8	1.048	.04688	.997	.00300	.04988	118.98	5.93
Feb.	296	127.3	1.045	.04401	.997	.00300	.04701	124.54	5.85
Mar.	295	129.8	1.020	.01980	.997	.00300	.02280	128.59	2.93
Apr.	295	135.7	1.045	.04401	1.000	0	.04401	132.72	5.84
May	186	100.4	0.740	-.30111	.630	.46204	.16093	117.17	18.86
June	136	110.2	1.098	.09348	.731	.31334	.40682	105.25	42.82
July	84	92.4	0.838	-.17674	.618	.48127	.30453	101.01	30.76
Aug.	49	69.6	0.753	-.28369	.583	.53957	.25588	80.45	20.59
Sept.	30	46.5	0.668	-.40347	.612	.49102	.08755	57.27	5.01
Oct.	30	47.4	1.019	.01882	1.000	0	.01882	46.94	0.88
Total production (lb.)									187.24

[a] Symbols in table follow Ricker (1958).

Table 6. --Estimated average annual production of rainbow trout during their second growing season, East Fish Lake

Mid-month	Estimated number	Standing crop (lb.)	$\frac{W_t}{W_{t-1}}$	$\text{Log}_e \frac{W_t}{W_{t-1}}$	s	i	g	$\bar{w}$	$g\bar{w}$
Oct.	30	47.4	-	-	-	-	-	-	-
Nov.	30	48.0	1.013	.01293	1.000	0	.01293	47.66	0.62
Dec.	30	48.6	1.013	.01293	1.000	0	.01293	48.26	0.62
Jan.	30	48.9	1.006	.00597	1.000	0	.00597	48.84	0.29
Feb.	30	49.5	1.012	.01191	1.000	0	.01191	49.27	0.59
Mar.	30	50.1	1.012	.01191	1.000	0	.01191	49.87	0.59
Apr.	30	51.0	1.018	.01784	1.000	0	.01784	50.55	0.90
May	14	26.6	0.522	-.65009	0.467	.76143	.11134	37.50	4.18
June	11	26.5	0.996	-.00401	0.786	.24080	.23679	26.53	6.28
July	8	22.7	0.857	-.15432	0.727	.31883	.16451	24.56	4.04
Aug.	5	14.8	0.652	-.42771	0.625	.47000	.04229	18.47	0.78
Sept.	3	9.6	0.649	-.43232	0.600	.51083	.07851	12.02	0.94
Oct.	3	9.8	1.021	.02078	1.000	0	.02078	9.70	0.20
Total production (lb.)									20.03

Table 7.--Estimated average annual production of brook trout from planting date to the following 15 October, East Fish Lake

Mid-month	Estimated number	Standing crop (lb.)	$\frac{W_t}{W_{t-1}}$	$\text{Log}_e \frac{W_t}{W_{t-1}}$	s	i	g	$\bar{w}$	$g\bar{w}$
Oct.	300	75.0	-	-	-	-	-	-	-
Nov.	300	96.0	1.280	0.24686	1.000	0	.24686	85.07	21.00
Dec.	200	70.0	0.729	-0.31608	0.667	0.40497	.08889	82.31	7.32
Jan.	181	68.8	0.983	-0.01715	0.905	0.09982	.08267	69.39	5.74
Feb.	170	68.0	0.988	-0.01207	0.939	0.06294	.05087	68.40	3.48
Mar.	160	65.6	0.965	-0.03563	0.941	0.06081	.02518	66.80	1.68
Apr.	148	65.1	0.992	-0.00803	0.925	0.07796	.06993	65.35	4.57
May	37	17.8	0.273	-1.29828	0.250	1.38629	.08801	36.45	3.21
June	18	10.8	0.607	-0.49923	0.486	0.72155	.22232	14.01	3.11
July	8	6.0	0.556	-0.58699	0.444	0.81193	.22494	8.17	1.84
Aug.	3	3.0	0.500	-0.69315	0.375	0.98083	.28768	4.33	1.25
Sept.	1	1.2	0.400	-0.91629	0.333	1.09961	.18332	1.96	0.36
Oct.	1	1.2	1.000	0	1.000	0	0	0	0
Total production (lb.)									53.56

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INSTITUTE FOR FISHERIES RESEARCH

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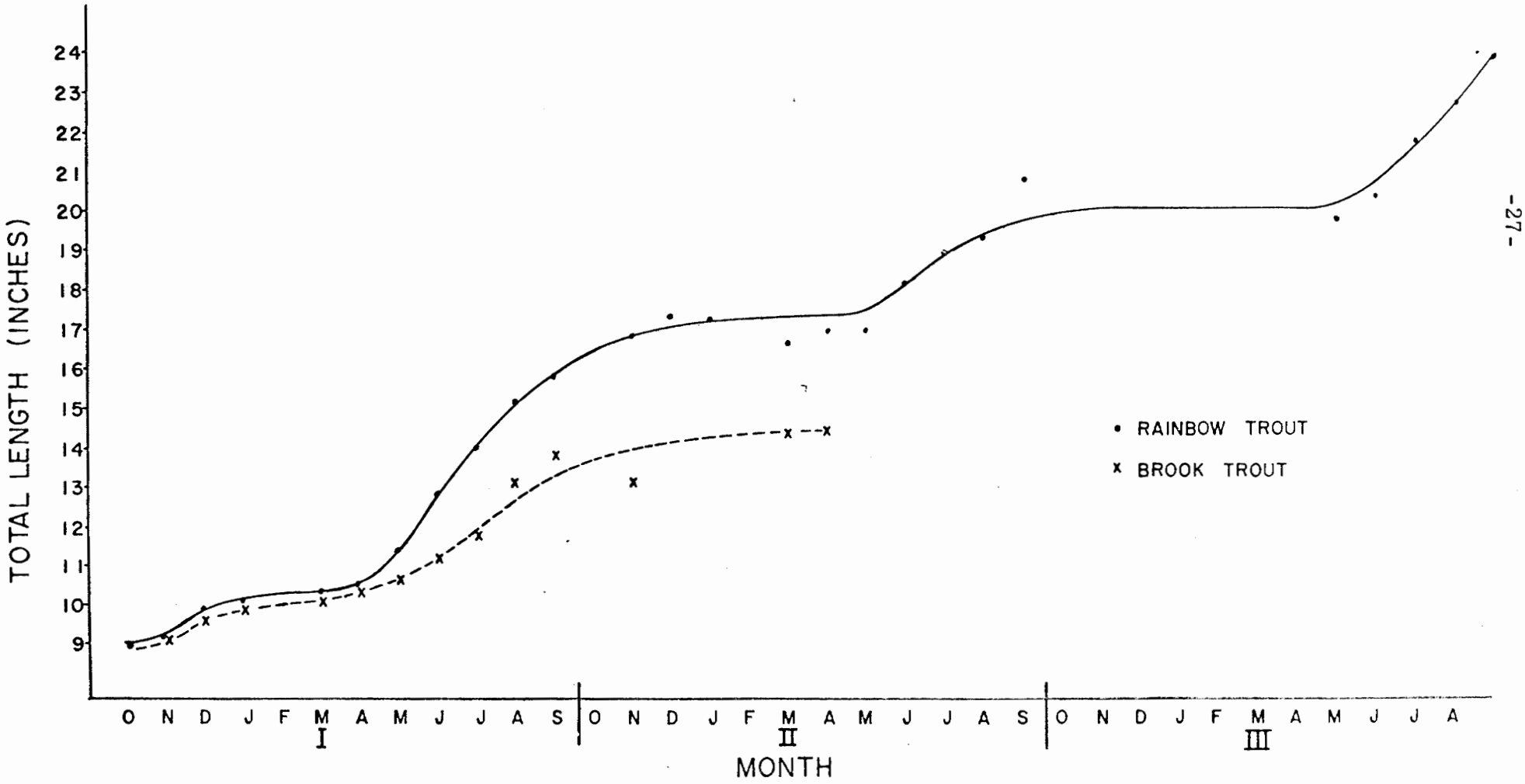

Figure 1.--Average total lengths of rainbow and brook trout per month (1958-1962) in East Fish Lake. Successive growing seasons after planting indicated by Roman numerals.

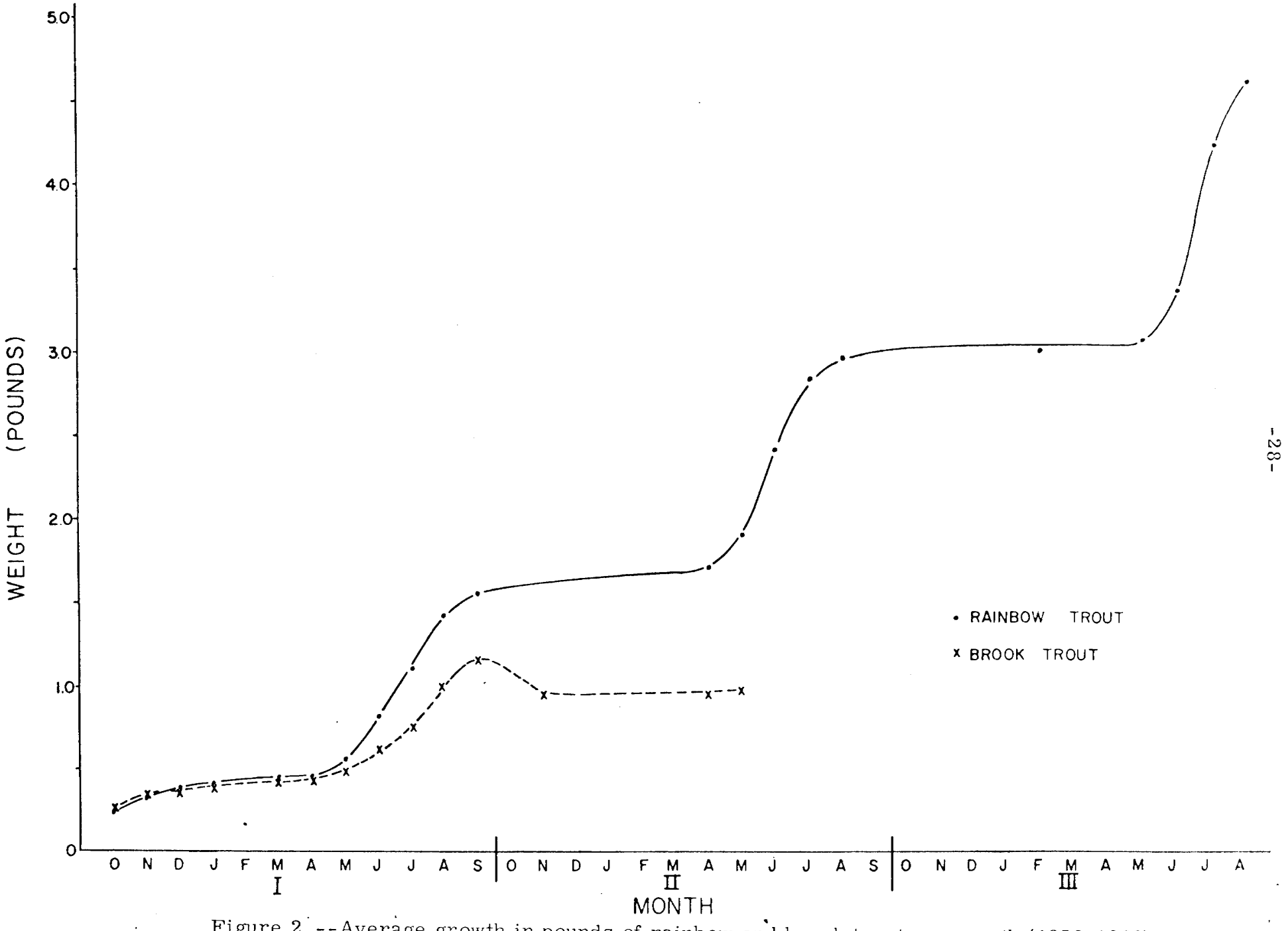

Figure 2.--Average growth in pounds of rainbow and brook trout per month (1958-1962) in East Fish Lake. Successive growing seasons after planting indicated by Roman numerals.