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STABILITY OF RESIDENCE AMONG BROWN TROUT AND RAINBOW TROUT IN EXPERIMENTAL SECTIONS OF THE PLATTE RIVER [1]

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ABSTRACT

An investigation of residence stability and movement of trout was carried out in conjunction with research on competition between trout and coho salmon in Platte River. The study was made mainly in three 1-mile experimental sections that were routinely inventoried in April and September to estimate the numbers of trout and salmon present. In the September 1969 survey, a large number of brown trout (3,788) and rainbow trout (2,734) were fin clipped. The whereabouts of these marked fish was observed on subsequent population surveys.

Invariably, many more marked brown trout were found in the section in which they had been fin clipped than were found in the other sections. This situation applied also to rainbow trout on the first inspection (7 months after marking), but thereafter rainbow trout that reached the smolt stage of life migrated to Lake Michigan, and those that remained in the river moved about more.

Residence location of brown trout in Platte River is quite stable, which will assist appraisal of competition between salmon and trout. Although the rainbow trout is more mobile, perhaps its mobility will not hinder appraisal because this species resides in the river a comparatively short time.

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[1] A contribution from Dingell-Johnson Project F-31-R.

Introduction

In the study of relationships between trout and coho salmon (Oncorhynchus kisutch) that began in the Platte River in 1967, the principal way of evaluating competition was to compare abundance and bulk of salmonid species in experimental sections before and after they contained salmon. As the field work progressed, I realized that if many trout changed residence from one section to another, this could significantly influence the character of the population data. Such movement could be inherent in the fish, or brought on by physical conditions in the environment, and it might also be caused by large numbers of salmon. The latter situation possibly could occur in the section into which a large number of adult coho salmon were to be introduced to populate it with young coho. As residence stability of the populations in the test sections could have a significant bearing on interpretation of results from the study of competition, a study of trout residence and movement was undertaken, mainly in conjunction with biannual population surveys.

Fishery biologists have given residence stability and movement of trout in streams a moderate amount of attention. Several of such studies involved hatchery-grown fish (Trembley, 1945; Newell, 1957; and others), but more of them were concerned with wild fish (Needham and Cramer, 1943; Schuck, 1945; Allen, 1951; Stefanich, 1952; Burnet, 1961; Shetter and Hazzard, 1939; Shetter, 1968; Latta, 1972). The usual finding was that most of the trout confined themselves to a short segment of the stream (usually not over 1 mile long) throughout their lifetime. It was also observed, however, that trout are inclined to move about more in some streams than in others (Shetter, 1968), and that a large part of a population may migrate from one area to another in the same stream (Needham and Cramer, 1943; McFadden, 1961), or into and out of a lake regularly year after year (Stuart, 1957).

Observations on residence stability of brown trout (Salmo trutta) and rainbow trout (S. gairdneri) in Platte River began with a pilot study that extended from July 1969 to April 1970. A more detailed investigation,

conducted in the 1-mile experimental sections, extended from September 1969 to April 1971, and some information was obtained through September 1972.

The study areas

The Platte River begins as the outlet of Lake Ann. From here it courses westward across Benzie County for approximately 25 miles to enter Lake Michigan. The three 1-mile sections of river (Control, I, and II) used in the study of competition (Fig. 1), are situated within a 4 1/2-mile stretch that begins about 4 1/2 miles below Lake Ann. The sections respectively average 51, 44, and 44 feet wide, and 10, 12, and 15 inches deep. Few of the pools are over 5 feet deep. The water is clear.

The dam associated with the weir at the Platte River Anadromous Fish Hatchery is located 200 feet above the upstream end of Section II (Fig. 1). From around mid-September until early spring, the dam almost completely prevents fish from moving upstream; at other times the head is lowered to about 2 feet, allowing salmonid fishes to pass quite freely in either direction.

Section I commences 2,100 feet above the dam, and the Control Section commences 120 feet above Section I. A fish barrier, that consisted of a row of steel pipes driven into the bottom across the stream, and steel framework for supporting the pipes, was used during 1969-1971 to prevent adult coho salmon from entering the Control Section. The barrier functioned only from October through December. The rest of the year it was no obstruction whatever to fish passage, and even when it functioned, fish smaller than adult salmon could swim freely through it.

The 1,500-foot section, which was used only for the pilot study on trout residence and movement, commences approximately 1 mile above the upper end of the Control Section, and ends at Burnt Mill Road. Its average width is about 40 feet, and average depth is less than 10 inches. This is the uppermost part of Platte River in which trout can reside the year round. Above Burnt Mill Road and below Platte Lake, the main

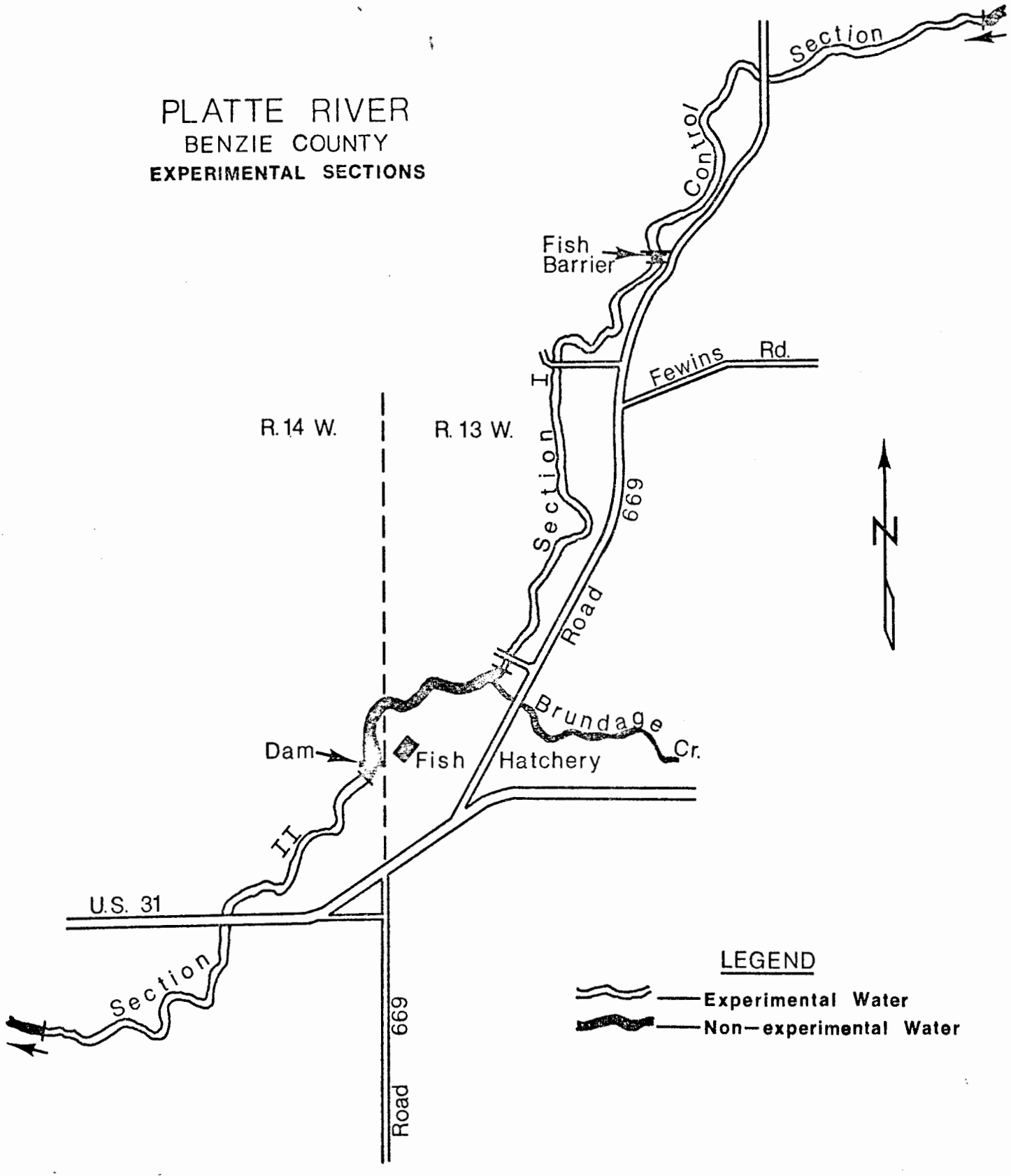

Figure 1.--Study area of the Platte River, showing the mile-long experimental sections in which most of the observations on trout residence and movement were made. The 1500-foot section where the pilot study was made is upstream from here.

stream becomes too warm for salmonids during the summer months, excepting small isolated areas that are cooled by springs.

Salmonid fishes

Rainbow trout, brown trout, and coho salmon are the main components of the salmonid fish population in Platte River. Rainbow trout outnumber brown trout most of the time. However, because rainbows migrate to Lake Michigan at the age of 2 years or earlier, few of legal length (at least 10 inches long) are in the river from June until September. Sexually mature rainbow trout (15-30 inches) return in the fall and spring. Most of the brown trout spend their entire life in the river. Only a few reach the age of 4 years. Some migrate to Lake Michigan, where they grow rapidly, and those that return to the river to spawn are large.

Coho salmon have been planted in Platte River annually since they were first introduced in 1966. These are yearlings, which enter Lake Michigan soon after they have been released. There is some natural reproduction. Coho produced in the river stay here a year, and then migrate to Lake Michigan, where they remain until all are sexually mature.

No trout were planted in the experimental sections during 1967-1972, when the field work for the study of competition was done, and few were planted elsewhere in the drainage system. Consequently, the observations on residence stability and movement were made almost exclusively on wild fish.

Methods

In the 1-mile experimental sections, trout were fin clipped for this study during the September 1969 population survey. They were collected by electrofishing with a 230-volt unit, and were marked and released as the crew progressed upstream. Some of the fish were withheld for scale sampling; these were sampled and fin clipped on

bank, following narcotization with M.S. 222. The fins removed from both brown trout and rainbow trout were the left ventral in Section II, the right pectoral in Section I, and both these fins in the Control Section. Two collecting trips were made through the sections; trout captured on the second trip that had not been caught on the first were fin clipped also for this study, except that this was not done on rainbow trout in Section II.

In subsequent population surveys of these sections, each captured trout was examined for fin clips, and recoveries were recorded. The examinations made in April and September 1970 and April 1971 provided the better information. Estimates were made of the numbers of marked trout surviving to the April 1970 and September 1970 surveys. These estimates were calculated like those of the total populations, by the Bailey formula (Bailey, 1951).

The procedures used in fin clipping trout and re-collecting them were somewhat different in the 1,500-foot section. Only one electrofishing trip was made through this section, each of the three times it was sampled. Trout were marked in July 1969. Collecting to recover marked fish was done in September 1969 and April 1970. Unmarked trout captured in September 1969 were fin clipped as in July, by removal of both the adipose and right pectoral fins. Fin clipping was done on the bank, during breaks periodically taken from collecting.

To help evaluate the outcome of this experiment of residence stability in trout populations, the results are quite closely compared by time periods with those from several other studies.

Results in the 1,500-foot section

In the sampling done in September 1969, 52% of the brown trout and 42% of the rainbows marked in July were captured. In the April 1970 inventory, recovery of trout marked the preceding July and September amounted to 33% of the browns and 23% of the rainbows (Table 1). In addition, one rainbow trout marked here was caught in the Control Section, and three brown trout and one rainbow trout were found in Section I.

Table 1.--Number of marked (fin-clipped) trout released, and number recovered, in a 1,500-foot section of the Platte River

When marked and released	When recovered	Inch group	Brown trout		Rainbow trout	
			Marked	Recovered	Marked	Recovered
July 1969	Sep 1969	2-4	12	...	13	6
		5-7	99	54	51	22
		8-9	15	9	2	0
		10-12	19	14	...	...
		13+	6	2	...	...
Total			151	79	66	28
July and Sep 1969	April 1970	2-4	50	7	71	8
		5-7	193	32	147	37
		8-9	41	50	2	5
		10-12	34	16	...	...
		13+	12	5	...	...
Total			330	110	220	50

Table 1 shows that some shift from lower to higher size groups resulted from growth between the times of marking and recapture.

The results obtained in September 1969 can be compared with those obtained by Shetter and Hazzard (1939) on Michigan streams 2 months after they had marked trout by fin clipping. Their test sections were about 100 feet long, they used seines, and on each occasion of collecting they seined until it was thought all the trout present had been captured.[2] In a section of the South Branch of the Pine River, which contained about equal numbers of brook trout (Salvelinus fontinalis) and rainbow trout, recovery was 18% in August and 13% in September (2 months after marking and both species combined, each time). In another section of the same stream, where rainbow trout outnumbered brook trout, combined recovery in the same months as those above was 17% and 3%, respectively. In a section of the Little Manistee River, populated about 50-50 with brown and rainbow trout, combined recovery at these times was 18% and 17%.

Other comparisons are afforded by a study that Stefanich (1952) made in a Montana stream, Prickley Pear Creek. Stefanich performed his research in six 600-foot sections, spaced approximately 2 miles apart, and each divided into four 150-foot sub-sections. With an a-c shocker, he attempted to capture all the fish present when tagging and recapturing. He collected and tagged brown trout and rainbow trout in each of the experimental sections six times over a period of approximately 15 months; each time after the first, he determined recovery rate and whereabouts of fish previously tagged. A creel census was also conducted as a part of this study, but the few recaptures recorded in the census are excluded from the data that follow.

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[2] The extent of capture quite certainly was short of total, however, as was to be demonstrated later on in a similar situation. After most of the water in a section of a small brook trout stream was drained out, the section was seined intensively until it appeared devoid of fish. But when the remaining isolated pools were treated with rotenone, a substantial number of trout were found (Shetter and Leonard, 1943).

Three collections made in the Montana stream 2 months after tagging (tagging done in June 1949, September 1949, and June 1950) can be compared with recovery of fin-clipped trout in the 1,500-foot section of Platte River 2 months after clipping. Stefanich respectively recovered 47, 17, and 26% of the marked brown trout by intensive collecting in the six sections (3,600 feet of stream), as compared to 52% in the Platte River section. Of 178 tagged brown trout recovered from the 512 released into Prickley Pear Creek, only 1 was found that had moved out of the section in which it was tagged. On the other hand, 65 (35%) of the recaptures had changed location from one 150-foot sub-section to another.

Recovery rates of rainbow trout in the Montana stream 2 months after tagging were 51, 23, and 34%, respectively in August, November, and August, as compared to 42% in Platte River after 2 months. Of the 94 rainbows Stefanich recovered from 234 released, only 1 was found outside the section in which it was marked. Thirty-one (33%) of the recaptures had moved to different sub-sections, however.

Results from inspection of the 1-mile sections, in April 1970

Brown trout

Seven months after trout had been marked in the 1-mile experimental sections of Platte River, the rate of recovery for brown trout within the section where they were fin clipped was 33% in the Control Section, 34% in Section I, and 20% in Section II. With recovery outside the "home" section included, the percentages were 34, 36, and 21, respectively (Table 2). Adjusting for over-winter mortality of marked fish, rate of recovery within the Control Section was 58% (1,120 ± 190 estimated as having survived and remained here), 61% in Section I (from an estimated population of 804 ± 97), and 54% in Section II (from the estimated 158 ± 73). [3]

[3] Obviously, rate of recovery based on residual population is more significant than that based on original number of marked fish released, provided the estimate of population is reasonably close. The confidence limits indicate that these are close point estimates.

Table 2. --Number of marked (fin-clipped) trout released during September 1969, and number recovered during April 1970, in experimental sections of the Platte River

Section where marked and released	Section where recovered	Inch group	Brown trout		Rainbow trout	
			Marked	Recovered	Marked	Recovered
Control	Same section	2-4	1,083	166	763	77
	"	5-7	566	236	607	159
	"	8-9	189	186	26	52
	"	10-12	84	53	...	...
	"	13+	20	8	1	0
	Upstream	All	...	2*	...	2*
	Downstream	All	...	11	...	6
	Total	All	1,942	662	1,397	296
Section I	Same section	2-4	521	66	465	26
	"	5-7	597	153	353	84
	"	8-9	150	172	10	18
	"	10-12	102	86	...	1
	"	13+	21	11	...	...
	Upstream	All	...	20	...	9
	Downstream	All	...	0	...	0
	Total	All	1,391	508	828	138
Section II	Same section	2-4	35	0	216	2
	"	5-7	200	12	246	8
	"	8-9	79	31	44	19
	"	10-12	83	25	2	2
	"	13+	58	22	1	1
	Upstream	All	...	4	...	1
	Downstream	All	...	...	...	...
	Total	All	455	94	509	33

* Recaptured in the 1,500-foot section.

About twice as many brown trout from Section I were found in the Control Section (20) as the number from the Control Section (11) found in Section I (Table 2). Two fish that had been fin clipped in the Control Section reappeared in the 1,500-foot section. None of the brown trout marked in these three areas was caught in Section II in April 1970, although one originally in the 1,500-foot section and one originally in Section I had entered the weir at the hatchery from the downstream side in the fall of 1969. Two brown trout marked in Section II were found in Section I, and two others showed up in the Control Section. One of the latter two was captured near the upper end of the Control Section, about 2.4 miles up from the dam; this fish evidently was the same 13.5-inch female that had come into the weir and was returned to the river above the dam in November 1969.

Rainbow trout

Rate of recovery of marked rainbow trout was distinctly lower than that of marked brown trout. Recovery of rainbow trout within the section where fin clipped was 21, 16, and 6%, respectively, in sections Control, I, and II; with captures of emigrants combined with those of "stay-at-homes," the recovery rates were 21, 17, and 6%, respectively (Table 2). Considerably different results were obtained for home-section recovery after adjustment was made for over-winter mortality [4] of marked rainbow trout. The recovery values for the three sections then were respectively 50, 63, and 28% (of these estimated numbers: 579 ± 164; 206 ± 41; and 115 ± 122). By this comparison, recovery of marked rainbow trout slightly exceeded that of brown trout in Section I.

As with brown trout that had vacated the section where marked, a few more marked rainbow trout had gone upstream than downstream (Table 2).

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[4] "Mortality" that had occurred by April 1970 included fish that moved out of the section in which they had been marked as well as those that died here, and by the following September it included removal by angling as well as natural death and emigration that had occurred since September 1969.

Results of the September 1970 inspection

Brown trout

One year after marking, about two-thirds as many of the brown trout that had been fin clipped in the Control Section were found there as were found after 7 months. In Section I, the number decreased about one-half, but in Section II four more were captured in September than had been captured in April. Recovery rates now differed but little between sections both as to (a) recovery within the "home" section, and (b) total recovery. The rates for these categories in the respective sections were as follows: (a) 21, 17, and 23%; (b) 22, 19, and 23%. Recovery rates obtained after adjusting for loss from mortality[4] of marked trout were quite different in value: 86% in the Control Section (whose population of marked brown trout was estimated at 483 ± 42); 84% (of 278 ± 38) in Section I; and 80% (of 123 ± 31) in Section II. But these recovery rates, like the others, were quite similar between sections, as was estimated survival of the marked populations 1 year after marking, which was 25, 20, and 27%, respectively. The number of marked brown trout found outside the "home" sections had increased slightly since April (Tables 2 and 3).

Data obtained on brown trout in the Pigeon River (Latta, 1972) a year after marking are well suited for comparison with the Platte River data because of the close similarity of the field methods and of the segments of stream used in the two experiments. The fish-collecting gear was almost identical, both groups of trout were marked and sampled during fall population surveys, and all sizes of trout were marked by fin clipping. One difference was that a creel census, as well as electrofishing, provided recovery records from the Pigeon River. The five experimental sections of this stream are adjoined, 1.1 to 1.3 miles long, 40 to 45 feet wide, and depths are similar to those in the 1-mile sections of Platte River. Recovery data from the two streams appear in Table 4. The more significant aspects of these data are that the rate of recovery of brown trout

Table 3.--Recovery of trout marked in 1-mile experimental sections of the Platte River 1 year after marking

Test section and species	Number found in this section	Number found in two other sections		Total
		Upstream	Downstream	
Control				
Brown trout	416	...	18	434
Rainbow trout	61	...	6	67
Section I				
Brown trout	233	25	4	262
Rainbow trout	15	12	1	28
Section II				
Brown trout	98	8	...	106
Rainbow trout	2	1	...	3

Table 4.--Recovery of marked brown trout by location 1 year after marking in two Michigan streams. In the Pigeon River, trout were fin clipped in fall of 1959, and sampled by creel census the next fishing season, and by electrofishing in fall of 1960. In the Platte River, trout were fin clipped in fall of 1969, and sampled in fall of 1970 by electrofishing.

Section*	Marked fish			Percent recovered by section, of total number recovered			
	Number marked	Percent recovered	Number recovered	Section where marked	Next section upstream	Next section downstream	All other sections
			Pigeon River				
E	234	29	67	85	..	9	6
D	290	15	43	70	21	0	9
C	400	10	42	64	7	10	19
B	403	11	43	75	2	0	23
A	211	10	22	77	9	..	14
			Platte River				
Control	1,942	22	434	96	..	4	<1
I	1,391	19	262	89	10	1	..
II	455	23	106	92	3	..	5

* Sections listed in downstream order.

still inhabiting the "marking" or "home" sections after 1 year was appreciably higher in Platte River, and the number residing in "away-from-home" sections was higher in the Pigeon River. Obviously, brown trout in the Pigeon River were inclined to move about more than those in the Platte River.

Data on recovery of brown trout a year after marking are available also from the study conducted on Prickley Pear Creek in Montana (Stefanich, 1952). Of 267 brown trout tagged in June 1949 that were available for recapture, electrofishing retook 25% of them in June 1950, of which 61% were located in the same 600-foot sections where they had been tagged. Recovery rates under the respective categories ("total" and "at home") for two other lots of tagged brown trout at the end of 1 year were 16% and 74% in August 1950, and 4% and 50% in September 1950. A few fish that anglers had caught from each group are not included in the figures above. Excepting the rate of total recovery for the June lot, these values by Stefanich are substantially lower than those obtained on Platte River.

Rainbow trout

Very few marked rainbow trout remained in the Platte River experimental sections by September 1970 (Table 3). A significant portion of the decrease resulted from an almost complete exodus of 2-year-old rainbows from the stream into Lake Michigan since April, whose departure was repeatedly demonstrated by electrofishing done in June. Doubtless some yearlings had also departed. Of the marked rainbow trout that had gone into a different section since September 1970, the greater number had moved upstream.

More marked rainbow trout remained in the test sections of Prickley Pear Creek after 1 year (Stefanich, 1952) than in the Platte River sections. Total recovery by electrofishing was 10, 6, and 5% from three marked lots sampled respectively in June, August, and September in the six 600-foot sections of Prickley Pear Creek; in the 1-mile sections of Platte River, total recovery amounted to 5, 4, and 1% of the original number.

Results of the April 1971 inspection

Approximately half as many marked brown trout were caught in each of the test sections in April 1971 as were caught 7 months previously. Marked rainbow trout were very scarce by this time. The distribution of recovery is tabulated below:

Section where marked	Species	Number recaptured, by section		
		Control	I	II
Control	Brown	204	9	5
	Rainbow	23	3	...
I	Brown	11	144	8
	Rainbow	11	11	...
II	Brown	9	4	43
	Rainbow	...	1	1

Later observations

Clipped fins had regenerated extensively by September 1971. It was decided not to enumerate marked trout at that time. Records were obtained during the April 1972 population survey, but these were incomplete. In the final (September 1972) population survey on the Platte River, one further attempt was made to inventory the remaining stock. However, little usable data resulted from a considerable amount of effort, because regeneration had progressed so far. Trout on which two fins were clipped (in the Control Section) provided the best information. At least 44 of the brown trout marked in the Control Section still lived here; 3 were recorded in Section I.

Discussion and conclusions

Besides two population surveys annually, trout were collected at various locations in the test sections each June and July to obtain scale samples. Despite such frequent disturbance, residence of brown trout was quite stable. Few of those marked in the experimental sections moved from one section to another; the restricted range was best illustrated by the small exchange of fish between Section I and the Control Section, which were only 120 feet apart. While invariably many more marked brown trout were found in the section in which they had been marked than in the other sections, the number found outside the "home" section progressively (although slowly) increased with time. Table 5 illustrates these characteristics. Some upstream migration occurred prior to spawning. During October and November in 1969, 1970, and 1971, respectively 51, 49, and 105 brown trout entered the weir at the fish hatchery. Nearly all were sexually mature, and nearly all were released on the upstream side of the weir. The percentage of fish in each total that had been marked in Section II in September 1969 was 15, 14, and 7, respectively. Other data concerning these trout appear in another report (Taube, 1974). Schuck (1945) observed upstream movement of brown trout in Crystal Creek, New York, during October and November. He reported that most of the tagged individuals in that migration were found the following September in the same experimental sections they had vacated the year before.

Location of rainbow trout was little different from location of brown trout 7 months after marking--that is, by far most of the recoveries were made in the section in which the fish had been fin clipped. Thereafter, proportionately more rainbow trout were caught in "away-from-home" sections. Stefanich (1952) noted that the rainbow trout observed in his study moved about more than the brown trout. Also, he usually recovered proportionately fewer marked rainbow trout than marked brown trout, which almost always was the result obtained on Platte River.

Table 5. --Distribution of recapture by location of brown trout marked in September 1969

Marking location and sampling period	Total number recaptured	Percentage of recaptures, by location		
		Section		
		Control	I	II
Control Section				
April 1970	662	*98	2	0
Sep 1970	434	96	4	<1
April 1971	218	94	4	2
Section I				
April 1970	508	4	96	0
Sep 1970	262	9	89	1
April 1971	163	7	88	5
Section II				
April 1970	94	2	2	96
Sep 1970	106	5	3	92
April 1971	56	16	7	77

* Two brown trout marked here (less than 1% of the total recaptured at this time) were found in the 1,500-foot section upstream.

No information was obtained on movement of trout in Platte River between the time of hatching and the following September. Hunt (1965) observed that large numbers of brook trout in Lawrence Creek, Wisconsin, moved appreciable distances during their first summer of life. McFadden (1961) previously found that considerable migration occurred here among brook trout of various ages.

I conclude that residence location of brown trout in Platte River, dating at least from the first autumn of life, is quite stable. I conclude further that this characteristic will assist appraisal of competition between salmon and trout. Although the rainbow trout are more mobile, perhaps mobility in their case will not hinder appraisal because they reside in the river a comparatively short time. The uncertainty should be settled when the population data are closely examined.

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