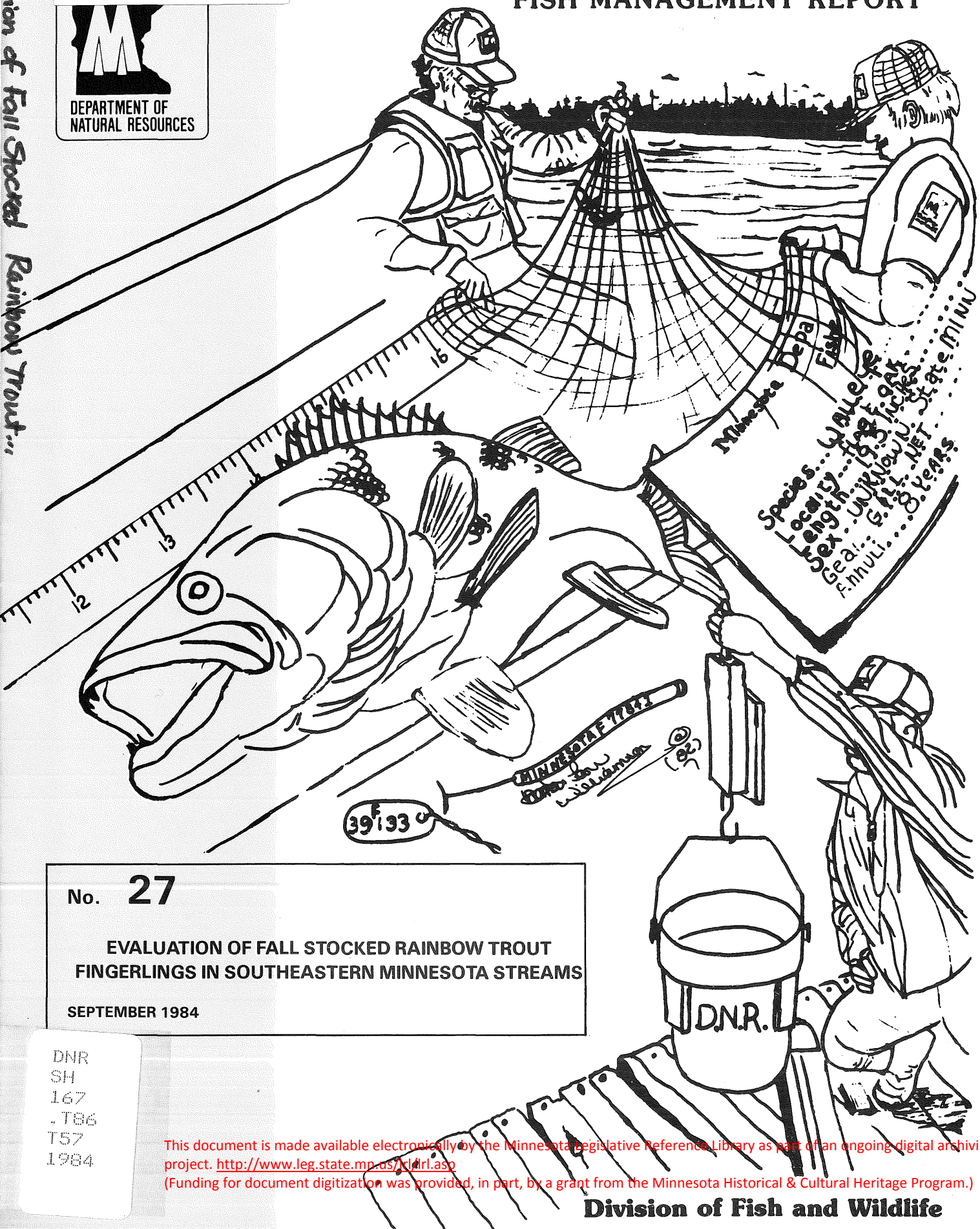
Evaluation of Fall Stocked Rainbow Trout...

DEPARTMENT OF NATURAL RESOURCES

Section of Fisheries

FISH MANAGEMENT REPORT



No. 27

EVALUATION OF FALL STOCKED RAINBOW TROUT FINGERLINGS IN SOUTHEASTERN MINNESOTA STREAMS

SEPTEMBER 1984

Division of Fish and Wildlife

EVALUATION OF FALL STOCKED RAINBOW TROUT FINGERLINGS IN SOUTHEASTERN MINNESOTA STREAMS[1]

by

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ABSTRACT

The field performance of rainbow trout stocked in the fall as fingerlings was evaluated. Performance of the rainbow trout exceeded that of stocked brown trout. Over-winter growth and survival was acceptable and a satisfactory early season fishery resulted. Angling and natural mortality, however, removed essentially all of the rainbow trout by mid-summer. Movement of rainbow trout from the study streams was minimal. None of the three strains of rainbow stocked during two years (Madison, Valley Creek, Arlee) demonstrated distinct superiority as an addition to the creel or the stream population. Stocking of rainbow trout fingerlings in the fall is recomended for suitable streams to supplement or replace the stocking of brown trout and to add diversity for the angler.

[1]This project was funded in part by Federal Aid Fish Restoration (Dingell-Johnson) program. Completion Report, Study 218; DJ Project F-26-R Minnesota.

INTRODUCTION

Rainbow trout (Salmo gairdneri) were among the first fish to be introduced into Minnesota and were first stocked in streams of southeastern Minnesota in the early 1900's (Eddy and Underhill 1974). In the 1950's, yearling rainbow trout accounted for half of the put and take fishery in these streams. This stocking practice was largely discontinued, however, because of excessive vulnerability to the angler, apparent emigration and a lack of contribution to the standing crop (Schumacher 1957). In early summer 1976, Madison strain rainbow trout fingerlings escaped from the Crystal Springs Hatchery, Winona County, into the South Branch of the Whitewater River during a massive flood. These fish grew to acceptable size and provided an unexpected fishery the following spring, prompting interest in experimental stocking of fingerlings in the fall.

The field performance of rainbow trout is known to vary by strain. Various authors have discussed survival, growth and catchability of domestic and natural strains (Rawstron 1973; Hudy 1980; Brauhn and Kincaid 1982; and Babey 1982). The majority of the work to date has dealt with lakes or reservoirs and related problems. In Minnesota, Madison, Donaldson and Kamloops strains have been evaluated in Lake Superior and northern Minnesota lakes (Close and Hassinger 1981; Close 1982). Successful performance of rainbow trout strains in Minnesota streams requires that the strain be non-migratory and exhibit suitable growth, survival and catchability.

The Minnesota production strain of Madison rainbow is known to be catchable and exhibits minimal 7% emigration (Kuehn and Schumacher

1957). In addition, a self-sustaining rainbow trout population was reported by Hanson and Waters (1974) in Valley Creek, Washington County, Minnesota. Subsequently, Cargill (1980) found this population to be sedentary and suggested stocking and evaluating this "strain" in other Minnesota trout streams. Vulnerability to angling was generally unknown because of lack of public access to Valley Creek.

Brown trout (Salmo trutta) are the resident trout in most southeastern Minnesota trout streams and effects of introduced rainbow trout on brown trout must be considered. Generally, rainbow and brown trout prefer a different niche in the stream. Rainbow trout prefer cover in faster water than do brown trout. Lewis (1969) found that cover and current velocity, respectively, were the most important physical factors of pools influencing brown and rainbow trout populations. Southeastern Minnesota streams are very productive (Waters 1961; Kruger 1979) and food should not limit trout populations in these streams (T. Waters, U. of Minn., personal communication 1979).

The objective of this study was to evaluate the field performance and movement of fall stocked rainbow trout fingerlings of available strains and their effect on resident brown trout in selected southeastern Minnesota streams.

METHODS

Study streams were the South Branch Whitewater River, the Middle Branch Whitewater River and Beaver Creek, Winona County (Figure 1). These streams are designated trout streams with physical characteristics conducive to fish sampling and creel census (Table 1).

Two study sectors were selected on the South Branch Whitewater River (SBW). The upper 6.9 km has good water quality, a substantial

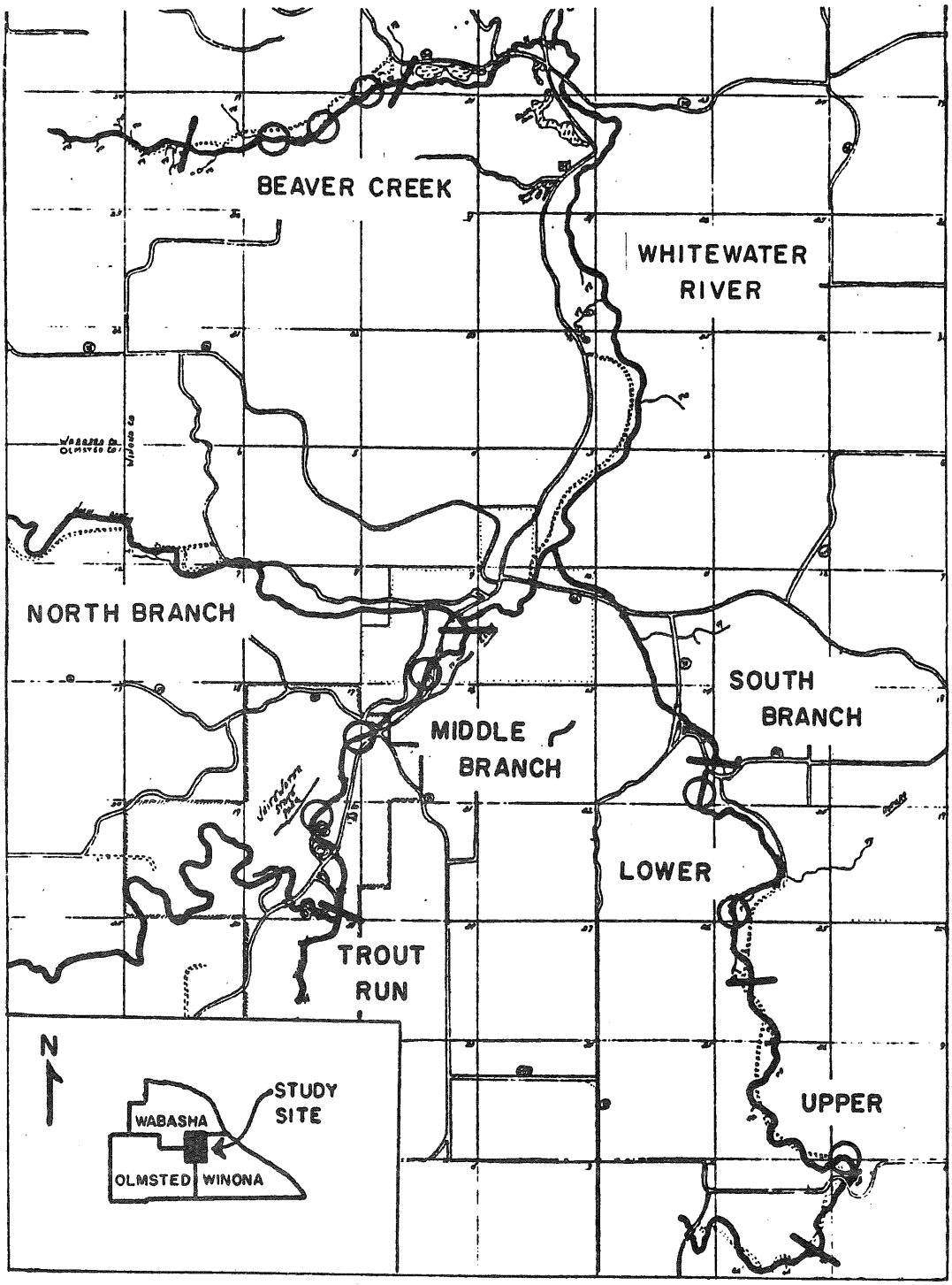

Figure 1. The study area for the fall fingerling rainbow trout stocking evaluation. Stream study sites are between bold lines perpendicular across each stream. Electrofishing stations are represented by open circles.

Table 1. Characteristics of selected southeast Minnesota streams and stream reaches stocked with fall fingerling rainbow trout, 1980-81.

Stream	Length (km)	Width (m)	Area (ha)	Normal summer flow (m^3/sec)
South Branch Whitewater River				
Upper	6.9	10.7	7.5	0.4-0.7
Lower	6.3	11.1	6.6	1.1-1.5
Middle Branch Whitewater River	5.6	11.1	6.1	1.0-1.3
Beaver Creek	10.1	5.2	5.2	0.2-0.4

wild brown trout (BNT) population (55-70 kg/ha) and suitable water velocity and cover for rainbow trout (RBT). The downstream 6.3 km has poorer water quality, a less abundant wild BNT population (18-27 kg/ha) and suitable RBT habitat.

The lower 5.6 km of the Middle Branch Whitewater (MBW) was selected for study. Conditions are marginal for trout but the stream sustains a minimal wild BNT population (9-18 kg/ha) and appears to have some RBT habitat.

Beaver Creek (BC) is the smallest of the study streams. It has a reputation as a good wild BNT stream. Water quality, trout habitat conditions and the abundance of BNT vary within the stream (70-90 kg/ha).

Three strains of RBT were stocked during the two study years (Table 2). In fall 1980, Valley Creek (VC) and Madison (MAD) RBT were stocked in all four study sections. In fall 1981, MAD and Arlee (AR) RBT were stocked in the two lower sections of SBW and MBW. VC RBT were progeny from brood stock removed from Valley Creek. MAD RBT are Minnesota production RBT and AR RBT were progeny of brood stock obtained from Arlee, Montana.

In 1980, the two strains were stocked in near-equal numbers. The anticipated total stocking rate was 625 RBT/ha or about 300/ha/strain. The full quota of VC was not available and stocking rates were reduced (Table 2). Stocking was restricted to lower SBW and MBW in 1982 and stocking rates were increased.

Fin clips were used to distinguish strains. Each paired strain in 1980 received a similar clip to minimize effects of fin removal between

Table 2. Numbers of fish, stocking rates (no/km, no/ha) and length (mm) of three strains of rainbow trout stocked into four southeast Minnesota streams, 1980-81.

Year	Stream	Strain[a]	Number	No/km	No/ha	Mean length (mm)[b]
1980	Upper South Branch Whitewater River	MAD	1,720	249	229	130
		VC	1,680	243	224	107
	Lower South Branch Whitewater River	MAD	1,170	196	177	130
		VC	1,150	183	174	107
	Middle Branch Whitewater River	MAD	1,050	188	172	130
		VC	1,000	179	164	107
	Beaver Creek	MAD	1,560	154	300	130
		VC	1,500	149	288	107
1981	Lower South Branch Whitewater River	MAD	4,000	635	606	152
		AR	4,000	635	606	150
	Middle Branch Whitewater River	MAD	1,506	269	247	152
		AR	1,508	269	247	150

[a] MAD = Madison, VC = Valley Creek, AR = Arlee
[b] Calculated from Bowen and Studdard (1970)

strains. In 1981, the MAD strain received an adipose clip while the AR strain was unmarked.

Distribution of the RBT varied by stream. Access restricted stocking the upper SBW to a single site near the upper end of the study area. On the lower SBW, fish were distributed throughout the study area. Access on the MBW allowed distribution throughout the study area but VC RBT were stocked at a single site near the upper end of the study area to determine if they would be sedentary. Stocking in Beaver Creek was restricted to the middle 3.0-3.5 km where the BNT population was least dense.

Sampling stations were established to assess growth, survival, standing crops, movement and effect on resident BNT. These stations were electrofished, when possible, before and after the trout fishing season. In some instances, inadequate access delayed spring sampling until after the trout season opener. The trout season began 1 March in 1981 but MBW and BC electrofishing was not possible until 1 April and the SBW could not be sampled until 1 May. The 1982 season began 17 April. MBW and BC were sampled prior to the opener but SBW was sampled one week after the openings. Post-season electrofishing was completed following the 30 September season closure

Trout were sampled with a DC stream shocker. Two electrofishing runs were made on each station to estimate the fish population by mark and recapture or removal. Total lengths of trout (except BNT young-of-the-year) were measured and a representative sample of weights was taken to establish a length-weight relationship. Mid-summer electrofishing provided additional data regarding RBT movement.

Harvest of RBT was estimated by a creel census based on instantaneous angler counts and angler interviews. During most of the 1981 trout season, the census clerk worked two 10 h weekdays per week and 10 h days all weekends and holidays. This was increased to three 10 h weekdays per week during August and September 1981 and most of 1982. Three streams or stream sections were sampled each day. Days were divided into 3 h sample periods and angler counts were made at the beginning and end of each period. Fishermen were interviewed between counts. Species, fin clip, and fish length and weight of creeled fish were recorded whenever possible.

RESULTS

Rainbow Trout Fishery

The fall stocked RBT primarily supported a May-June fishery the first season after stocking (Tables 3 and 4). These two months accounted for 42% and 82% of the annual harvest for 1981 and 1982, respectively, and 28% and 47% of the angling use. Angling pressure approached 1,200h/km for the SBW and MBW (Lake City Management Area Files). Catch rates were also highest during May and June (Table 5). Rates of 0.25-0.50 fish/h were maintained prior to 1 July.

Return of RBT by number and weight varied between strains and streams (Table 6). The only consistent harvest advantage of any strain was the greater return by weight for VC. Return of RBT by number and weight was greatest in MBW in 1982. Returns the second year were calculated for the entire SBW even though all fish were stocked in the lower SBW.

Table 3. The estimated monthly and seasonal harvest of three strains of fall stocked fingerling rainbow trout and 95% confidence intervals (in parentheses) from four southeast Minnesota streams, 1981. MAD are Madison strain, VC are Valley Creek strain and AR are Arlee strain.

Strain	Stream	March[a]	April	May	June	July	Aug	Sept	Total
MAD	Upper S. Branch	0 (0)	0 (0)	13 (0-29)	19 (0-53)	0 (0)	55 (39-71)	5 (0-33)	92 (30-154)
	Lower S. Branch	0 (0)	0 (0)	41 (27-55)	12 (0-26)	19 (0-45)	11 (0-33)	15 (0-35)	198 (54-112)
	Middle Branch	0 (0)	52 (20-84)	20 (11-29)	25 (17-33)	8 (0-18)	21 (0-43)	0 (0)	126 (82-170)
	Beaver Creek	90 (0-252)[b]	0 (0)	23 (0-57)	12 (0-32)	0 (0)	32 (0-68)	6 (0-20)	163 (0-335)
	TOTAL	90[b]	52	97	68	27	119	26	479
VC	Upper S. Branch	0 (0)	0 (0)	62 (16-108)	90 (0-196)	17 (0-49)	67 (0-225)	2 (1-3)	238 (38-438)
	Lower S. Branch	0 (0)	15 (0-45)	41 (29-53)	6 (0-16)	0 (0)	0 (0)	9 (0-23)	71 (35-107)
	Middle Branch	0 (0)	17 (0-73)	25 (15-35)	9 (0-23)	47 (0-132)	13 (0-29)	0 (0)	101 (0-205)
	Beaver Creek	0 (0)	0 (0)	12 (0-28)	12 (0-38)	65 (0-143)	10 (6-14)	13 (0-31)	112 (28-196)
	TOTAL	0	32	140	117	129	90	24	532
Both		90	84	237	185	156	209	50	1,011

[a] Trout season opened 1 March 1981.

Table 4. The estimated monthly and seasonal harvest of three strains of fall stocked fingerling rainbow trout and 95% confidence intervals (in parentheses) from four southeast Minnesota streams, 1982. MAD are Madison strain, VC are Valley Creek strain and AR are Arlee strain.

Strain	Stream	April[a]	May	June	July	Aug	Sept	Total
MAD	South Branch	47 (0-101)	222 (64-380)	165 (45-228)	5 (0-47)	5 (0-31)	25 (0-63)	469 (255-683)
	Middle Branch	96 (0-212)	148 (18-278)	89 (9-169)	42 (0-110)	0 (0)	0 (0)	375 (111-639)
	TOTAL	143	370	254	47	5	25	846
AR	South Branch	21 (0-65)	186 (68-304)	253 (111-395)	30 (0-70)	13 (0-41)	27 (7-47)	530 (332-728)
	Middle Branch	38 (0-86)	287 (173-401)	36 (0-112)	42 (0-100)	0 (0)	0 (0)	403 (165-641)
	TOTAL	59	473	289	72	13	27	933
Both		202	843	543	119	18	52	1,777

[a] Trout season open 17 April 1982

Table 5. Mean monthly and seasonal catch rates (no/h kept and released) and their 95% confidence intervals (in parentheses) for fall stocked fingerling rainbow trout from four southeast Minnesota streams, 1981-82.

Stream	March	April	May	June	July	Aug	Sept	Season
				1981[a]				
Upper S. Branch	0.03 (.00-.07)	0.02 (.00-.10)	0.25 (.09-.41)	0.58 (.00-1.16)	0.18 (.00-.42)	0.21 (.01-.41)	0.29 (.00-.69)	0.14 (.07-.21)
Lower S. Branch	0.01 (.00-.02)	0.07 (.01-.13)	0.25 (.07-.43)	0.11 (.01-.21)	0.09 (.00-.19)	0.05 (.00-.11)	0.04 (.00-.08)	0.09 (.05-.13)
Middle Branch	0.02 (.00-.04)	0.29 (.05-.53)	0.33 (.15-.51)	0.27 (.03-.51)	0.20 (.09-.31)	0.11 (.03-.19)	0.00 (.00)	0.19 (.13-.25)
Beaver Creek	0.09 (.00-.09)	0.00 (.00)	0.12 (.02-.22)	0.05 (.00-.11)	0.34 (.00-.72)	0.11 (.03-.19)	0.11 (.03-.19)	0.10 (.06-.14)
				1982[a]				
Upper S. Branch		0.13 (.05-.21)	0.31 (.00-.68)	0.09 (.00-.23)	0.18 (.00-.48)	0.00 (.00)	0.00 (.00)	0.16 (.06-.26)
Lower S. Branch		0.30 (.10-.50)	0.31 (.17-.45)	0.37 (.23-.51)	0.05 (.01-.09)	0.06 (.00-.14)	0.07 (.00-.15)	0.25 (.19-.31)
Middle Branch		0.25 (.11-.39)	0.49 (.23-.75)	0.21 (.11-.31)	0.08 (.00-.16)	0.00 (.00)	0.00 (.00)	0.20 (.14-.26)

[a] Trout season opened 1 March 1981 and 17 April 1982.

Table 6. Percent angler return of fall stocked fingerling rainbow trout by number and weight from four southeast Minnesota streams, 1981-82.

Year	Stream	Percent return by number		Percent return by weight	
		MAD	VC	MAD	VC
1981	Upper S. Branch	5.3	14.2	24	123
	Lower S. Branch	16.9	6.2	47	52
	Middle Branch	12.0	10.1	79	122
	Beaver Creek	10.4	7.5	27	69
	MEAN	11.1	9.5	44	92
		MAD	AR	MAD	AR
1982	South Branch	11.7	13.3	33	43
	Middle Branch	24.9	26.7	88	77
	MEAN	18.3	20.0	61	60

Survival

Over-winter survival of RBT ranged from 28->100% among strains and streams (Table 7). Average overwinter survival for the study streams was 52% and 36% for MAD RBT and VC RBT in 1980-81, respectively, and 49% and 72% for MAD RBT and AR RBT, respectively, 1981-82. Best survival in both winters was noted in MBW.

Few RBT survived through the summer. Post-season population estimates could not be made because of small numbers of sampled fish (8 MAD RBT and 11 VC RBT in 1981; 3 MAD RBT and 1 AR RBT in 1982). Electrofishing and creel census results from 1982 indicate that most RBT were caught or lost to natural causes by July since few fish were sampled in July or creeled after June. A single electrofishing run of Station 1 lower SBW captured no RBT and in Station 3 of MBW only six AR RBT and five MAD RBT were sampled. In 1982, 89% of the RBT harvest had occurred prior to July (Table 4). Angling accounted for only 18% of the total mortality.

Growth

Over-winter growth of rainbow trout ranged from 15-68 mm for the strains, streams and years (Table 7). Growth increments for MAD RBT and VC RBT were similar while MAD RBT grew better than AR RBT. Best growth both years was noted in SBW.

Growth of RBT strains during the summer as indicated from the creel census (Table 8) was best in MBW in 1981 but comparable between the two streams in 1982. Low sample size precluded accurate late season growth estimates.

Table 7. Overwinter survival (%) and growth increment (mm) of three strains of fall stocked fingerling rainbow trout in four southeast Minnesota streams, 1980-81 and 1981-82.

Winter	Stream	Survival (%)		Length increment (mm)	
		MAD	VC	MAD	VC
1980-81	Upper S. Br. Whitewater	40	40	66	68
	Lower S. Br. Whitewater	52	35	68	66
	Middle Br. Whitewater	75	35	25	43
	Beaver Creek	43	33	27	28
	AVERAGE PER STREAM	52	36	46	51
		MAD	AR	MAD	AR
1981-82	South Br. Whitewater[a]	28	28	43	38
	Middle Br. Whitewater	70	>100[b]	28	15
	AVERAGE PER STREAM	49	72	36	26

a RBT stocked in lower S. Branch but survival estimates include upper and lower S. Branch.

b S. Branch spring electrofishing estimates indicated more trout present than stocked.

Table 8. Average monthly total length (mm) and its 95% confidence interval (in parentheses) of three strains of fall stocked fingerling rainbow trout in angler creels, April-June 1981-82.

Year	Strain	Stream	Length (mm) April	May	June
1981	Madison	Upper S. Branch		210 (±28)	220 (±24)
		Lower S. Branch	200[a]	219 (±10)	222 (±10)
		Middle Branch	205 (± 6)	242 (±10)	264 (±17)
		Beaver Creek		188 (±18)	210[a]
	Valley Cr.	Upper S. Branch		218 (±14)	232 (±24)
		Lower S. Branch		221 (±12)	
		Middle Branch	180[a]	224 (± 6)	259 (± 8)
		Beaver Creek		198 (±14)	221[a]
1982	Madison	Lower S. Branch	181 (± 5)	220 (± 7)	228 (± 7)
		Middle Branch	219 (±12)	229 (± 9)	241 (± 0)
	Arlee	Lower S. Branch	183 (±17)	212 (± 8)	228 (± 8)
		Middle Branch	208 (± 9)	210 (± 9)	222 (± 13)

[a] Sample of one.

Movement

Movement of RBT during the winter after stocking was limited and varied between strains. VC RBT demonstrated more movement than MAD RBT the first winter, while MAD RBT moved more than AR RBT the second winter in SBW. Spring sampling 1981, captured two VC RBT stocked in lower SBW in upper SBW (7 km) and one VC RBT from upper SBW stockings in lower SBW but no MAD RBT were taken outside their area of stocking. In Beaver Creek, VC RBT were captured 2.4 km downstream and 1.7 km upstream from the stocking area but MAD RBT were not found at the same locations. However, in MBW only one VC RBT stocked at Station 3 was captured downstream in Stations 1 and 2. At the upper SBW sampling station, spring 1982, RBT estimates were 26 MAD RBT/km and 4 AR RBT/km which had moved upstream from lower SBW. Also, an estimated 92 MAD RBT and 41 AR RBT from lower SBW were harvested in upper SBW during 1982.

RBT exhibited some movement into adjacent spring tributaries both years. All strains were captured with resident BNT in small SBW tributaries. The tributaries only have habitat for a small number of fingerling trout. Anglers reported catching RBT in Trout Run, a tributary stream to MBW at the upstream end of the study sector.

Extensive movement of RBT out of study streams was not indicated either year. Electrofishing did not indicate movement either upstream into the North Branch Whitewater River from MBW or downstream from MBW and SBW into the Main Whitewater River. RBT were not captured in streams other than those in which they were stocked.

Resident Brown Trout Populations

Resident BNT populations did not appear to be adversely affected by stocked RBT. Few adult RBT remained after the fishing season to

possibly compete with BNT during the winter. BNT reproductive success has not decreased since RBT were stocked (Table 9).

DISCUSSION

RBT stocked as fall fingerlings survived and grew over-winter sufficiently to sustain a fishery during mid-April through June when 73% and 67% of the annual pressure was recorded in 1981 and 1982, respectively. In these streams, survival of 40-50% is considered successful management. Stocking of RBT was most successful in larger streams with less dense BNT populations, marginal water temperatures and heavy fishing pressure. Movement of RBT was not excessive and resident BNT were not adversely affected. None of the three RBT strains evaluated demonstrated distinct superiority.

Over-winter survival of RBT fingerlings surpassed that of BNT fingerlings stocked in southeastern Minnesota streams in previous years. RBT survival ranged from 28->100% and averaged 52% among strains for the 2 winters. BNT survival in 3 streams during the winter of 1977-78 ranged from 4.5-6.0% (Lake City Management Area Files). Haugstad (Mn. Dept. Nat. Res., personal communication 1982) reported 20% average survival of BNT in 8 streams with a range of 3-42%.

Growth of RBT fingerlings during winter was generally equivalent to growth by BNT fingerlings. Overwinter growth of BNT fingerlings in BC, 1977-78, and lower SBW, 1978-79, averaged 46 mm and 38 mm, respectively. BNT fingerlings stocked the fall of 1977 in two Wabasha County streams grew 43 and 64 mm overwinter (Lake City Management Area Files).

RBT emigration from the study area was minimal. Movement was detected into better water quality upstream and into spring tributaries. Lack of RBT movement had earlier been reported for North

Table 9. Annual fall brown trout year-class strength (fingerlings/km and its 95% confidence interval (in parentheses) in four southeast Minnesota streams, 1980-82, following fall fingerling rainbow trout stocking, 1980-81.

Stream	1980	1981	1982
Upper SBW	1,333(404-2,424)a	909(634-1,360)	1,395(374-1,603)
Lower SBW	5(1-5)	396(229-743)	195(128-312)
MBW	41(13-75)	414(325-508)	460(332-658)
Beaver Creek	76(41-156)	267(191-382)	1,375(1,147-1,647)

a Based on one recapture. Subsequent sampling indicated this estimate to be high.

Branch Creek (Kuehn and Schumacher 1957). Kendall and Helfrich (1981) found that 75% of the marked catchable RBT were caught within 400 m of the stocking site in a Virginia mountain stream.

Stocking of RBT was not accompanied by a decrease of the resident BNT populations. BNT recruitment, as indicated by fingerling populations (Table 8), appeared to increase during the study years. Few adult RBT survived the summer to compete with BNT adults during winter when competition would be expected to be most severe. Shetter (1967) concluded that after stocking 3,000 RBT fingerlings in 2.8 km of Hunt Creek, that the brook trout (Salvelinus fontinalis) population was not noticeably affected.

No strain of RBT clearly demonstrated an advantage for stocking in southeastern Minnesota streams. Close and Hassinger (1981) also found variable results from testing three strains in Lake Superior. However, Moring (1982) concluded that one strain of RBT yielded higher catches and less emigration than the other two strains tested. Huddy (1980) observed differences in strain performance which varied from year to year in the same environment. He concluded that strain evaluations should consider performance over a number of years under different conditions and in different waters.

Angling and natural mortality reduced RBT populations to unacceptable angling levels by mid-summer. Schumacher (1957) found RBT to be more vulnerable than BNT and Kuehn and Schumacher (1957) reported less than 1% survival of stocked RBT to the second fishing season. In this study, stocked RBT were vulnerable to heavy fishing pressure during May and June after reaching acceptable size. In addition, natural mortality may have increased with seasonally declining habitat

quality. Water levels dropped during the summer, and water depth in the faster, open water preferred by RBT may have become ineffective cover against avian predators such as kingfishers (Megaceryle alcyon) and great blue herons (Ardea herodious).

The success of stocking is usually evaluated by the return in number and weight to the angler. Fingerling stocking is considered successful when more weight is returned than was stocked This was realized only from the MBW but adjusting stocking quotas should increase the return in weight. Poorer BNT fingerling survival and growth appeared to preclude a weight return equal to RBT fingerling (Lake City Management Area Files).

Recovery rates of 80-90% for catchables in heavily fished streams should be expected but managers are often satisfied to recover 50% (Cooper 1974). The return of catchable BNT, the traditional management tool, on the lower SBW in 1982 was 20-25% with 7% estimated remaining after the fishing season. Fingerling rainbow trout returned from the lower SBW at rates of 11 and 14% by number and 76 and 41% by weight in 1981 and 1982, respectively. The greater weight return of fingerling rainbow as a result of biomass gain offsets the comparative disadvantage of lower numerical return.

Benefit:cost ratios for RBT varied because of the experimental nature of this study. Best and worst examples from this study assess benefit:cost ratios of fingerling RBT stocking of 1.4:1 and 0.2:1, respectively. In general, RBT returned in greater numbers during this study than BNT fingerlings and in greater weight than BNT yearlings. These generalizations and the more expensive costs of production for BNT ($2.98/kg of RBT fingerlings, $3.62/kg of BNT fingerlings and

$4.09/kg of BNT yearlings; John Huber, Mn. Dept. Nat. Res., personal communication 1982), suggest that economic considerations can favor RBT fingerling stocking in some situations.

RBT fingerling stocking can be used to replace or supplement BNT stocking in some streams and provide angling diversity. Fingerlings grew over winter to enter the creel 1 May at a length of 200-220 mm. Catchable BNT are usually 210-220 mm when stocked beginning in mid-May. Hunt (1981) found that similar management on a physically comparable stream added diversity to the fishery and increased catch rates.

MANAGEMENT IMPLICATIONS

1) Rainbow trout fall fingerlings may be used to replace or supplement traditional brown trout yearling or fingerling stockings in selected streams
2) Rainbow fall fingerling stocking, with the present season regulations, will sustain an early season fishery and provide diversity for the angler. An early season rainbow fishery can eliminate the need for fall or spring yearling brown trout stocking for that purpose. Spring brown trout fingerling stocking can provide late season angling.
3) Rainbow trout should be stocked in large streams (width 8 m and flow 0.7 m^3/sec) with low resident trout populations. In southeastern Minnesota these streams often have marginal water temperature and heavy fishing pressure. Stocking smaller streams with low resident trout populations should be evaluated.
4) The recommended stocking rate is 400/km (650/mi) or 300/ha (120/A) at a length of 125-150 mm (5-6 in).

5) A high quality trophy fishery for stocked rainbow trout with present strains does not appear possible because of high natural mortality.

6) The Valley Creek strain should be tried in a suitable stream with light fishing pressure. A better quality fishery may result because of the apparent potential for greater weight return to the angler.

7) Future stockings of different strains should be evaluated for a longer time because of annual variation.

LITERATURE CITED

Babey, G.J. 1982. Field performance of three strains of trout stocked as fingerlings in a mountain reservoir. 112th Annual Meeting, Amer. Fish. Soc., Hilton Head Island, South Carolina. September 1982.

Bowen, J.T., and N. Studdard. 1970. English and metric length-weight relationships for rainbow, brown, and brook trout. Manual of Fish Culture, Appendix 1. Bur. Sport Fish. Wildl. 54 pp.

Brauhn, J.L., and H. Kincaid. 1982. Survival, growth, and catchability of rainbow trout of four strains. N. Am. J. Fish. Manage. 2:1-10.

Cargill, S. 1980. Lack of rainbow trout movement in a small stream. Trans. Am. Fish. Soc. 109:484-490.

Close, T. 1982. Field evaluation of hatchery-reared trout (Minnesota F-26-R, Study 210, in progress).

Close, T., and R. Hassinger. 1981. Evaluation of Madison, Donaldson, and Kamloops strains of rainbow trout (Salmo gairdneri) in Lake Superior. Minn. Dept. Nat. Res., Div. Fish Wildl., Sect. Fish. Invest. Rep. No. 372: 17 pp.

Cooper, E.L. 1970. Management of trout streams. Pages 153-162 in N.G. Benson, ed. A century of fisheries in North America. Am. Fish. Soc. Sp. Pub. No. 7. Washington, D.C.

_____. 1974. Trout in streams. Pages 4-11 in A.G. Grove, Jr. ed. Salmonid Management. Supplement to Trout, Vol. 15.

Eddy, S., and J.C. Underhill. 1974. Northern fishes. Third ed. Univ. Minn. Press. Minneapolis. 414 pp.

Hanson, D.L., and T.F. Waters. 1974. Recovery of standing crop and production rate of a brook trout population in a flood-damaged stream. Trans. Am. Fish. Soc. 103:431-439.

Huddy, M. 1980. Evaluation of six strains of rainbow trout (Salmo gairdneri) stocked as fingerlings in Porcupine Reservoir, Utah. M.S. Thesis, Utah State University, Logan. 72 pp.

Hunt, R.L. 1981. A successful application of catch and release regulations on a Wisconsin trout stream. Wisc. Dept. Nat. Res. Tech. Bull. No. 119:30 pp.

Kendall, W.T., and L.A. Helfrich. 1981. Dispersion patterns of hatchery-reared rainbow trout stocked in a Virginia mountain stream. Proc. Ann. Conf. Southeast Assoc. Fish Wildl. Agencies 34:318-329.

Krueger, C.C. 1979. Macroinvertebrate production in three eastern Minnesota streams. Ph.D. Thesis, U. of Minn., St. Paul. 230 pp.

Kuehn, J.H., and R.E. Schumacher. 1957. Preliminary report on a two-year census on four southeastern Minnesota trout streams. Minn. Dept. Nat. Res., Div. Fish Wildl., Sect. Fish. Invest. Rep. No. 186: 41 pp.

Lewis, S.L. 1969. Physical factors influencing fish populations in pools of a trout stream. Trans. Am. Fish. Soc. 98:14-19.

Moring, J.R. 1982. An efficient hatchery strain of rainbow trout for stocking Oregon streams. N. Am. J. Fish. Manage. 2:209-215.

Rawstron, R.R. 1973. Harvest, mortality, and cost of three domestic strains of tagged rainbow trout stocked in large California impoundments. Calif. Fish and Game J. 59:245-265.

Shetter, D.S. 1967. Effects of jaw tags and fin excision upon growth, survival, and exploitation of hatchery rainbow trout fingerlings in Michigan. Trans. Am. Fish. Soc. 96:394-399.

Schumacher, R.E. 1957. Duschee Creek creel census-population study for 1954-1955. Minn. Dept. Nat. Res., Div. Fish Wildl., Sect. Fish. Invest. Rep. No. 176: 33 pp.

Waters, T.F. 1961. Standing crop and drift of stream bottom organisms. Ecology. 42:532-537.

ACKNOWLEDGEMENTS

This study depended upon the assistance and cooperation of many people. M.E. Kelly and R. Willenberg were dedicated and conscientious census clerks. Personnel from the Lake City Management Area staff (L. Gates, S. Hirsch, D. Sogla, G. Grunwald, D. Thompson) ably provided assistance for electrofishing.

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