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EVALUATION OF FISHING QUALITY INDICES AND SIZES OF BROWN TROUT PREFERRED BY ANGLERS IN SOUTHEAST MINNESOTA[1]

by

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ABSTRACT

Catch Quality (CQ), Trip Quality (TQ), and simple catch rates were compared with ratings of fishing success and of trip enjoyment from trout anglers in southeast Minnesota. Catch rates were as good or better at predicting ratings of fishing success as either CQ (summed for each angler) or TQ. All three catch descriptors were poorly related to ratings of trip enjoyment. Having anglers simply rate their fishing success is likely the best method available to measure fishing quality. Responses to individual quality-related questions can direct management efforts to improve fishing quality. Angler ratings for five quality-related variables showed most anglers felt catch and release was most important, followed by size, number, kind, and diversity of fish caught, respectively. Relative importance of each quality variable was similar between special regulation (catch and release) and standard regulation streams and among angler groups identified by terminal tackle, organized angling group membership, or trout-angling experience. Logistic models showed angler preferences for brown trout increased most rapidly as length of fish increased from about 250 to 350 mm.

INTRODUCTION

Fisheries managers have traditionally measured fishing quality with angling variables such as effort and harvest, size of fish caught, and catch rates. Angler attitude studies now show that importance of these variables varies among anglers and their use as indices of fishing quality is questionable. To address this problem, Weithman and Anderson (1978) introduced some formulas to measure fishing quality that combine subjective variables with traditional catch and effort statistics. Subjective variables in the formulas are the importance of kind, size, number, and diversity of fishes caught, of catch and release of fish, and of individual species in the creel. During creel surveys, anglers rate each of these variables on a scale from 1 (most important) to 5 (no importance). The ratings are then used to weight catch and effort data and produce indices for catch quality (CQ), harvest quality (HQ), and trip quality (TQ) for each angler. Ratings for importance of catch and release of fish, of catching a particular species, and of fish size are used to calculate CQ for each fish caught and HQ for harvested fish. TQ for each angler is calculated with ratings for importance of number of fish caught, diversity of fish species caught, and summed CQ points.

Since their introduction in the late 1970's, only one reported study has tested the Weithman and Anderson (W/A) indices. Weithman and Katti (1979) used data from a

statewide survey of Missouri anglers to test the ability of the CQ and TQ indices to predict which fish or group of fishes anglers would prefer to catch when given two choices; four warm water species and one cold water species were used in the comparisons. Weithman and Katti (1979) found that at least 90% of the anglers chose the fish or group of fishes with the higher CQ or TQ value (when there was a 30% difference or more) and concluded that these indices were "extremely" accurate.

This study further tests the quality indices with angler-survey data from trout streams in southeast Minnesota. CQ, TQ, and catch rate (a traditional index of fishing quality) are compared to direct angler ratings for fishing success and trip enjoyment.

Additional objectives of this study were: 1) to measure anglers' expectations of average size and catch rate for brown trout, 2) to compare attitudes of selected angler groups, 3) to describe indices for angler-perceived levels of fishing success and fishing trip enjoyment, and 4) to identify sizes of brown trout preferred by angler groups.

METHODS

Angler Interviews

Roving clerks interviewed trout anglers on eight stream sections (six streams) in southeast Minnesota during weekends in April and May 1989 (Table 1). Standard regulations (daily harvest up to five trout, no more than 3 trout >406mm) exist on six of the stream sections. Special

Table 1. Stream sections where anglers were interviewed in 1989, mean width (m) of each section, and the distribution of interviews among sections.

Stream	Mean width	Number of interviews	Percent of interviews
Garvin Brook	3.6	34	9
Main Branch Whitewater River	16.5	88	23
Rupprecht Creek	4.2	45	12
South Branch Root River			
-Special regulations[a]	14.0	36	9
-Standard regulations	9.9	51	13
Trout Run Creek			
-Special regulations[b]	8.3	18	5
-Standard regulations	12.9	66	17
West Indian Creek	6.0	44	12

[a] Single-hooked, artificial lures only; release all trout.
[b] Single-hooked, artificial lures only; release all trout >280mm.

regulations exist on the remaining two stream sections; harvest of trout less than 280 mm long was prohibited on one section and a complete no-kill rule for trout was set on the other. Brown trout (Salmo trutta) are the numerically dominant game species in each of the stream sections (Lake City and Lanesboro Area Fisheries files).

Clerks walked the stream sections at various times

between 0800 and 1900 hours and interviewed anglers. Individual anglers were interviewed only once per weekend. Clerks recorded all catch, effort, and importance/enjoyment ratings (for kind, size, number, diversity, and species of fish caught and for fish caught and released) for computing Weithman and Anderson's Catch Quality (CQ) and Trip Quality (TQ) indices. Anglers were asked to rate the importance of individual harvested trout (Nelson 1983). Ratings for individual fish were substituted for species ratings to calculate CQ an TQ for anglers that kept trout.

Anglers often experience difficulty interpreting and rating fishing quality questions (Hirsch 1989), so clerks carefully explained to each angler the direction of the rating scale (i.e. a response of "1" indicated extreme importance and "5" indicated no importance). A notecard with a brief description of the 5-point rating scale was also given to each angler for reference.

Anglers' expectations were measured by having each angler estimate the average size (to nearest inch) brown trout caught in the stream he or she was fishing and state how catch rates compared with other streams in the area. Anglers chose one of five responses to compare catch rates: much higher=1, higher=2, about the same=3, lower=4, and much lower=5.

At the end of each interview, anglers were asked to rate both their fishing success and their total trip enjoyment using the scale: excellent=1, good=2, average=3,

below average=4, or poor=5.

Data Analyses

Angler-survey data were stratified by stream section, angling regulations, terminal tackle, angling group affiliation, and years of trout-angling experience for statistical analyses. Standard t-tests and orthogonal contrasts with Bonferroni control (when more than two indices were compared) (Wilkinson 1987) identified differences in angler responses to fishing quality questions, and in mean catch rate, CQ and TQ, among angler groups.

Linear regression analysis was used to compare the relationships between the ratings for fishing success and CQ, TQ, and catch rate (fish/h). CQ points were summed (SCQ) for each angler to account for all fish caught. Regressions were computed only for anglers that had fished at least one hour before being interviewed. Catch rate, SCQ, and TQ values were transformed by log(X+1) to account for 0 values (Snedacor and Cochran 1967) and make them approach normality (Weithman and Katti 1978).

Data on angler preferences for sizes of brown trout were obtained by asking anglers to rate (using the 5-point scale) the importance of one of five sizes of a black-and-white drawing of a brown trout (Figure 1) displayed by the clerk. Lengths of trout drawings were 203, 254, 305, 356, and 406 mm; these represent the size range of most brown trout caught by anglers in southeast Minnesota

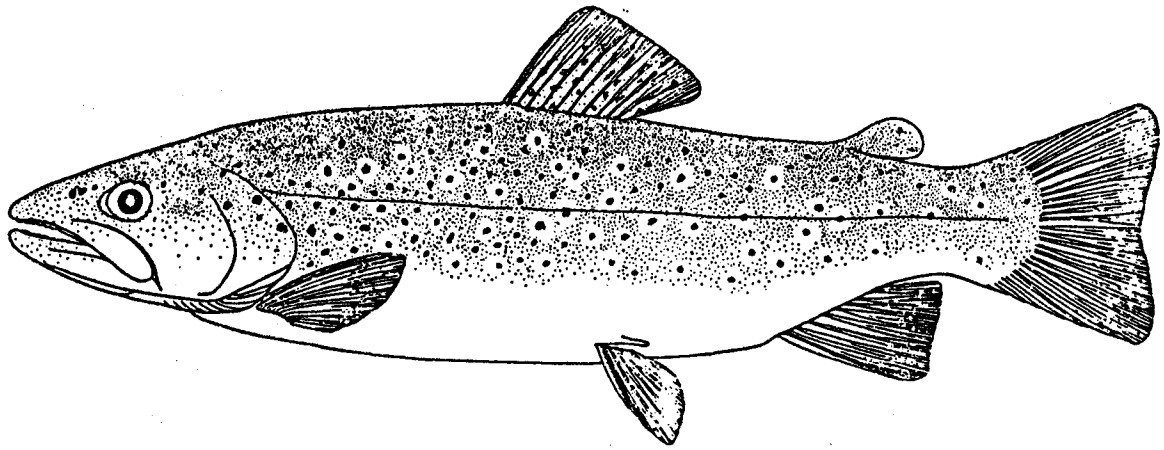

Figure 1. Brown trout drawing displayed to anglers for size-preference ratings. Actual lengths of the drawing were 203, 305, 356, and 406 mm. Each angler rated one length using the 5-point scale developed by Weithman and Anderson (1978).

streams (Minnesota DNR, Lake City Area Fisheries files). Only one drawing was displayed to an angler. Standard t-tests compared mean ratings for each size drawing with mean ratings for comparable-sized (lengths within 26 mm of drawing) harvested brown trout to determine if anglers were able to relate the drawings to actual fish.

Both ratings for drawings and for harvested fish were used for size-preference analysis. Additional ratings for harvested brown trout, from previous (1981-1988) angler surveys on five other trout streams in southeast Minnesota (Minnesota DNR, Lake City Area Fisheries files) were included in the analysis. Preference for the size of a trout (or a trout in a drawing) was coded as a dichotomous variable (1=preferred, 0=non-preferred) where trout that received above average ratings (1 or 2 on the 5-point scale) were assumed to be of a preferred size. Maximum likelihood logistic regression was used to describe the proportion of anglers who would give a preferred rating to brown trout at any given size (Reckhow et al. 1987; Wilkinson 1987; Die et al. 1988). The length at which 50% of anglers in a group were predicted to give a preferred rating was used as an index for the group's size preference. Visual comparisons of plots of regression lines were used to identify trends in brown trout size preferences.

RESULTS

Composition of Interviews

A total of 382 anglers were interviewed on the eight

stream sections during six weekends in April and May 1989. Of those anglers, 86% were interviewed while fishing the standard-regulation sections and 14% were fishing the special regulation sections (Table 2). Nearly half (49%) of anglers interviewed used bait (i.e. worms, insect larva), 25% used flies, 8% used lures, and 17% used a combination of tackle. Only 20% of anglers interviewed were members of an organized angling group.

Relations of Fishing Success and Trip Enjoyment to CQ , TQ, and Catch Rate

Most anglers rated their trip enjoyment higher than their fishing success (Table 3). Of the anglers that had fished for at least one hour before being interviewed, 76% rated enjoyment of their trips as either good or excellent yet only 37% rated fishing success good or excellent. Anglers who felt their fishing success was either good or excellent experienced mean catch rates above 2.0 fish/h, mean TQ values above 2.0, and caught fish with CQ values averaging about 1.0 or higher. In contrast, anglers felt their trip enjoyment was good or excellent despite mean catch rates below 2.0 and CQ values for fish caught averaging 1.0 or less.

Catch rates, CQ, and TQ for individual anglers were reflected in their ratings of fishing success (Tables 3 and 4). Mean catch rate, CQ, and TQ declined ($P < 0.05$ with Bonferroni control) as ratings of fishing success went from excellent to poor. Ratings of fishing success were

Table 2. Distribution of interviews among angler groups.

Group category	Angler group	Number of interviews	Percent of interviews
Angling regulations	Standard	328	86
	Special (no-kill)	36	9
	Special (no-kill >280mm)	18	5
Terminal tackle	Bait	189	49
	Flies	96	25
	Lures	31	8
	Mixture (of above)	65	17
	Unknown	1	<1
Organized angling group	Member	75	20
	Non-member	307	80
Years fishing for trout	0	23	6
	1-5	132	35
	6-10	87	23
	11-20	70	18
	>20	68	18
Dollars spent for trip	0-10	204	53
	11-25	94	25
	26-50	50	13
	>50	34	9
Hours driven to stream	<0.5	60	16
	0.5-1.0	137	36
	1.1-3.0	176	46
	>3.0	9	2

Table 3. Number of anglers (N) and mean catch rate (fish/h), Catch Quality (CQ), and Trip Quality (TQ) for each rating of fishing success and of trip enjoyment. Letters indicate significant ($P < 0.05$ with Bonferroni control) differences among success or enjoyment ratings (i.e. means without a similar letter are different).

Rating	N	(%N)	Catch rate	CQ	TQ
Fishing success					
Excellent	36	(12)	2.7a	1.2a	5.2a
Good	72	(25)	2.6a	0.9a	2.9ab
Average	74	(26)	1.5b	0.7ab	1.8bc
Below average	47	(16)	1.2bc	0.4bc	1.0bc
Poor	61	(21)	0.2c	0.2c	0.2c
Trip enjoyment					
Excellent	106	(37)	1.9a	1.0a	3.3a
Good	113	(39)	1.8a	0.5b	1.5a
Average	48	(17)	1.0a	0.5b	0.8a
Below average	12	(4)	0.9a	0.5b	1.3a
Poor	10	(3)	0.6a	0.1b	0.6a

significantly correlated (Pearson, $P < 0.05$) with SCQ on all eight stream sections, with catch rate on seven stream sections, and with TQ on six stream sections.

Neither CQ or TQ improved predictions of fishing success made with catch rates alone. Regressions of individual anglers' ratings of fishing success with catch

Table 4. Correlation coefficients of log-transformed catch rate (CR), Trip Quality (TQ) and summed Catch Quality (SCQ) with angler ratings for fishing success and for trip enjoyment. Ratings were on a 5-point scale where 1=excellent and 5=poor, thus producing negative correlations. All values are significant at ($P < 0.05$); ns indicates no significant correlation.

Stream section	Fishing success			Trip enjoyment		
	CR	SCQ	TQ	CR	SCQ	TQ
Garvin Brook	ns	-0.48	ns	ns	-0.45	ns
Main Branch Whitewater	-0.66	-0.66	-0.56	-0.28	-0.34	-0.32
Rupprecht	-0.61	-0.65	-0.55	ns	-0.43	-0.41
South Branch Root River:						
Special reg.	-0.55	-0.49	-0.45	ns	ns	ns
Standard reg.	-0.41	-0.42	-0.39	-0.37	ns	ns
Trout Run Creek:						
Special reg.	-0.69	-0.59	ns	ns	ns	ns
Standard reg.	-0.66	-0.65	-0.65	-0.35	-0.36	-0.39
West Indian	-0.55	-0.38	-0.47	ns	ns	ns
Sections combined	-0.55	-0.56	-0.52	-0.24	-0.25	-0.25

rate, SCQ, and TQ explained similar amounts of variation (r^2=0.29, 0.33, and 0.27, respectively; Figure 2). Catch rate actually explained more of the variation in mean ratings of fishing success for individual stream sections (r^2=0.45) than either TQ (r^2=0.33) or SCQ (r^2=0.13; Figure 3).

Anglers' ratings for trip enjoyment were only slightly

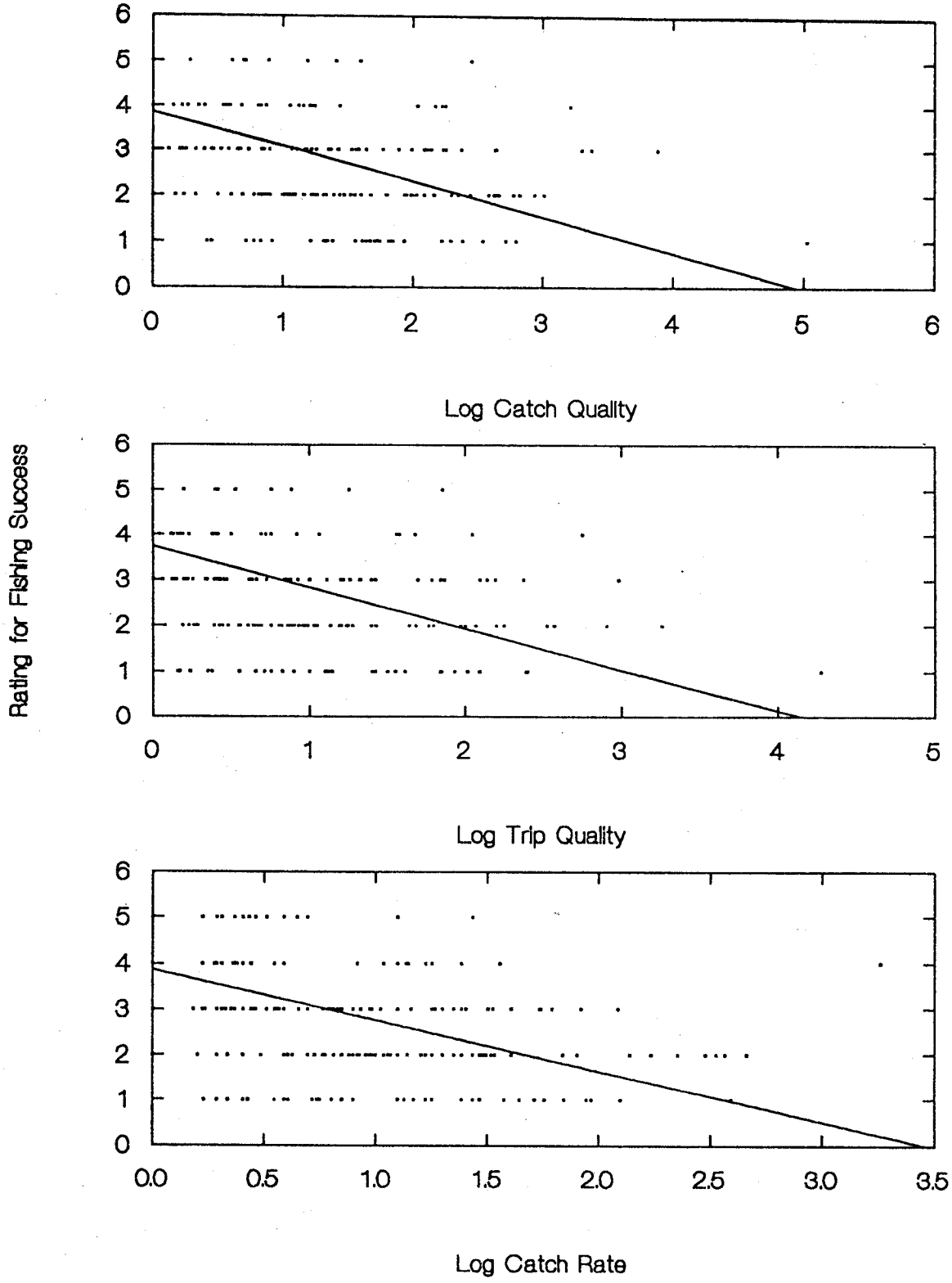

Figure 2. Relationships of angler ratings for fishing success with log-transformed values of Catch Quality (summed for each angler; $r^2 = 0.33$), Trip Quality ($r^2 = 0.27$) and catch rate (fish/h; $r^2 = 0.29$).

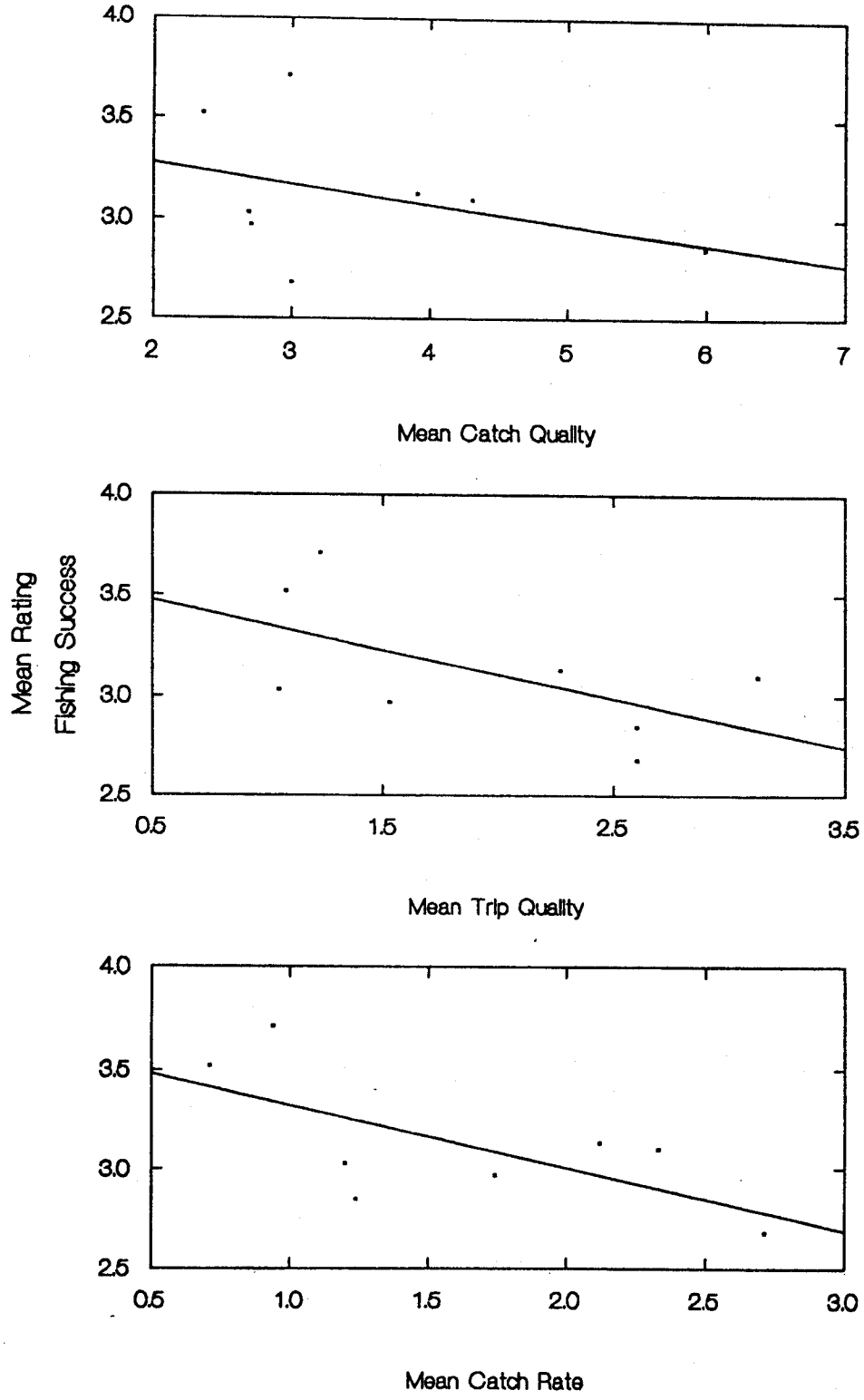

Figure 3. Relationships of mean angler ratings for fishing success with mean values of Catch Quality (summed for each angler; $r^2 = 0.13$), Trip Quality ($r^2 = 0.33$), and catch rate ($r^2 = 0.45$) for the eight stream sections surveyed.

related to any of the catch descriptors. Mean catch rate and TQ declined as ratings for trip enjoyment fell from excellent to poor but changes were not statistically significant. Mean CQ was higher ($P < 0.05$ with Bonferroni control) for anglers rating trip enjoyment excellent than for anglers that indicated less trip enjoyment (Table 3). Ratings for trip enjoyment were either poorly correlated ($r < 0.50$) to catch rate, CQ, or TQ among individual stream sections (Table 4).

Angler Expectations

Anglers' expectations of size and rate at which brown trout are caught differed somewhat from survey estimates. Among stream sections, angler estimates of average size brown trout caught were consistently higher (mean=32 mm) than survey data on actual sizes caught (Table 5). Most anglers on each stream section felt catch rates were about the same or a little higher than those in other streams in the area while survey estimates showed catch rates varied (0.6-3.0 fish/h; Table 6). Mean angler estimates for average size brown trout caught and mean ratings for how catch rates compared with other streams were not significantly ($P > 0.05$, Bonferroni control) influenced by terminal tackle, angling group membership, or trout-angling experience (Table 7).

Responses to Individual Fishing Quality Questions

Fishing quality variables were rated in a similar order by most angler groups, with catch and release most

Table 5. Mean angler estimates and survey estimates of average length (mm) brown trout caught, and differences (D) in estimates, for surveyed stream sections. Survey estimates were calculated with measurements of harvested fish and angler estimates of released fish.

Stream	Angler estimate	Survey estimate	D
Garvin Brook	277	213	64
Rupprecht Creek	229	222	7
West Indian Creek	251	222	29
Main Branch Whitewater River	272	245	27
Trout Run Creek			
-Special regulation	254	218	36
-Standard regulation	244	216	28
South Branch Root River			
-Special regulation	267	234	33
-Standard regulation	245	213	32
Overall mean	255	223	32

important, size and number of fish caught of intermediate importance, and kind and diversity of fish caught least important (Table 8). Each fishing quality variable was rated differently ($P < 0.05$ with Bonferroni control) by anglers on standard-regulation stream sections and by anglers not belonging to an organized angling group.

Angling preferences were not as evident for other angler groups. Anglers in their first season fishing for trout placed similar importance on catch and release, size,

Table 6. Mean angler ratings for how catch rates compared with other other trout streams in southeast Minnesota and mean catch rates (fish/h) for surveyed stream sections. Ratings were on the scale: much higher=1, higher=2, about the same=3, lower=4, and much lower=5.

Stream	Angler rating	Catch rate
Garvin Brook	2.5	3.0
Rupprecht	3.0	0.6
West Indian	3.0	1.5
Main Branch Whitewater River	2.6	1.4
Trout Run Creek		
-Special regulation	2.6	2.4
-Standard regulation	2.4	2.2
South Branch Root River		
-Special regulation	2.6	1.0
-Standard regulation	2.8	1.2
Overall mean	2.7	1.7

number, and kind of fish caught. Size, number, kind, and diversity of fish caught were of similar importance to anglers on special-regulation stream sections, members of organized angling groups, and fly anglers.

The degree of importance of individual quality variables differed among angler groups. Catch and release was more important to anglers on special-regulation stream sections than on standard-regulation stream sections ($t=3.17$, $P=0.002$), to members of organized angling groups

Table 7. Mean angler estimates (by angler group) for average length (mm) brown trout (BNT) caught and mean ratings for how catch rates compared with other streams in the area.

Angler group	Estimated average length BNT caught	Ratings of catch rate
Terminal tackle:		
Bait	251	2.7
Flies	254	2.7
Lures	234	2.6
Combination	264	2.7
Organized angling group:		
Members	262	2.6
Non-members	251	2.7
Trout-angling experience (yrs):		
1-5	244	2.6
6-10	257	3.0
11-20	259	2.5
>20	267	2.7
Regulations:		
Special	262	2.6
Standard	251	2.7

than non-members ($t=5.61$, $P < 0.001$), and to anglers that used flies, lures, or a combination of tackle than anglers that used bait ($P < 0.05$ with Bonferroni control). Size of fish caught was rated more important ($P < 0.05$ with Bonferroni control) than number of fish caught by anglers on standard-regulation stream sections, anglers not belonging to an organized angling group, and anglers that used bait.

Table 8. Mean ratings by angler groups for the importance of catch and release (CR), size, number, kind, and species diversity (SD) of fish caught. Ratings were on a 1 to 5 scale where 1=highest importance and 5=no importance. Underlining denotes means of variables that were rated similarly ($P < 0.05$ with Bonferroni control). Letters indicate significant differences ($P < 0.05$, t-test or Tukey-Kramer multiple comparison) in how a variable was rated among angler groups (in a group category).

Group category	Angler group	Importance of: CR	Size	Number	Kind	SD
Angling regulations	Special	1.7a	2.8	2.7	3.4	3.8
	Standard	2.2b	2.6	3.0	3.3	3.6
Organized angling group	Member	1.5a	2.8	2.7	3.1	3.5
	Non-member	2.3b	2.6	3.0	3.4	3.7
Terminal tackle	Bait	2.5b	2.6ab	3.1	3.4	3.6
	Flies	1.6a	2.8b	2.8	3.5	3.9
	Lures	2.0a	2.2a	2.9	3.0	3.8
	Combinations	1.9a	2.6ab	2.9	3.1	3.4
Years trout angling experience	0	2.6	2.6	2.8	3.2	3.7
	1-5	2.3	2.7	2.9	3.4	3.6
	6-10	2.0	2.5	3.0	3.3	3.4
	11-20	2.0	2.6	3.0	3.5	3.8
	>20	2.1	2.6	3.0	3.2	3.9

Size Preferences for Brown Trout

Brown trout drawings and similar-sized harvested brown trout were rated similarly (Table 9). Both showed anglers preferred larger brown trout (longer than about 275 mm) over smaller ones.

Size preferences for brown trout varied among anglers grouped by stream, terminal tackle, and trout-angling experience. Estimated lengths of brown trout preferred by 50% of anglers (50% preference) ranged from 225 mm to 335 mm among five streams surveyed between 1981 and 1988 (Table 10). One of five streams tested (Middle Branch Whitewater River), had a noticeably lower proportion of anglers give a preferred rating for brown trout at lengths greater than about 200 mm (Figure 4). Among tackle groups, lengths preferred by 50% of anglers ranged from 238 mm for fly anglers to 273 mm for anglers using a combination of tackle (Table 11). Brown trout between about 250 mm and 450 mm long were preferred by greater proportions of fly anglers than anglers using other tackle (Figure 5). Anglers using lures were less discriminating on the basis of fish size than anglers using flies, bait, or a combination of tackle (Figure 5). Among levels of trout-angling experience, anglers with more than 20 years experience were less sensitive to small differences in fish size and were much less likely to give a preferred rating to fish longer than 275 mm than less experienced anglers (Figure 6). Size preferences were similar between members of an organized

Table 9. Mean ratings for brown trout drawings and for comparable length-groups of harvested brown trout (groups within 26 mm of each size drawing). Ratings were on a 1 to 5 scale where a 1=highest importance or catch enjoyment and 5=no importance or catch enjoyment. Letters indicate significant differences ($P < 0.05$ with Bonferroni control) among sizes of drawings and among length groups.

Drawings		Harvested fish	
Trout length (mm)	Mean rating	Length group (mm)	Mean rating
203	3.2c	178-227	3.1b
254	2.5b	228-278	2.7b
305	2.0a	279-329	2.2a
356	1.8a	330-380	1.7a
406	1.6a	381-432	1.0[1]

[1] Insufficient sample size to test difference.

Table 10. Estimated lengths (mm) for brown trout at which 50% of anglers would give a preferred rating (1 or 2 from a 5-point scale where 1=highest catch enjoyment and 5=no catch enjoyment) on five trout streams in southeast Minnesota (data from Lake City Area Fisheries files).

Stream	Years surveyed	Length 50% prefer
Beaver Creek (Winona Co.)	1981-83	225
East Beaver Creek (Houston Co.)	1984-88	235
Hay Creek (Goodhue Co.)	1983-87	250
Middle Branch Whitewater River (Winona Co.)	1981-82, 1988	335
South Branch Whitewater River (Winona Co.)	1981-87	255

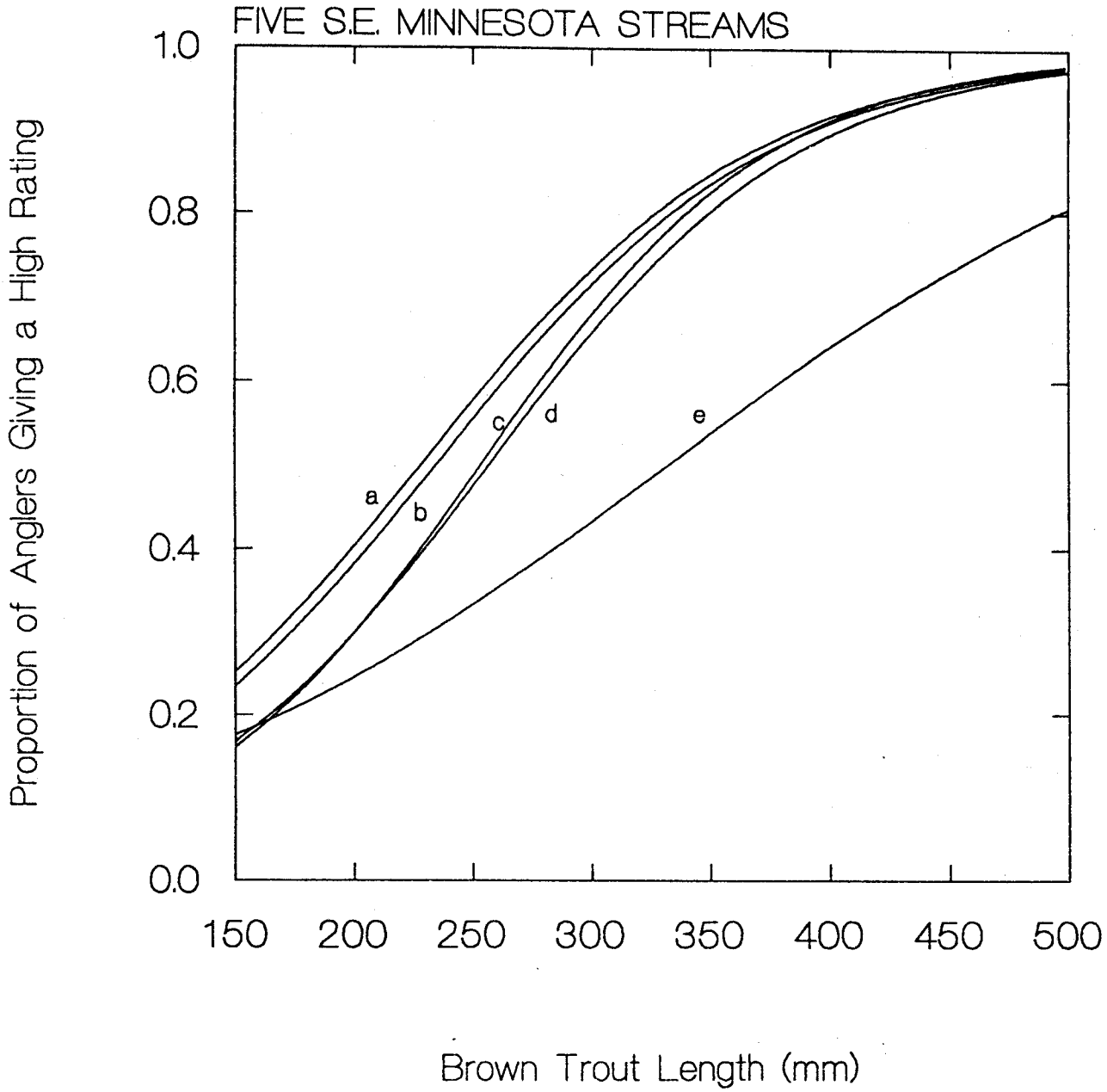

Figure 4. Proportion of anglers giving a high rating to brown trout as a function of fish length for five trout streams in southeast Minnesota: Beaver Creek, Winona Co. (a), East Beaver Creek, Houston Co. (b), Hay Creek, Goodhue Co. (c), South Branch Whitewater River, Winona Co. (d), and Middle Branch Whitewater River, Winona Co. (e). Curves were determined from logistic models of angler ratings for known-length brown trout.

Table 11. Estimated lengths (mm) for brown trout at which 50% of anglers in a group would give a preferred rating (50% preference). Estimates for angler groups identified by tackle and organized angling group status were computed with data from five streams surveyed between 1981 and 1988 (Lake City Area Fisheries files) and data from the eight stream sections surveyed in 1989. Estimates for angler groups identified by trout-angling experience were computed with 1989 data only.

Angler group	50% preference
Terminal tackle	
Bait	264
Fly	238
Lure	250
Combination	273
Organized angling group	
Member	267
Non-member	260
Years trout-angling experience	
1-5	260
6-10	289
11-20	238
>20	>500

angling group and non-members (Figure 7).

Despite differences in preferred sizes, for most angler groups, the proportion of anglers that gave a preferred rating for a brown trout increased most rapidly between 250 mm and 350 mm (Figures 4-7). Nearly all anglers with 20 years or less trout-angling experience gave a preferred rating for brown trout longer than about 350 mm (Figure 6).

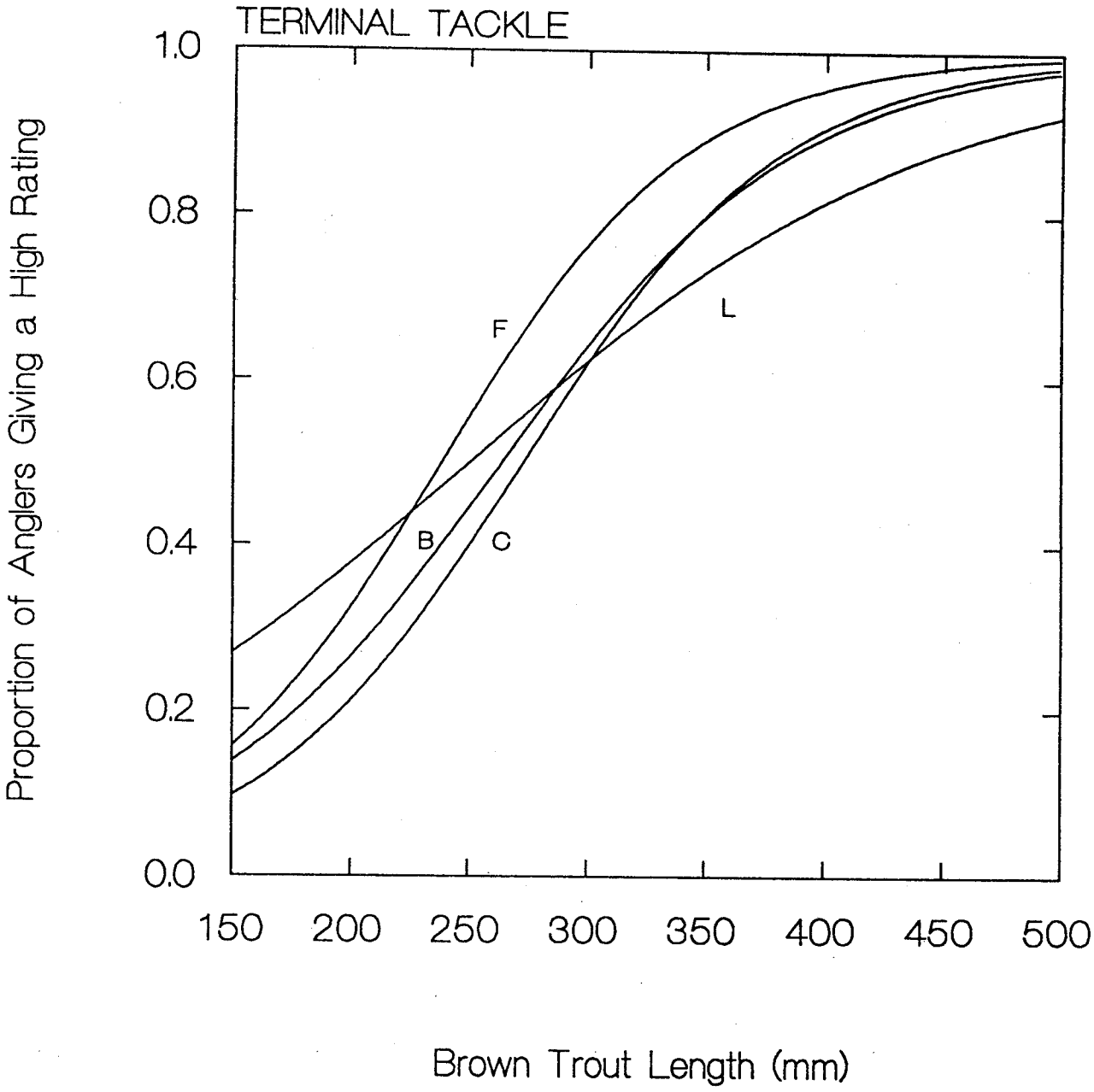

Figure 5. Proportion of anglers giving a high rating to brown trout of various lengths, as influenced by terminal tackle: flies (F), natural bait (B), artificial lures (L), and combinations of tackle (C).

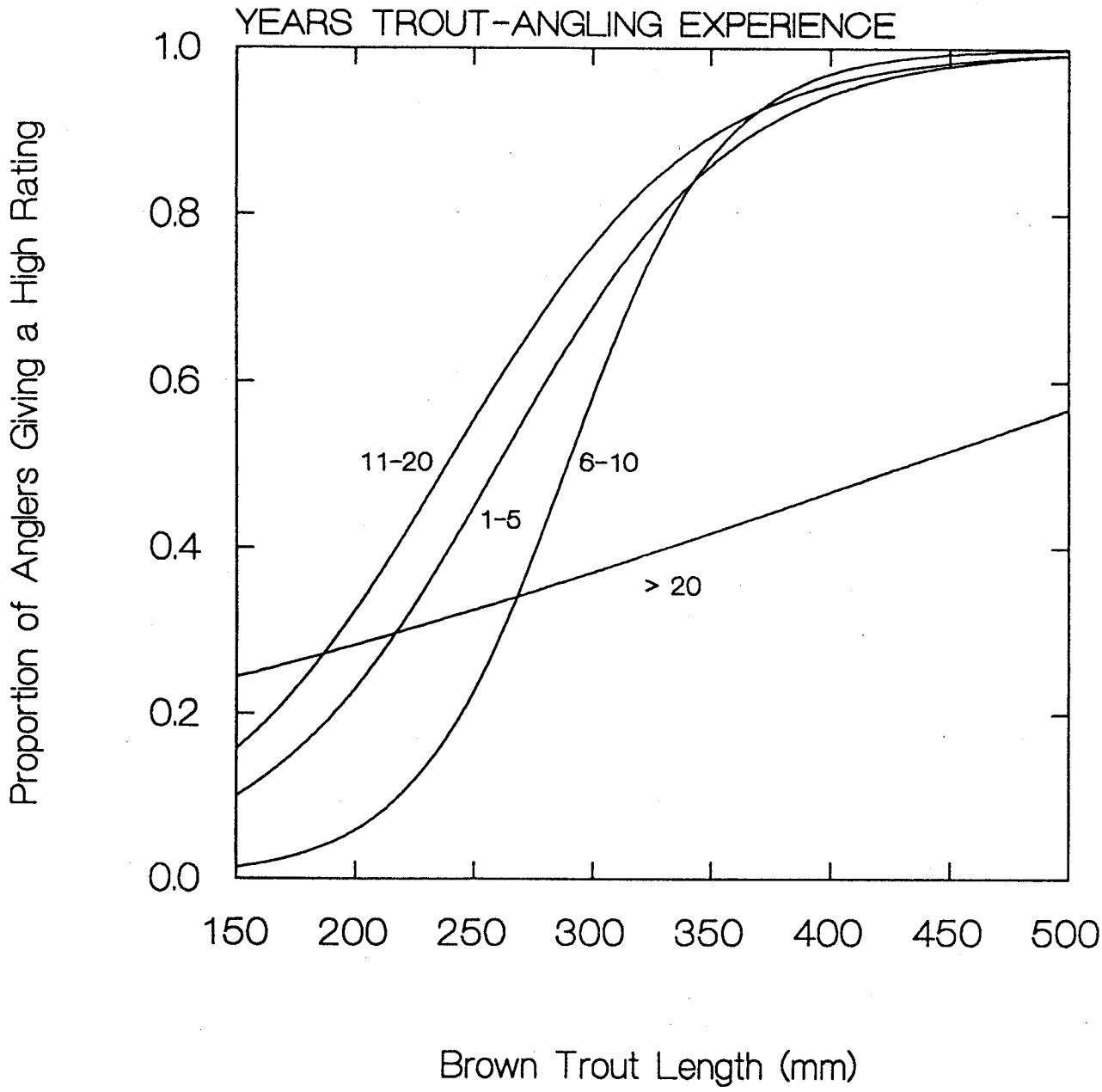

Figure 6. Proportion of anglers giving a high rating to brown trout of various lengths, as influenced by years of trout-fishing experience.

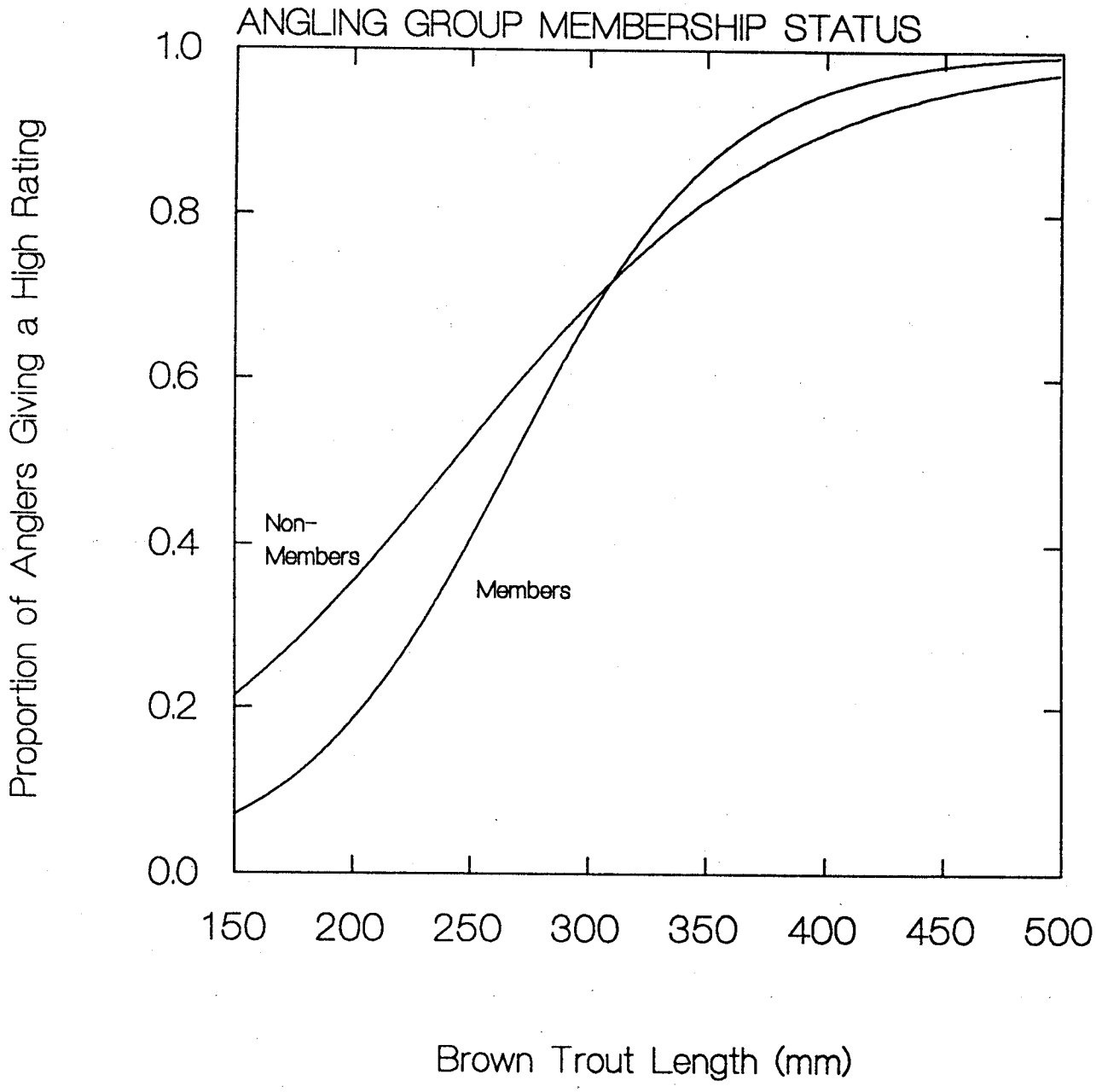

Figure 7. Proportion of anglers giving a high rating to brown trout of various lengths, for members and for non-members of an organized angling group.

DISCUSSION

CQ and TQ did not improve measures of fishing success or trip enjoyment and their value as indices of fishing quality on southeast Minnesota trout streams is questionable. However, angler ratings for quality-related variables (e.g., importance of size of fish caught) added insight into angler preferences that would not have been available with conventional angler-survey data alone.

Previous studies concerning angling motivations and satisfactions also found poor relationships between trip enjoyment and angler catch. Anglers were satisfied with their angling trip despite poor fishing success, indicating that anglers desire much more from their fishing experiences than just catching fish (Weithman and Katti 1979; Hudgins and Davies 1984; Spencer 1989). Variables found most important in determining quality in an angling experience have included: water quality, natural beauty, and privacy (Moeller and Engelken 1972; Jackson 1988); attitude of the fisheries manager and companionship (Hampton and Lackey 1976); enjoyment of the outdoors and fishing as a sport (Manfredo and Anderson 1989); nearness to public facilities and ease of access (Fenske 1983); and the opportunity to relax and get away from people (Wiley et al. 1989).

Weithman and Anderson (1978) purposely did not include aesthetic and social factors in their fishing quality indices because such variables were not considered easily managed. Fisheries managers must remember that these

indices were not designed to measure total benefits or satisfactions derived from angling and should not use the indices for that purpose. Measures of total angling benefits will become more important as demands on aquatic resources by various user groups continue to grow. Professionals trained in the fields of sociology, psychology, and recreation should be consulted to help design techniques to measure these benefits.

Weithman and Anderson's indices were designed to measure quality of fish caught and it is not evident why ratings for fishing success and CQ and TQ were not more closely related. Formulas for the indices may need adjusting for regional characteristics of a fishery. For example, Weithman and Anderson's methods place a standardized value on each fish caught (Fish Quality or FQ) based on its length as a percentage of the world record length for the species. This standardized value is influenced most when lengths vary between 40 and 60% of the world record (see Weithman and Anderson 1978, Figure 1). In southeast Minnesota, most brown trout caught by anglers fall into a relatively small size range (200-300 mm) which is only about 20 to 30% of the world record length for brown trout (1016 mm). As a result, FQ values for most trout caught are weighted similarly with respect to length even though results of this study showed different lengths were important to anglers. Use of a regional record length should improve FQ and other indices (CQ and TQ) calculated

with FQ.

Angler expectations also may have influenced ratings of fishing success. Success results when actual experience exceeds expectations (Hampton and Lackey 1976; Hudgins and Davies 1984; Jackson 1988; Spencer 1989) and anglers have been shown to adjust expectations of fishing success for the river system fished (Hudgins and Davies 1984). In this study, I used two questions to measure expectations: 1) angler estimates of average length brown trout caught and 2) angler ratings for how catch rates compared to other streams on the area. I found anglers consistently over-estimated sizes of brown trout caught and rated catch rates average or a little above average regardless of the stream or stream section fished. In other words, angler expectations did not match angling results and it is likely that this influenced anglers' perceptions of fishing success. Weithman and Anderson's fishing quality indices could be improved by accounting for expectations of individual anglers.

Other problems were observed during this study which could have influenced results. First, the use of ratings for individual harvested fish for calculations of CQ (modification by Nelson 1983) often resulted in higher CQ's for smaller released fish than for larger harvested fish. This was inconsistent with angler ratings of the importance of individual fish where larger fish were more important than smaller fish (Table 9). Hirsch (1989) recommended use

of species ratings for all fish caught (kept or released) to avoid this problem. Second, growing popularity of catch and release angling may have caused anglers to give a high rating to catch and release (regardless of actual importance to them) because it was the socially "correct" response to give. Artificially high ratings for catch and release produces inflated CQ's for released fish. It may be better to rephrase Weithman and Anderson's (1978) original catch and release question from "How important (desirable) is catching and releasing fish?" to "How important (desirable) is releasing fish you catch?." This wording removes the phrase "catch and release" and directs anglers to rate their own feelings about releasing fish rather than rating the concept of catch and release in general. Finally, anglers that were interviewed together often gave the same responses to the fishing quality questions. To avoid one angler having an effect on responses of another, only one angler in a group should answer fishing quality questions or anglers should be separated during interviews.

The accuracy of the fishing quality indices may be improved by: 1) refinements in the wording of fishing quality questions, 2) use of species ratings to calculate CQ for all fish caught (as originally proposed by Weithman and Anderson 1978), 3) use of regional record lengths to calculate FQ, and 4) accounting for expectations of individual anglers. However, until complex quality indices are developed and tested, having anglers simply rate their

fishing success is the most direct and unambiguous method available to evaluate fishing quality.

Management efforts to improve fishing quality can be directed by analysis of angler ratings for individual quality-related questions. Despite problems with the quality indices, this study and Hirsch (1989) found analysis of responses to Weithman and Anderson's subjective questions informative on angler preferences. In this study, catch and release was more important than species, size, number, or diversity of fish caught. Even bait anglers, who are generally considered to be harvest-oriented, rated catch and release most important. It is important to note, however, that concepts of catch and release likely differ among anglers. To some anglers catch and release may be returning all fish caught while other anglers may perceive it as returning only "small" fish and keeping "large" fish (or vice versa). Nevertheless, trout anglers in southeast Minnesota feel that catch and release in some form is highly important. Because decreases in harvest will not always improve angling quality (Thorn 1990), managers should consider increasing efforts to educate anglers about appropriate uses of catch and release to minimize any misconceptions concerning its application.

Most anglers also felt size of fish caught was more important than number of fish caught and that diversity of species caught was relatively unimportant. This suggests that when trout abundance is adequate, management should

focus on increasing the size of fish available for anglers rather than maximizing abundance or biomass or providing a variety of game species.

Trout drawings proved to be useful for obtaining data on size preferences for brown trout. The drawings were easy to use, obtained data from anglers who had not caught or kept fish, and many anglers even seemed to enjoy rating them. Most importantly, the drawings received ratings that were comparable to those given real fish. These findings support the use of drawings for size-preference analysis and suggest that ratings for harvested fish were not significantly affected by characteristics of the fish other than size (e.g., fighting ability, exceptional color or markings).

Logistic models of brown trout ratings showed size preferences varied among angler groups, but in general, angler preference increased at the greatest rate as length of brown trout increased from 250 mm to 350 mm. Management techniques designed to increase abundance of brown trout near 350 mm long should result in the greatest increases in angler satisfaction.

LITERATURE CITED

Die, D.J., V.R. Restrepo, and J.M. Hoenig. 1988. Utility-per-recruit modeling: a neglected concept. Transactions of the American Fisheries Society 117:274-281.

Fenske, J.L. 1983. Attitudes and attributes of anglers who fish for trout in Michigan. Michigan Department of Natural Resources, Fisheries Division, Research Report No. 1916, Ann Arbor, Michigan, USA.

Hampton, E.L., and R.T. Lackey. 1976. Analysis of angler preferences and fisheries management objectives with implications for management. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners. 29:310-316.

Hirsch, S. 1989. Fishing quality indices for three southeast Minnesota trout streams. Minnesota Department of Natural Resources, Section of Fisheries, Management Report No. 30, St. Paul, Minnesota, USA.

Hudgins, M.D., and W.D. Davies. 1984. Probability angling: a recreational fishery management strategy. North American Journal of Fisheries Management. 4:431-439.

Jackson, R.M. 1988. Human dimensions of trout angling. Pages 9-15 in P.J. Wingate editor, Proceedings of Trout and the Trout Angler in the Upper Midwest Workshop. Minnesota Department of Natural Resources, Section of Fisheries, Special Publ. 143, St. Paul, Minnesota, USA.

Manfredo, M.J., and D.H. Anderson. 1981. Recreation preferences of Oregon trout fishermen. Pages 64-68 in Forest and River Recreation: Research Update, USDA Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota, USA.

Moeller, G.H., and J.H. Engelken. 1972. What fishermen look for in an angling experience. Journal of Wildlife Management 36:1253-1257.

Nelson, K.K. 1983. A qualitative and quantitative roving creel census with a modification of the Weithman-Anderson methodology. Minnesota Department of Natural Resources, Section of Fisheries, Management Report No. 25, St. Paul, Minnesota, USA.

Reckhow, K.H., R.W. Black, T.B. Stockton, Jr., J.D. Vogt, and J.G. Wood. 1987. Empirical models of fish response to lake acidification. Canadian Journal of Fisheries and Aquatic Sciences 44:1432-1442.

Snedacor, G.W. and W.G. Cochran. 1967. Statistical methods, sixth edition. Iowa State University Press, Ames.

Spencer, P.D. 1989. Angler expectations as a factor in the perception of quality of the fishing experience. Master's thesis. University of Minnesota, St. Paul, Minnesota, USA.

Thorn, W.C. 1990. Evaluation of special regulations for trout in southeast Minnesota streams. Minnesota Department of Natural Resources, Section of Fisheries, Investigational Report No. 401: 64 pp.

Weithman, S.A., and R.O. Anderson. 1978. A method for evaluating fishing quality. Fisheries 4(3):6-10.

Weithman, S.A., and S.K. Katti. 1979. Testing of fishing quality indices. Transactions of the American Fisheries Society 108:320-325.

Wiley, R.W., D. Anderson, and C. Phillips. 1989. Executive summary of a statewide survey of angler preferences and fishing patterns. Wyoming Game and Fish Department, Laramie, Wyoming, USA.

Wilkinson, L. 1987. SYSTAT: The system for statistics. SYSTAT,Inc., Evanston, Illinois, USA.