FISHERMAN EXPENDURES AND CAPITALIZED VALUES OF AN OKLAHOMA SMALLMOUTH BASS STREAM BISECTED BY AN IMPOUNDMENT[1]

by

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ABSTRACT

A stratified, random survey was conducted from 1 August 1970 through 31 July 1971 at the 15 public access points on the unimpounded riverine flowing portions of the Mountain Fork River in McCurtain County, Oklahoma. The purpose of the study was to compare fisherman expenditures and capitalized resource values in the portions of the river above and below Broken Bow Reservoir, a flood control and hydroelectric impoundment. Of the estimated 16,485 fishermen who spent $156,864, 8,403 fishermen above the reservoir spent 76,757 and 8,082 fishermen below the resevoir spent $80,107. The difference was not statistically significant. Estimated expenditures at the various access sites ranged from $238 to $49,322. Mean expenditure per man-day was $9.52 for the entire river and ranged from $3.60 to $24.84 at different sites. The average expenditures per man-day were higher than those allowed by authorizing legislation for use in resource-loss mitigation planning, and also higher than values observed for most other rivers. Capitalized value of the remaining riverine lotic portions of the Mountain Fork River was nearly $6 million ($2.9 million above and $3.1 million below Broken Bow Reservoir). The value of the portion of the river inundated by the reservoir was estimated to be $4.2 million, based on a mean value of $2,743 per km for sites located in habitat similar to that flooded by the reservoir.

INTRODUCTION

Traditionally, warm-water streams have provided the most accessible source for sport fishing in the United States (Funk 1970). In 1960, they accounted for 16% of all fishing effort and fish harvest in inland waters of the United States (Outdoor Recreation Resources Review Commission 1962). Due to increasing demands for use of streams for energy production, agricultural and domestic purposes, and flood control, many have been impounded and others are under consideration for impoundment. The value of recreational use of warm-water stream fisheries must be known for evaluation of alternative uses of streams when reservoirs and other water development projects are planned (Funk 1970). Too few post-impoundment analyses have been undertaken to reveal deficiencies in the evaluation process. The premise of the present investigation was that critical post-impoundment analyses of total fisherman expenditures, expenditures per man-day of fishing, and the capitalized value of the water would substantially improve future resource-loss mitigation planning. Thus, this study was deemed relevant to the important problem of adequately evaluating alternative uses of water resources.

The Mountain Fork River, which was categorized as having an outstanding smallmouth bass (Micropterus dolomieui) fishery by Finnell et al. (1956), was bisected by the construction of Broken Bow Dam which inundated 41.2 km of the original river. To protect the scenic and recreational value of the remaining river above the reservoir from impoundment, the Oklahoma legislature included this portion of the river in the Scenic Rivers Bill (Oklahoma House Bill 1152) to preserve this resource for the future. Therefore, the Mountain Fork River was selected for a post-impoundment analysis and comparison of total expenditures, expenditures per man-day, and capitalized values on the flowing portions of the river in McCurtain County, Oklahoma, above and below Broken Bow Reservoir.

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Before 15 May 1962, the U.S. Fish and Wildlife Service[3] valued a stream fishery on the basis of the "sportsmen expenditure" method (S. H. Wilkirson, personal communication). After 1962, values for recreational fishing were based on Senate Document Number 97, 87th Congress, "Policies, standards, and procedures in the formulation, evaluation, and review of plans for use and development of water and related land resources; Supplement Number 1 (4 June 1964), evaluation standards for primary outdoor recreation benefits" (hereafter referred to as SD 97-S1). Although the U.S. Army Corps of Engineers estimates of fishery values for the Broken Bow Dam and Reservoir project (U.S. Department of Army, Corps of Engineers 1967) were formulated in 1967 under the guidelines of SD 97-S1, the Fish and Wildlife Service estimates (U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife 1960) for the present project were based on the "sportsmen expenditure" method.

DESCRIPTION OF THE STUDY AREA

The Mountain Fork River, a tributary of the Little River (Fig. 1), has a basin of 3,134 km^2 and an average gradient of 1.7 m/km (Oklahoma Water Resources Board 1969).

The Mountain Fork River was 136.8 km long. The length of river included in this study extended from the Beachton entry point into Oklahoma to its confluence with the Little River (112.4 km), but 41.2 km was flooded when the 5,747-ha Broken Bow Reservoir was filled to the conservation pool level of 182.7 m above mean sea level (Fig. 2). Of the remaining 72.2 km of river that remained in McCurtain County, 39.0 km were above the reservoir and 33.2 km below it.

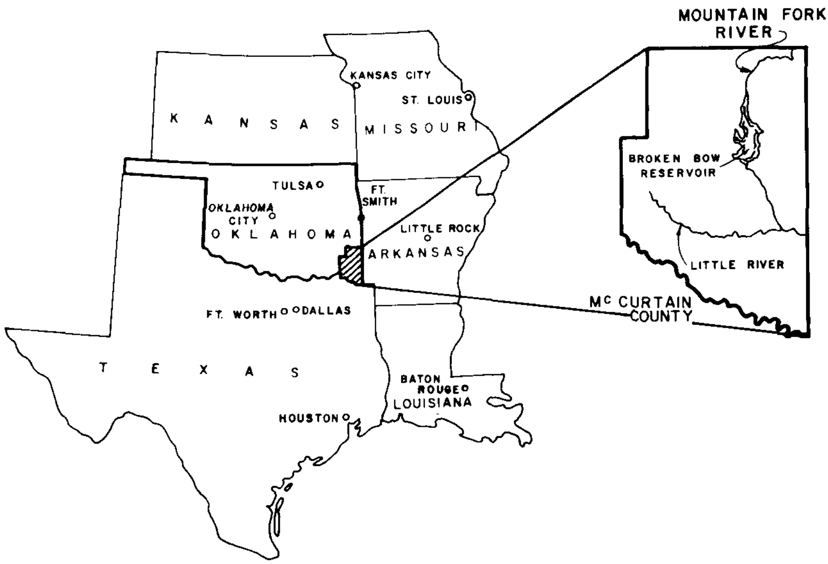

Figure 1. Location of the Mountain Fork River in relation to McCurtain County, Oklahoma, and adjacent states.

[3]The Bureau of Sport Fisheries and Wildlife became the U.S. Fish and Wildlife Service on 1 July 1974.

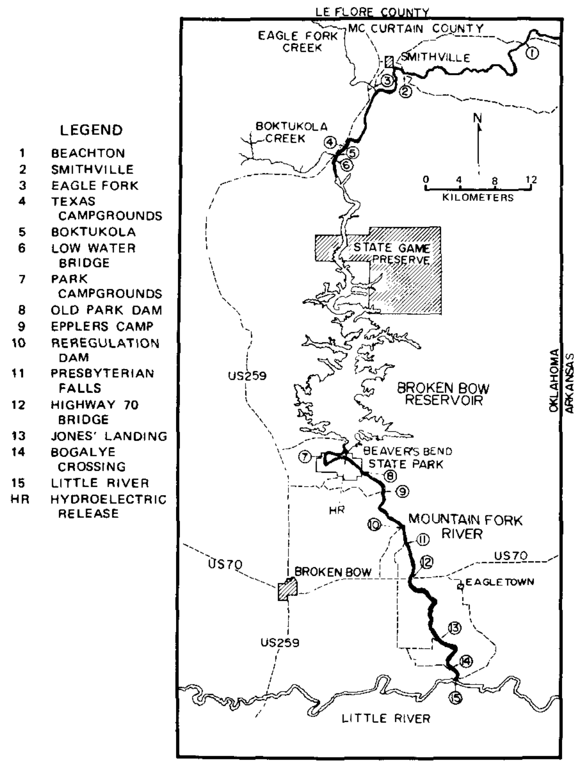

Figure 2. Locations of sampling stations in Mountain Fork River.

The upper portion of the Mountain Fork River is northeast of the major population center of McCurtain County (45.2 people/km^2). Smithville, Oklahoma, population 144 (U.S. Department of Commerce 1972), is the only town in the vicinity of the upper portion of the river. The town of Broken Bow, Oklahoma population 2,980 (U.S. Department of Commerce 1972), is 14.5 km west of the lower portion of the river (Fig. 2).

Due to the nature of the terrain, dense vegetation, lack of roads and extensive private land holdings immediately adjacent to the river, public access was limited to a few entry points. These sites were used as sampling stations. The six sample sites (1-6) above Broken Bow Reservoir and nine sites (7-15) below it included all major public access points to the river (Fig. 2). This limited access allowed the creel census clerk to contact all people entering or leaving a site during a sampling period. Public access to the river at points other than at the designated sample sites was considered insignificant.

METHODS

The basic measure of recreational use is the "man-day", which in the present study was defined as a day's fishing trip regardless of length of time spent; therefore, number of man-days equals number of fishermen. Sample collections were scheduled for each day from 1 August 1970 through 31 July 1971. Sampling effort was stratified into weekday mornings, weekday afternoons, weekend mornings, and weekend afternoons (holidays were treated as weedend days). The morning sampling period extended from

10 a.m. to 2 p.m. and the afternoon period included the 4 hours preceding darkness. Timing of morning and afternoon samples was based on the assumption that fishermen contacted during these hours would yield the maximum number of completed fishing trips (for estimation of certain fish harvest statistics in another part of the study).

Sampling effort for each site was based on random sampling within each of the four strata (weekday mornings, weekday afternoons, etc.) during a month. Total sampling effort allotted to a particular site was based on the percentage of the total fishermen interviewed during the previous month that were contacted at that particular site. This scheme was operated under the constraint that each site must be sampled at least once each month. Distribution of sampling effort during the first month (August 1970) was based on estimates of fisherman use obtained by conferring with a local fishing guide and from preliminary field observations. Total estimates were derived by expansion of the data by time strata. Strata estimates were summed for each site and total fisherman expenditures obtained by simple summation. Mean expenditures per man-day by month and for the year were obtained by dividing total expenditures by total man-days.

Because heterogeneity among the habitats above and below the reservoir, comparisons of harvest, species composition, fish weight, and fisherman expenditures between these two areas may conceal effects of impoundment on the fishery. The sites were grouped in various combinations for comparison of the several economic characteristics, as follows:

1) Sites 1-5 represented the unchanged river.

2) Site 6 was separated from the other upstream sites because of its proximity to Broken Bow Reservoir and the large portion of the annual fish harvest at this site, which was apparently influenced by the reservoir.

3) Sites 1-6 represented all of the high gradient (2.3 m/km) portion of the river above the reservoir, ignoring harvest implications.

4) Sites 7-15 represented all of the portion of the river below the reservoir ignoring habitat differences.

5) Site 7 was deleted from some comparisons because it was cut off from direct channel flows and had been physically altered by the Corps of Engineers with a series of low dams to form a series of what were essentially oxbow lakes. Water level in these lakes was maintained by flows from a low-flow sluice gate in Broken Bow Dam.

6) Sites 8-11 were located in high gradient habitat similar to that at sites 1-5 (+6), and formed the below the reservoir site grouping most directly comparable with the upstream site grouping(s).

7) Sites 12-14 were grouped because of their location in the low gradient (0.4 m/km) Gulf Coastal Plains habitat.

8) Site 15 was dropped from all calculations except those for capilized values because no fishermen were observed at this site during the study period.

The problem of assigning a dollar vlaue to a recreational resource has been a persistent and elusive problem because public outdoor recreation has, in most instances, developed as a non-market commodity and rarely are prices charged which reflect the value to the users (Clawson and Knetsch 1966). However, Clawson and Knetsch (1966:211-212) stated that, "under many circumstances consumers are able to evidence their preference for different uses of resources through market behavior. Even when a formal market does not exist, their choices, as backed up by their willingness to spend part of their income, may serve as a basis for estimating what results of a freely functioning market would have been."

Gordon et al. (1973) concluded that gross (total) expenditures are only indices of the value of a fishery resource and are useful only for trend analyses. Their gross expenditures were composed of two categories "transfer or variable expenditures" and "durable expenditures." Transfer expenditures were expenses for "transportation, food, lodging, etc., incurred while traveling to, using, and returning home from a fishery resource." Durable expenses included all clothing, equipment, and tackle that could be used over a period of years. Gordon et al. (1973) regarded estimates of net economic value by transfer expenditures as a good basis (although minimal, because durable expenses are not included) for estimating the economic benefits derived from a fishery resource.

In the present study, fishermen expenditures were estimated from only those expenses incurred on a particular fishing trip; e.g., lodging, meals, guide fees, live bait, travel costs to and from the fishing site, and certain items of tackle. Fishing tackle already owned by fishermen was not included because of the difficulty in determining whether the cost was a direct result of the individual's plans to fish the Mountain Fork River. During the interviews, the creel census clerk asked the fishermen to include only expenses for tackle and lures that they would not have purchased if they had not planned to fish this river.

In my analyses, durable expenses that were included in total cost estimates were limited to those items of tackle purchased specifically for use in the Mountain Fork River. Therefore, the total fisherman expenditrues estimated for the Mountain Fork River are considered to be approximately equal to the net economic value as defined by Gordon et al. (1973). Travel costs were estimated for each fisherman or party of fishermen on the basis of the round trip mileage, from the fisherman's home to the site of the interview, at the rate of $0.05 per mile (U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife 1970). These travel costs underestimated actual trip costs because (1) travel during the fisherman's stay at the river was not included, and (2) the mileage rate used greatly underestimated the actual costs of operating the vehicle.

The value of a renewable resource may be computed by assuming that the resource is invested capital and that total expenditures represent the interest on that capital. The relationship would thus be represented by the model: $V = N/i$, where V = the present (1970-71) capitalized value, N = the annual return (total expenditures) and i = the interest rate (Gordon et al. 1973). The interest rate chosen for capitalization of the Mountain Fork River fishery resource is the 2.625% rate used by the Corps of Engineers (U.S. Department of Army, Corps of Engineers 1967) for the 50-year repayment period for costs attributed to the Broken Bow project.

RESULTS

Total expenditures by the 16,485 fishermen on the Mountain Fork River were $156,864; 8,403 fishermen spent $76,757 above the reservoir and 8,082 fishermen spent $80,107 below the reservoir (Table 1). There was no significant difference (P 0.50, df = 12) between the expenditures above and below the reservoir (Table 2). Total expenditures by site ranged from a low of $238 (site 14) to a high of $49,332 (site 7).

Mean expenditures per man-day were $9.52 for the entire river and $9.13 at sites 1-6 and $9.91 at sites 7-14 (Table 3). Expenditures per man-day by site ranged from $3.60 at site 14 to $24.84 at site 8 (Table 1). When selected site groupings were compared, only the differences in total expenditures between sites 1-6 and sites 8-14 (difference = $45,973; P=0.0109, df=11) and sites 1-6 and sites 8-11 (difference = $51,240; P=0.0120, df=8) were significant (Table 2).

Table 1. Summary of expense computations and expenditures per man-day of fishing, by site, Mountain Fork River, 1 August 1970 to 31 July 1971. (Sites 1-6 were above Broken Bow Reservoir and sites 7-14 were below it).

Site	Total expenses	Number man-days	Amount per man-day
1	$ 2,957	189	$ 15.65
2	12,435	587	21.18
3	. 958	64	14.97
4	5,001	421	11.88
5	17,782	1,800	9.88
6	37,624	5,342	7.04
7	49,322	3,571	13.85
8	2,236	90	24.84
9	2,486	275	9.04
10	18,316	2,857	6.41
11	2,479	336	7.38
12	2,891	772	3.74
13	2,139	125	17.11
14	238	66	3.60
Total or mean	$156,864	16,485	$ 9.52

Table 1. Comparison of total fisherman expenditures between selected site groupings, Mountain Fork River, 1 August 1970 to 31 July 1971.

Sites	1 = Total expenditures	Sites	2 = Total expenditures	Difference	t	df	P=
1-6	$ 76,756.60	7-14	$ 80,105.40	$-3,348.80	-0.1540	12	0.8802
1-6	76,756.60	8-14	30,783.70	45,972.90	3,0566	11	0.0109
1-6	76,756.60	8-11	25,516.30	51,240.30	3.2332	8	0.0120
1-5	39,132.90	8-14	30,783.70	8,349.20	0.8890	10	0.3949
1-5	39,132.90	8-11	25,516.30	13,616.60	1.2801	7	0.2413
8-11	25,516.30	12-14	5,267.40	20,248.90	2.5076	5	0.0540

Model: t = (1 - 2) 1/VAR(1) + VAR(2) df = n1 + n2 - 2

Table 3. Expenditure per man-day (R) fishing and associated 95% confidence intervals (C.I.) for selected site groupings, Mountain Fork River, 1 August 1970 to 31 July 1971.

Sites	(n)	Amount / man-days=R	VAR(R)	95% C.I.
1-5	(5)	$ 12.78	6.945323	$4.56 - $20.10
1-6	(6)	9.13	3.045013	4.64 - 13.62
8-11	(4)	7.17	0.790369	4.34 - 10.00
12-14	(3)	5.74	6.220001	0.00 - 16.20
8-14	(7)	6.81	0.665028	4.81 - 8.81
7-14	(8)	9.91	5.652707	4.29 - 15.53
1-14	(14)	9.52	2.238692	6.29 - 12.75

Models: X = Man-days fishing, Y = Expenses

$$R = Y / X$$

$$VAR(R) = [\ Y^2 + R^2\ X^2 - 2(R)\ XY] / [(\ X)^2 (n-1) / n]$$

$$95\%\ C.I. = R - t\ .025\ VAR(R)$$

Expenditures per man-day for selected site groupings ranged from $5.47 (sites 12-14) to $12.78 (sites 1-5) (Table 3). Variances were large because of the large difference between the relatively low costs of local fishermen and the relatively high costs of nonlocal fishermen. Although differences in average expenditure per man-day ranged up to $5.97 (between sites 1-5 and sites 8-14), there were no significant differences at the = 0.05 level for any of the site groupings that were compared (Table 4). However, at the = 0.10 level the average difference in expenditure per man-day between site groupings 1-5 and sites 8-11 and between site groupings 1-5 and sites 12-14 were both statistically significant (Table 4).

The capitalized value of the remaining riverine portions of the Mountain Fork River was nearly $6 million and the back-calculated value of the original river before construction of Broken Bow Dam and Reservoir was about $10.2 million (Table 5).

Capitalized values for selected site groupings ranged from a low of $200,666 at sites 12-15 to a high of nearly $3.1 million at sites 7-15 (Table 5). Of the latter amount, nearly $1.9 million was attributed to site 7, the oxbow area which had been extensively developed by the Corps of Engineers for camping, picnicking, and swimming and was immediately adjacent to Beaver's Bend State Park.

DISCUSSION

According to SD 97-S1 (page 5), "The unit values per recreation day set forth herein are intended to measure the amount that users should be willing to pay, if such payment were required, to avail themselves of the project recreational resources."

Table 4. Comparison of expenditures per man-day of fishing between selected site groupings, Mountain Fork River, 1 August 1970 to 31 July 1971.

Sites	Cost per man-day	Sites	Cost per man-day	Difference per man-day	t	df	P=
1-6	$ 9.13	7-14	$ 9.91	$ 0.78	0.264	12	0.7963
1-6	9.13	8-14	6.81	2.32	1.204	11	0.2539
1-6	9.13	8-11	7.17	1.96	1.001	8	0.3461
1-5	12.78	8-11	7.17	5.61	2.017	7	0.0835
1-5	12.78	8-14	6.81	5.97	2.164	10	0.0557
8-11	7.17	12-14	5.47	1.70	0.642	5	0.5491

Table 5. Capitalized values for the Mountain Fork River, 1 August 1970 to 31 July 1971.

Site grouping	River distance (km)	Total expenditures	Value per km	Capitalized value per km	Total capitalized value
1-5	37.26	$ 39,133	$ 1,050	$ 40,010	$ 1,490,77
1-6	39.00	76.757	1,968	74,976	2,924,061
7-15	33.25	80,105	2,409	91,778	3,051,634
8-14	28.10	30.784	1,096	41,734	1,172,712
7-11	16.27	74,839	4,600	175,230	2,850,998
8-11	12.25	25,516	2,083	79,351	972,050
12-15	16.98	5,267	310	11,818	200,663
1-11	55.27	151,595	2,743	104,488	5,775,032
1-15	72.25	156,862	2,171	82,709	5,975,695
Ua	40.25	110,398b	2,743	104,488	4,205,627
1-15+U	112.50	267,250	2,376	90,506	10,181,322

aRepresents portion of the river inundated by Broken Bow Reservoir.

bBased on a value of $2,742.81/km from the value derived from sites 1-11, which represent a habitat similar to that which was inundated.

One problem in assigning a value for a man-day of fishing is in determining what the fisherman population would be willing to pay for use of the resource if payment were required. Moeller and Engelken (1973), when developing prediction curves to determine the amount fishermen would be willing to pay for permits in a pay-lake fishery, stated that one of the questions that the pay-lake operator must answer is: "What kind of fishing experience can I provide that is not readily available at no charge?" Because the accuracy of an estimated cost per man-day cannot be tested until the "free" option has been removed, the procedure required by SD 97-S1 is a cost analysis system which operates with premises that cannot be verified.

Although Gordon et al. (1973) concluded that gross expenditures were not good estimates of the value of a fishery resource, they did concede that the fishing experience is valued by the user at least as highly as other activities or goods for which the money could have been spent. In addition, they concluded that the net value (which the cost estimates in the present study closely approximate) yielded at least a minimal estimate of the resource value.

To compare estimated expenditures per man-day for the Mountain Fork River with that developed in other studies, I selected $9.52 per man-day as the best overall estimate because this value represented the entire river. There are two major problems associated with comparing dollar values derived during different studies: 1) the models by which the estimates were derived vary, as noted by Gordon et al. (1973) and 2) dollar values derived from studies conducted at different times are not directly comparable because of inflationary changed in the U.S. monetary system. Whenever possible, I adjusted the listed expenditures per man-day given in other studies to compensate for differences in the model by which the value was derived, and adjusted all values to a base of 1970 = 100% (Table 6). Although all discussions and comparisons of expenditures per man-day between the Mountain Fork River and other waters are made on the basis of the adjusted values, comparisons between the various estimates must be considered only approximations because not all differences could be compensated.

The $9.52 per man-day average for the Mountain Fork River is not only much higher than the $1.00 per man-day used by the U.S. Department of Army, Corps of Engineers (1967) and the $4.20 per man-day various values used by the U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife (1960) in deriving fishery values for their respective project statements, but also exceeds the upper limit of $6.00 per day allowed by SD 97-S1 and the maximum of $9.00 per man-day allowed by "Principles and Standards for Planning Water and Related Land Resources - Water Resources Council," a document that replaced SD 97-S1 in October 1973.

Scheftel (1958b) estimated expenditures per man-day for fishermen on the Mississippi River in extreme southeastern Minnesota. Scheftel's data are the only source which represent a warm-water river fishery similar to that of the Mountain Fork River. The $6.90 per man-day for the Mississippi River suggests that fishermen regarded the Mountain Fork River as the more valuable resource. This conclusion is strengthened by the fact that there were no alternate fisheries available in the vicinity of the Mississippi River fishery, whereas the Mountain Fork River fishery competes with several nearby river fisheries which are at least equally accessible to fishermen. In other waters, tailwater fisheries were valued at $4.85 per man-day in Carlyle Lake, Illinois (Fritz 1971), and at $4.14 per man-day below Bull Shoals Reservoir, Arkansas (Baker 1960). The Bull Shoals tailwater fishery was described by Baker (1960) as a high quality trout water. The mean expenditure per man-day for the Mountain Fork River was more than twice that for the Bull Shoals tailwater, again indicating that angling on the Mountain Fork River is regarded as a high-quality experience.

Table 6. Expenditure per man-day for fisheries in certain U.S. rivers.

Year data were collected	River or general area	Cost per man-day	Adjusted per man-day	Source
1956	Minnesota streams	$ 9.88b	$14.12	Scheftel (1958a)
1956	California streams	11.40b	16.29	Mahoney (1960)
1957	Bull Shoals tailwater	3.00	4.14	Baker (1960)
1957	Mississippi	5.00b	6.90	Scheftel (1958b)
1968	Idaho (average)	3.12c	3.48	Gordon et al (1973)
1968	Idaho (a lake salmonid)	0.26c	0.29	Gordon et al (1973)
1968	Idaho steelhead	11.37c	12.69	Gordon et al. (1973)
1968	Oklahoma (lake)	5.04	5.62	McNeely and Badger (1968)
1969	Kentucky streams (average)	1.83	1.94	Bianchi (1969)
1969	Kentucky 2nd order	1.36	1.44	Bianchi (1969)
1969	Kentucky 3rd and 4th order	1.84	1.95	Bianchi (1969)
1970	Mountain Fork	9.52	9.52	Present study
1971	Carlisle Lake tailwater	5.06b	4.85	Fritz (1971)

aAdjusted to a base of 1970 = 100% from U.S. Department of Labor, Bureau of Labor Statistics, Consumer Price Index, U.S., where 1967 = 100%. For the 13 values shown the mean is $6.96 and the median is $4.85.

bAdjusted to include only those items that correspond to the present study.

cDoes not include fishing tackle.

The average expenditure per man-day for Kentucky streams was $1.94, and varied from $1.44 for 2nd order streams to $1.95 for 3rd and 4th order streams (Bianchi 1969). These values are not segregated by fishery type and represent all types of stream fisheries in Kentucky. The mean value per man-day for Idaho waters was $3.48 and ranged from $0.29 for a lake salmonid fishery to $12.69 for a steelhead fishery (Gordon et al. 1973). (Steelhead fisheries were singled out as "unique" experiences at the upper end of the range of values per man-day in SD 97-S1.) The expenditures per man-day observed for the Mountain Fork River more closely approximated those for the highly regarded steelhead fishery than those for warm-water fisheries.

The two highest values for expenditures per man-day that I found were $16.29 for all California freshwater fisheries (Mahoney 1960) and $14.12 for nonresident anglers in Minnesota (Scheftel 1958a). No explanation was offered by Mahoney for either the high average expenditure or for the relative composition and contribution of the various types of California freshwater fisheries. The Minnesota value (Scheftel 1958a) was biased upward because it excluded resident and local anglers who would be expected to have lower transfer costs.

McNeely and Badger (1968) estimated a $5.62 per man-day expenditure for lakes near Duncan, Oklahoma (approximately 160 km west of the Mountain Fork River). Although these lakes generally draw from the same fisherman population as the Mountain Fork River, the average expenditure per man-day is much lower.

On the basis of average expenditure per man-day: 1) the $9.52 for the Mountain Fork River was 1.37 times larger than the mean of $6.96 and 1.96 times the median of $4.85 for relatively comparable values for other streams (Table 6); 2) fishermen in the present study spent 1.36 times as much as the $7.02 listed as an average value for freshwater fishermen throughout the United States during the period 1965-1970 (U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife 1970). I suggest that these comparisons emphasize that clearwater, free-flowing, "smallmouth bass streams" are held in higher regard by fishermen than is often assumed.

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EFFECTS OF EFFLUENTS FROM TROUT HATCHERIES ON THE BENTHOS AND FISH IN RECEIVING STREAMS

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ABSTRACT

This study evaluated the effects of discharges from three southeastern trout hatcheries on the benthic organisms and fish in the receiving streams. The U. S. Fish and Wildlife Service hatcheries were at Suches, Georgia; Walhalla, South Carolina; and Brevard, North Carolina. Although effects differed somewhat for each hatchery, the numbers and kinds of both benthos and fish generally increased immediately downstream from the hatchery outfalls. Pollution intolerant benthic organisms were not lost from the fauna below the hatchery outfalls. No detrimental changes in the fish communities were apparent.

INTRODUCTION

Trout hatcheries sometimes produce water pollution. Liao (1970) cited examples of such pollution and named three kinds of pollutants that are discharged from fish hatcheries: (1) fish fecal material and unused fish food, (2) chemicals and drugs normally used for disease and parasite control, and (3) pathogenic bacteria and parasites. Since the first of these occurs continuously throughout most of the year, it is of most concern; the other two kinds may sometimes be serious, but occur only sporadically.

Mackenthun (1966) suggested that an accurate picture of the effects of pollution on the aquatic life of a stream can be obtained by comparing the kinds and numbers of aquatic animals found in unpolluted and polluted sections of a stream. Benthic macroinvertebrates are particularly useful because their habitat preference and low motility causes them to be affected directly by a pollutant (Wilhm 1967). We determined the effects of discharges from three southeastern trout hatcheries on the aquatic organisms in the receiving streams by comparing the kinds and numbers of benthic organisms and fish upstream and downstream from the hatcheries.

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