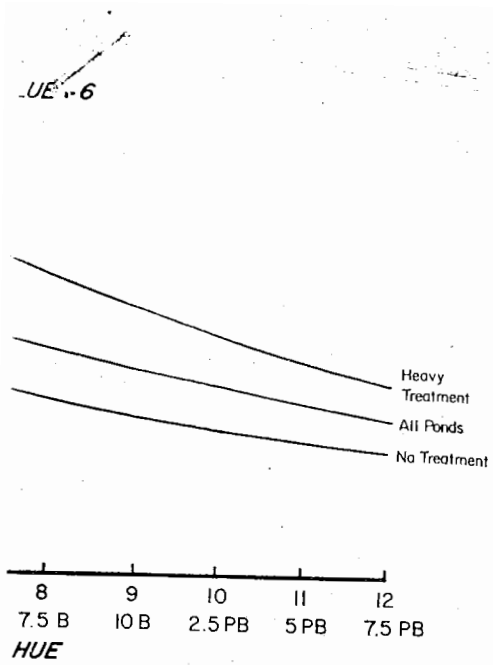

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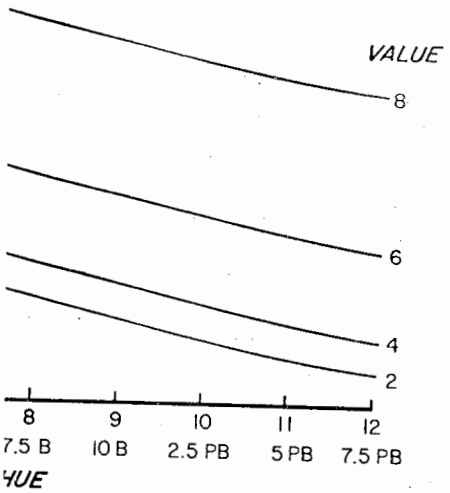

anic solids to hue and value for all ponds.

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COST/BENEFIT ANALYSIS OF A CATCHABLE RAINBOW TROUT FISHERY IN TEXAS

by
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Texas Parks and Wildlife Department
Inland Fisheries Research[1]

ABSTRACT

An evaluation of stocking catchable rainbow trout, *Salmo gairdneri*, in a section of the Brazos River was made in 1972-73 to determine if trout stocking is an economically and recreationally justifiable fishery management technique in Texas. A creel survey to measure fishing pressure and harvest, gross annual expenditures, and net economic value of the fishery was made before and after trout introduction. Benefits, in terms of increased harvest and utilization, were found to be substantially higher than the cost of stocking catchable rainbow trout.

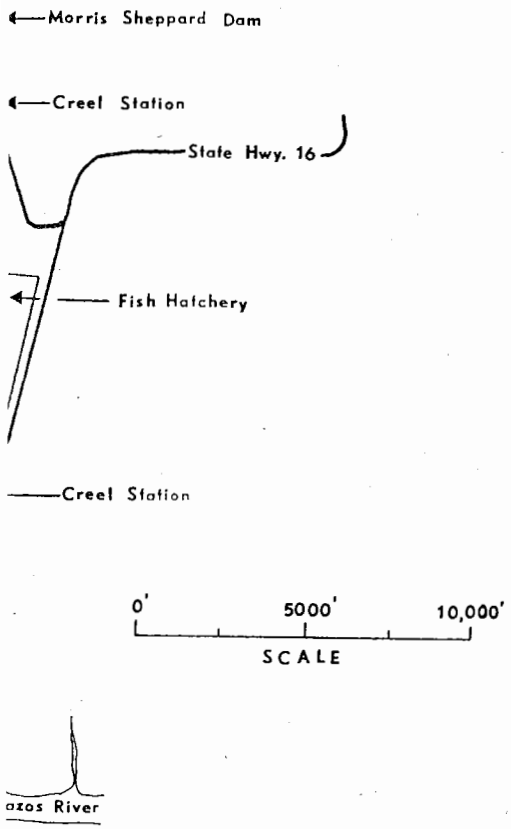
INTRODUCTION

It is the responsibility of the Inland Fisheries Branch of the Texas Parks and Wildlife Department to manage all public freshwater fishery resources in Texas. Tailrace waters created by the construction of large multiple purpose dams represent an area suited to diversification of fishery management techniques. In 1966, a put-and-take trout fishery was established in the Guadalupe River below Canyon Reservoir in south-central Texas. The fishery met with good public response and a sufficiently high per cent of the stocked trout were harvested (White, 1968). The overall program was considered to be quite successful and it was recommended the put-and-take fishery be continued. Due to this success, additional tailrace waters were evaluated to determine if similar fisheries could be developed in other parts of the State. In 1972, a 20-mile section of the Brazos River below Possum Kingdom Reservoir was studied and suitable trout habitat was found in the first 4 miles of river below the dam (Forshage, 1972).

The Department felt before expanding its trout program an evaluation was necessary to determine if stocking catchable-size trout is an economically and recreationally sound fishery management technique. This study, through a creel survey designed to measure fishing pressure and harvest, gross annual expenditures, and net economic value of the fishery resource before and after the introduction of trout in the Brazos River, was initiated to determine the practicability of maintaining tailrace trout fisheries in Texas.

[1] Contribution from Federal Aid Restoration Funds under Dingell-Johnson F-4-R, State of Texas.

to Richard L. Wh[illegible] Director of Environmental Research, as assistance in planning the study; to Dr. Tom Hellier, [illegible]nds and Neil Carter, Texas Parks and Wildlife Department, w of this paper; and to Biologist Robert Gamble and fisheries Mack, Jr., and Kenneth R. Moore for their assistance in field



ingdom Reservoir showing creel survey stations.

METHODS AND MATERIALS

The study was conducted on a section of the Brazos River [illegible] miles northwest of Mineral Wells in Palo Pinto County, Texas. The study area began at the large pool below the dam of Possum Kingdom Reservoir and extended 2.6 miles downstream (Figure 1).

Physical features of this area vary greatly with releases from the reservoir. At low flow under 500 cubic feet per second - cfs) the river is characterized by narrow, shallow riffle areas with long, wide pools. During periods of high flow (over 500 cfs) the river channel is filled. Water releases are controlled by the Brazos River Authority and are governed by the demand for power or flood control. Discharges during the study had a mean of 800 cfs and ranged from 16 to 17,000 cfs (U. S. Department of the Interior Geological Survey, 1974). When turbines are not in operation, a cold water discharge of 20 cfs is maintained. Water flow from the reservoir is drawn at a depth of 79 ft. insuring cold water temperatures during hot summer months. Other physical characteristics as well as chemical and biological conditions of this section of the river have been described by Forshage (1972).

A creel survey was made to determine the characteristics of the sport fishery provided by this section of the Brazos River. The survey was conducted monthly during 1972 and 1973. Survey days were stratified into weekend days and weekdays. Two consecutive weekdays and two consecutive weekend days for each month were selected randomly at the beginning of each year for the creel survey.

A complete survey of all anglers was made by checking the study area every two hours from dawn until dusk when fishing pressure was light. Two survey stations were established at the only two access points to the area during periods of heavy fishing use. Each station was manned by a survey clerk during daylight hours.

Creel information collected from each fishing party consisted of general creel data and fisherman expenditure statistics. To provide an estimate of fishing pressure and harvest, the number of anglers in each fishing party, total hours fished, and the number of fish caught by species was recorded. Also the total length of each fish was measured and recorded. Expenditures by trip were determined by obtaining distance traveled to the fishery and amount spent for lodging, bait, tackle, food, ice, refreshments and incidental expenses associated with the fishing trip. Expenditures for automobile transportation were set at 10 cents per mile.

Yearly estimates for number of fishermen, man-hours fished, fisherman harvest by species, and total expenditures were calculated by taking the average for each day type and multiplying these by the number of days of each stratum (weekend and weekdays) in the year. These products were added to obtain the yearly estimates.

Harvest of trout during 1973 was calculated differently than that of other harvest totals. In addition to prescheduled creel survey days, two extra weekend days and two weekdays were sampled during months when trout were stocked. The increase in sample days after stocking accounted for the decrease in the day to day trout catch as the stocked population declined with fishing. Total harvest of trout was found by stratifying 1973 into three sample periods of similar harvest rates: November through March, April through June, and July through October. Estimates were determined separately for each period and added to obtain an estimate for the whole year.

The economic value of the fishery provided by this section of the Brazos River was estimated by utilizing expenditures attributable to the fishing experience and the number of anglers using the fishery from various distances. To use this method as the basis for determining the net economic value of a fishery, it must be assumed the amount of use the fishery provides for a fisherman is directly related to distance the fisherman lives from the resource. The farther an individual lives from the fishery the less likely he is to make use of it due to increased cost in both time and money to get to the resource (Gordon *et al.*, 1973). Based on this relationship, arbitrary zones of varying distances from the fishery were defined (Figure 2). Expenditures per angler day were plotted against fishing days from each distance zone to derive a simulated demand curve for the recreational experience. Fishing days is defined as an angler sport fishing during a particular day regardless of the length of time fished. This demand curve was used to determine the optimum theoretical relationship between the price of a hypothetical fishing fee and number of people using the resource (Clawson, 1959). The hypothetical fee on a previously free fishery was assumed to reduce number of anglers in the same manner as increased travel and sustenance expenditures. The maximum or net economic value of the resource was the point where, if the fee was either increased or decreased, the total return to the owner will decrease. This value represents money obtainable from the recreational experience or potential revenue (user-value) to the owner of the fishery. In this case, the owner of the fishery is the Texas Parks and Wildlife Department.

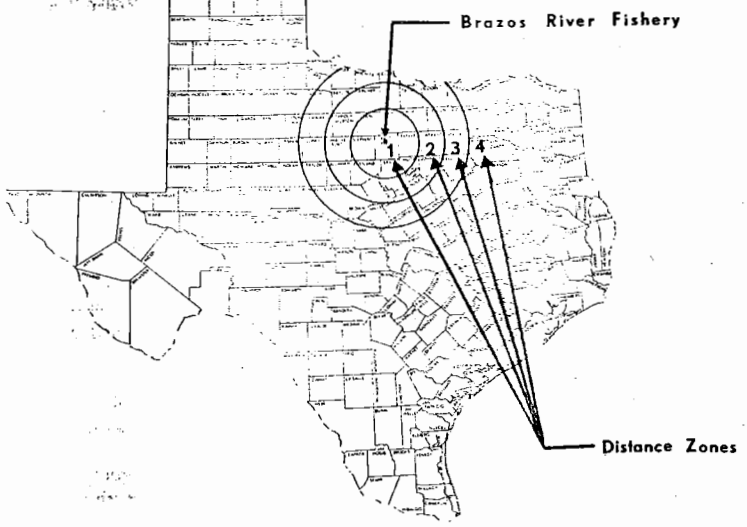


Figure 2. Arbitrary distance zones used for demand curve analysis.

RESULTS AND DISCUSSION

The Brazos River below Possum Kingdom Reservoir was open to public fishing throughout both years of the study. Good access to the river was available near the dam and from State Highway 16 bridge crossing. Wading and bank fishing were common over the extent of the study area, at low flow. Poor fishing conditions existed when the river was at high flow and anglers were limited to areas near access points. Boat fishermen contributed very little to the pressure on the fishery because steep banks at access points limited boat launching.

Creel survey trip-effort statistics are shown in Table 1. Estimates of fishing trips, number of fishermen, and man-hours fished were found to be significantly higher for 1973 than 1972 estimates (F-test: 0.05 level). Fishing trips increased by 5,234 trips in 1973, but the per trip number of anglers and length of time fished did not markedly change from that of 1972. An estimated 15,196 anglers fished the tailrace during 1973. This is an increase of 211 per cent over 1972 figures. The total fishing pressure exerted by these fishermen was estimated at 48,040 man-hours. This is an increase of 36,357 man-hours over that of 1972 pressure. Weekend pressure remained higher than weekday pressure during both years, but the difference was not as great during 1973 as in 1972.

Fishes caught by anglers during the study were grouped into 10 major categories for analysis (Table 2). Estimated harvest for 1972 and 1973, difference in harvest between the 2 years, and the significance of difference determined by F-test, 0.05 level, is also shown. Sunfish species (redbreast, green, warmouth, bluegill, longear, and redear sunfish; common names obtained from Bailey, *et al.* 1970), were generally the most abundant during 1973. Rainbow trout was the most common fish caught in 1973. The bass group, which was comprised of largemouth and spotted bass, was the most sought after fish group during 1972. These species declined in importance after the introduction of trout. Channel catfish comprised 98 per cent of all catfish species caught. The remaining 2 per cent was comprised of flathead and black bullhead catfishes. The 1973 harvest of catfishes increased 98 per cent over that for 1972 and can be explained by the change in fishing methods. Many fishermen used corn and cheese as bait and were effective in catching channel catfish. Increases in the harvest of carp, white crappie, white bass, and freshwater drum were observed during 1973. These species were usually caught incidentally while fishing for other species. The increases in harvest of these species

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redhorse) were observed during 1973. Only small numbers of ea
years.

Table 1. Estimated creel survey trip-effort statistics.

Year	Fishing Trips	Number of Fishermen	Man-Hour
1972			
Weekdays	993	1,932	3,772
Weekends	1,129	2,947	7,911
	2,122	4,879	11,683
1973			
Weekdays	3,210	7,597	20,833
Weekends	4,146	7,599	27,207
	7,356	15,196	48,040

Table 2. Estimated yearly harvest of fish (± one standard erro
fishery, 1972 and 1973. Differences from one year to

Species Group	1972 Number		N
Gar	98	(± 557)	10
Trout			8,165
Carp	1,044	(±2,440)	2,047
Suckers	169	(± 937)	120
Catfish	741	(±2,656)	1,471
White bass	594	(±2,247)	874
Sunfish	3,976	(±8,968)	5,049
Black bass	1,202	(±2,697)	950
Crappie	108	(± 316)	682
Drum	610	(±1,730)	2,071

F-tests
ns = non-significant
*Significant at 0.05 level

In 1973, approximately 16,000 rainbow trout were stocke
introduction was divided into four stockings. The first stocking
trout stocked. This was followed by 3,000 in March, 4,000 i
Harvest of trout was higher after stocking in January than at any
An estimated 52 per cent of the trout had been harvested 15
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except in August. Stocking during August met with limited
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the year was estimated at 8,165. This was 51 per cent of all trou
during the winter months (93 per cent of total harvest), but lowe

Total estimated harvest during 1972 was 8,542 fish. Harve
estimated to be 13,274 fish. This was an increase of 55 per cent
in harvest of native fishes was not significant (F-test; 0.05 level
including trout, was estimated to be 21,439 fish. This was a
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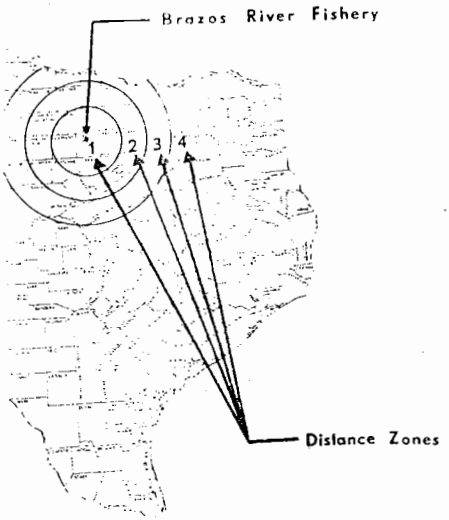

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Table 1. Estimated creel survey trip-effort statistics.

Year	*Fishing Trips*	*Number of Fishermen*	*Man-Hours*	*Number of Anglers Per Trip ($\bar{x}$)*	*Time Fished Per Trip ($\bar{x}$)*
1972					
Weekdays	993	1,932	3,772	1.9	2.5
Weekends	1,129	2,947	7,911	2.6	3.0
	2,122	4,879	11,683	2.3	2.8
1973					
Weekdays	3,210	7,597	20,833	2.4	2.7
Weekends	4,146	7,599	27,207	1.8	2.7
	7,356	15,196	48,040	2.1	2.7

Table 2. Estimated yearly harvest of fish (± one standard error) for the Possum Kingdom tailrace fishery, 1972 and 1973. Differences from one year to the next are shown.

Species Group	*1972 Number*	*1973 Number*	*Difference*
Gar	98 (± 557)	10 (± 83)	−88*
Trout		8,165 (±26,148)	8,165
Carp	1,044 (±2,440)	2,047 (± 5,436)	1,003*
Suckers	169 (± 937)	120 (± 683)	−49 ns
Catfish	741 (±2,656)	1,471 (± 2,883)	730*
White bass	594 (±2,247)	874 (± 3,273)	280 ns
Sunfish	3,976 (±8,968)	5,049 (±17,550)	1,073 ns
Black bass	1,202 (±2,697)	950 (± 2,220)	−252 ns
Crappie	108 (± 316)	682 (± 2,981)	574*
Drum	610 (±1,730)	2,071 (± 7,011)	1,461*

F-tests
ns = non-significant
*Significant at 0.05 level

In 1973, approximately 16,000 rainbow trout were stocked in the Brazos River fishery. The introduction was divided into four stockings. The first stocking was on January 17, with 4,000 8-inch trout stocked. This was followed by 3,000 in March, 4,000 in August, and 5,000 in November. Harvest of trout was higher after stocking in January than at any other time during the year (Figure 3). An estimated 52 per cent of the trout had been harvested 15 days after stocking. Harvest declined rapidly until the next stocking in March. Trout harvest showed the same trend with each stocking except in August. Stocking during August met with limited success. Water temperatures in the fishery were near maximum levels tolerated by trout. Survival of the stocked trout was questionable. Only 11 of the stocked trout were accounted for in the creel survey. The total harvest of trout during the year was estimated at 8,165. This was 51 per cent of all trout stocked. Harvest of trout was higher during the winter months (93 per cent of total harvest), but lower during spring and summer months.

Total estimated harvest during 1972 was 8,542 fish. Harvest during 1973, excluding trout, was estimated to be 13,274 fish. This was an increase of 55 per cent over the 1972 estimate. The difference in harvest of native fishes was not significant (F-test; 0.05 level). The estimated total harvest for 1973, including trout, was estimated to be 21,439 fish. This was a 151 per cent increase over the 1972 estimate and was significantly higher (F-test; 0.05 level).

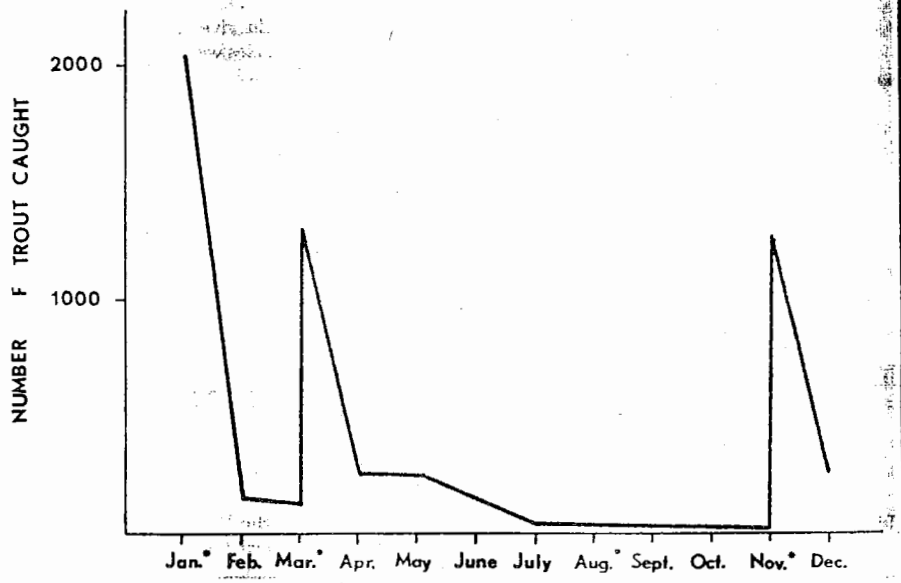


Figure 3. Estimated number of trout caught by month from the Possum Kingdom tailrace fishery during 1973 (* = trout stockings—Jan. 4,000, March 3,000, August 4,000, Nov. 5,000).

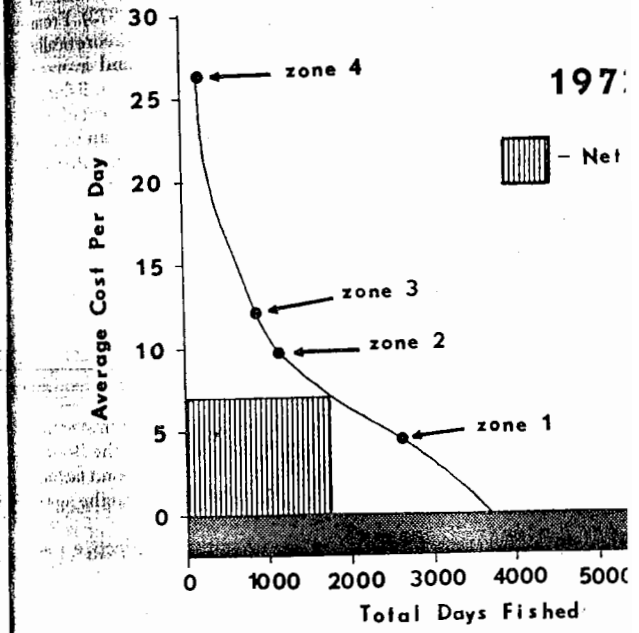
The gross annual expenditures were assessed on the basis of expenditures by anglers. These expenditures consisted of cost for transportation, food, lodging, bait, etc., incurred while traveling to, using, and returning home from the fishery. Relating daily expenditures to total days fished, an estimated $35,715 was spent by anglers on the Brazos River fishery during 1972. The estimated average expenditure for an angling day in 1972 was $7.32 per fisherman (ranged from $1.89 to $18.82/day). After the introduction of trout, in 1973, an estimated $106,745 was spent by anglers on the fishery with an average of $7.02 per angler (ranged from $3.66 to $14.16/day). This represents an increase in 1973 of $71,030 in gross annual expenditures by sport fishermen on the fishery. Increase in gross annual expenditures during 1973 was attributed to the increase in the number of fishermen who were attracted to the fishery because of introduction of trout.

Cost per angler did not differ significantly during the two study years (F-test; 0.05 level). The largest expenditure item during both years was transportation. In 1972, transportation accounted for 70 per cent of the gross fishermen expenditures and in 1973, 68 per cent.

Estimates of the net economic value of the Brazos River fishery before and after trout introduction were made from the simulated demand curves (Figure 4). In 1973, the fishery, provided by native fishes, had a net economic value of $11,900. This was the product of an estimated daily fishing fee of $7 times an estimated 1,700 fishing days. After the introduction of trout, during 1973, the value of the fishery was approximately $48,000. The daily fishing fee, theoretically acceptable by individuals using the fishery, increased to $10 with 4,800 days fished. This method of analysis indicated estimated economic value of the fishery increased by $36,000. Apparently anglers were willing to pay more for the opportunity to fish for trout as compared to native fishes in the same fishery.

An estimated $5,120 was spent by the State to stock 16,000 trout in the Brazos River. Cost was based on Texas hatchery production cost of $0.32 per 8-inch trout which included the cost of buying, rearing, and stocking trout (William P. Rutledge, Personal Communications).

In determining cost/benefits of a fishery management technique, it must be assumed there are only two measurable benefits generated by a sport fishery. These consist of number or pounds of fish harvested, and hours of recreation provided. Measurements of both statistics were made before and after the stocking of trout in the Brazos River. Information collected during the study indicated harvest and utilization of the fishery increased significantly.



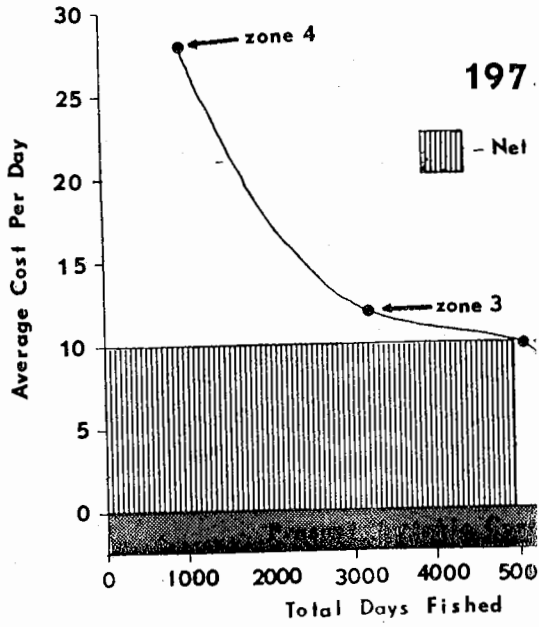
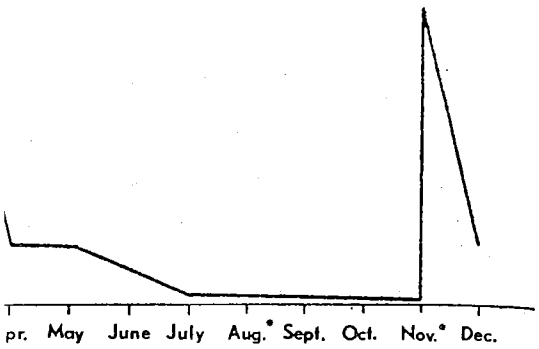


Figure 4. Simulated demand curves showing relationship betwe of fishing days by distance zones for the Possum Kingd 1973.



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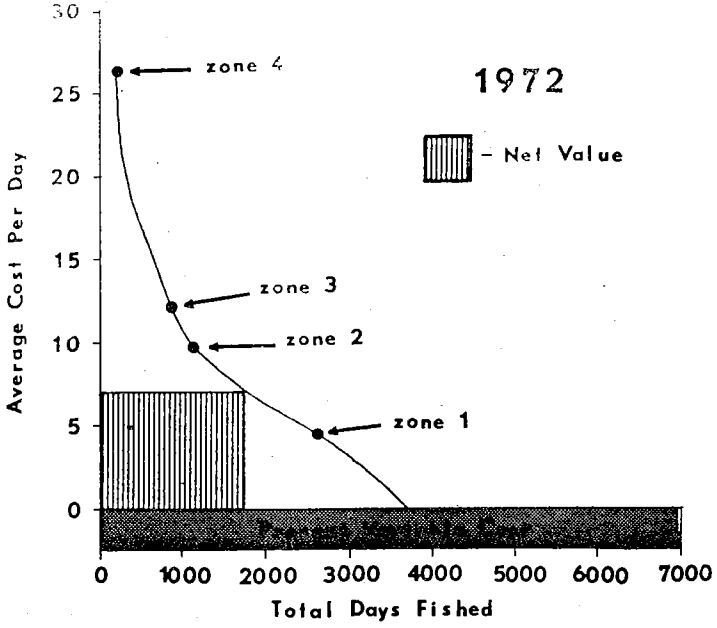

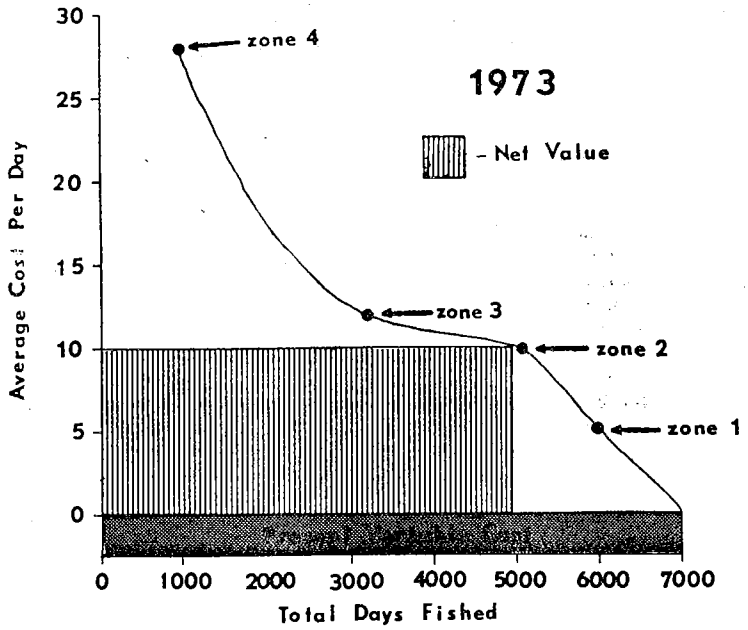

Figure 4. Simulated demand curves showing relationship between average cost per day and number of fishing days by distance zones for the Possum Kingdom tailrace fishery during 1972 and 1973.

Problems involved in estimating the value of man-hours of fishing are complex and similar to difficulties encountered in estimation of the value of outdoor recreation (Gordon *et al.*, 1973). From the simulated demand curve (Figure 4), a daily fishing fee of $10 was determined to be theoretically acceptable by anglers using the fishery after stocking trout. Using the $10 value and average man-hours per fishing day, it was estimated anglers were willing to pay $3.70 per man-hour fishing. This was assumed to be the value to anglers for a man-hour of fishing on the Possum Kingdom tailrace fishery. Expanding the increase in man-hours of fishing attributed to the introduction of trout by this value, an estimated $134,520 of recreation was provided. In addition to the value generated by recreation, the value accrued by anglers, from the pursuit, catching, keeping, and eating, of the fishes which constitute their harvest was considered. This value was determined by expanding the number of fish harvested by the monetary value of each species. Monetary values for each species group were obtained from American Fisheries Society, Pollution Committee, Southern Division, 1970. Using this approach, increased harvest attributed to the trout introduction had an estimated monetary value of $7,203.

When values for harvest and man-hours were combined to estimate dollar benefits generated by the trout fishery, $141,723 of benefits were found. The only expense to produce these benefits was the cost of stocking trout, $5,120. The cost/benefit ratio of stocking trout was 1:28. For each dollar spent to stock trout $28 of recreation was provided.

Several factors accounted for the high cost/benefit ratio of this trout fishery. The most important was the novelty of a rainbow trout fishery in north-central Texas. Prior to stocking trout in the Brazos River, anglers in this area had to travel 200 miles to the nearest Texas trout fishery. A second factor, which added to the utilization of the trout fishery, was the publicity of the trout stockings in the news media.

The stocking of catchable rainbow trout in the Brazos River apparently is an effective and economically justified fishery management technique to increase fishing pressure and harvest. The creel survey indicated little fishing was done on the Possum Kingdom tailrace fishery during 1972. The little that was done was directed toward largemouth and spotted bass, sunfish species, and channel catfish. Trout introduction caused an increase in utilization of the river, especially during the winter months. Harvest of native fishes was observed to increase, and a good trout fishery was provided. The number of trout harvested by anglers indicated a sufficient rate of return to justify continuation of a stocking program. Economic information collected indicated benefits derived by the trout fishery were substantially higher than the cost to provide them.

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ANGLER ORIENTED OBJECTIVES WEED CONTROL PRO

by

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ABSTRACT

Chickahominy Reservoir, Virginia, was treated with a mixture of herbicides d *Egeria densa* Planchon. Herbicides were undetectable in water by the 16th day aft at levels higher than those in the water. Only diquat accumulated in hydrosoils. Di and water decreased. All diquat had dissipated from hydrosoils after two years. A Aerial photographic monitoring revealed the amount of surface acreage and fisha treatment. Weed regrowth was greater in shallow areas than in deeper areas after to determine the sportsmen's opinion of the weed control project believed th increased fishing and boating enjoyment.

INTRODUCTION

Sport fishing is enjoyed by millions of Americans. Seventy effort on freshwater lakes, ponds, and reservoirs (U. S. Dept factor to increasing recreational use of such impoundments is (Corning, 1969). The extent of this problem has been well doc the southeastern United States (Holm *et al.*, 1969; Gangstad macrophyte egeria (*Egeria densa* Planchon) severely limited th iny Reservoir, a high-use warmwater fishery located in the between Richmond and Norfolk.

This reservoir alone supplied 24,500 days of recreational fis Virginia's fishermen in 1969 (U. S. Army, 1969). Fishermen seriously detracted from their fishing experience by reducin tackle, and inhibiting navigation. The Virginia Commission U. S. Army Corps of Engineers jointly sponsored a chemical sportsmen's requests for improvement of the reservoir's recr the efficacy of the control program with respect to meeting th and accumulation of the chemicals in the environment are

MATERIALS AND METH

A 1:1 mixture of diquat dibromide [6,7-dihydrodipyrido-(1. and potassium endothall [7-oxabicyclo-(2,2,1) heptane-2,3-di cation rate of 2.83 liter of each chemical per surface 0.4 ha yield 0.11 mg/liter active ingredient of diquat and 0.17 mg Herbicide was applied to the eastern half of the reservoir western half was treated using a siphon arrangement from an completed in one week (July 9-13). The lake was closed to fish the chemicals from the water.

Intensive monitoring was conducted in two quadrants cho of the reservoir. These quadrants covered 11.3 ha and 14.2 ha were collected from the surface of each quadrant daily befor and 40 h after treatment and then on a daily basis for one m once a week for six weeks following treatment, then approxim

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