COST/BENEFITS FROM THE ROTENONE RENOVATION OF A 485-HECTARE TEXAS RESERVOIR

by
WILLIAM C. PROVINE
Texas Parks and Wildlife Department
Houston, Texas 77044

ABSTRACT

To determine the effects of a large-scale rotenone renovation on a fish community and sport fishery, a 5-yr study was conducted on Sheldon Reservoir, a 485-ha Texas reservoir with small sport fish populations and poor fishing. The lake level was lowered and the remaining water treated with liquid rotenone. Gill nets, seines and a creel survey were used before and after treatment to evaluate this renovation. The relative abundance of sport fish populations increased from 17.54% (by weight) before treatment to a high of 46.27% after the renovation and restocking. Although high populations of sport fishes were maintained, turbid water conditions adversely affected fishing pressure and success, and prohibited accurate long-range evaluation of the effects of this treatment on the fishery. Cumulative cost/benefit ratios for the first 3 yr after renovation were 1:1.63, 1:1.20 and 1:0.93 consecutively.

Rotenone has been used as a piscicide in the United States for over 40 yr (Ball 1948). Treated waters have included ponds, lakes, reservoirs, lagoons, estuaries and streams; treatments have been either total or partial, depending upon the desired effect and the location of fish (Schnick 1974). Success of rotenone treatments in freshwater impoundments has been varied. Anderson (1970) found the rehabilitation of Minnesota lakes lasts from 5 to 15 yr with more rapid growth of sport fishes than in other natural situations. After 30 experimental Oklahoma ponds were treated with rotenone, Clemens and Martin (1953) found fish remaining in two of the ponds after 2 or 3 months. Partial reclamations have improved fishing with target species not becoming reestablished (Gerking 1950).

Although volumes of literature are available concerning the use of rotenone as a fish toxicant, there has been no attempt to objectively determine fishermen benefits from its use in reservoirs. This study was initiated to determine the cost/benefit ratio of the rotenone renovation of a 485-ha reservoir in southeast Texas.

Financial support for this study was provided by the Federal Aid in Fish Restoration Act under Project F-12-R of the Texas Parks and Wildlife Department. Appreciation is expressed to the personnel of Project F-12-R for their assistance in the study and to the editorial staff of the Texas Parks and Wildlife Department for their review of the manuscript.

MATERIALS AND METHODS

Research was conducted on Sheldon Reservoir, owned and operated by the Texas Parks and Wildlife Department. This 485-ha reservoir has an average depth of 1 m when at spillway level and is located in the San Jacinto River system approximately 32 km from Houston, Texas. Free public fishing is allowed from 5:00 a.m. to 9:00 p.m., 6 days per week (closed Mondays).

Physicochemical data were collected monthly, 1971 through 1974, from the area adjacent to the sluice gates on Sheldon Reservoir. The fish community was sampled at predetermined stations with gill nets and seines from 1971 through 1974. Netting was accomplished at six permanent locations with 45.72-m multifilament experimental gill nets. Seine collections were made monthly with a 7.62-m bag seine from May through October, 1971 through 1974 (except May, 1972 as the reservoir was lowered for rotenone treatment).

To categorize the sport fishing in Sheldon Reservoir prior to rotenone treatment, a creel survey was conducted in 1971 from March through November. Thirty weekdays and 30 weekend days were chosen randomly and surveyed. According to a random selection, the survey day either ran from 5:00 a.m. to 1:00 p.m. or from 1:00 p.m. to 9:00 p.m. These periods included every hour the reservoir was open to fishing. Creel clerks were stationed at each of the two lake exits and they were concerned with only completed fishing trips.

During March, 1972, Sheldon Reservoir was lowered approximately 1.52 m below spillway level in preparation for chemical treatment. Information concerning the date and objectives of the chemical treatment were released through local news media. The area of the lowered lake was approximately 44 ha and the volume calculated to be 192,557 m^3.

An agricultural spray plane was employed to treat the major portion of the reservoir. Treatment began at 9:00 a.m. on April 8, 1972 and was completed in approximately 1 hr. A total of 1080 l of 5% liquid Nox-Fish (Pennick Company, New York) was applied at a rate of 6 ppm total material.

To estimate the immediate recreational benefits provided by the rotenone treatment, "instantaneous" fisherman counts (Lambou 1961) were made hourly from a Texas Parks and Wildlife Department airplane, and harvest was measured at eight creel census stations located along the perimeter of the reservoir. Information obtained from this census was used to calculate (1) recreational benefits in terms of total attendance and man-hours spent salvaging fish at the rotenone treatment and (2) harvest in terms of total number and weight of fish taken by species.

Approximately 1 month after treatment, fishes were restocked according to the schedule given in Table 1.

Table 1. Record of fish stocked in Sheldon Reservoir following rotenone renovation, April through September, 1972.

*Species**	*Number*	*Size Range (cm)*	*Date Stocked*
Threadfin shad	4,000	5-10	May 4
Blue catfish	4,800	15-25	May 10
Channel catfish	3,320	15-35	April 26
	4,400	15-35	April 27
	37,500	15-35	May 1, 2, 3
	4,800	15-35	May 9
Flathead catfish	354	10-13	August 8
	675	7-10	August 31
	1,000	10-13	September 7
Tidewater silversides	1,000	5-10	May 4
Hybrid sunfish (green x redear)	20,000	3-5	September 22
Warmouth	41,600	3-5	May 16
Largemouth bass	25,000	3	May 4
	25,000	3	May 8
	23,000	3	June 14
White and black crappie	51,000	3-5	May 16

*Common names taken from Bailey, 1970.

During the 6 months after restocking (July 1 through December 31, 1972), a creel survey was conducted as described earlier, with the exception that one randomly selected weekday and weekend day were surveyed weekly. Creel surveys were conducted in 1973 and 1974 similarly to that described for 1971.

Values of the fishery after rotenone treatment were compared with those which would have been provided without treatment. Cost estimates used in this study were based on Texas state fish hatchery rearing and stocking costs for each species in Sheldon Reservoir (Fred G. Lowman, Texas Parks and Wildlife Department, Austin, Texas, personal communication) and actual costs of rotenone and commercial application. Benefit estimates and the value of the base-line fishery were derived by applying the monetary values of fishes (American Fisheries Society 1970) to harvest estimates from each year (Wegener and Holcomb 1973).

RESULTS AND DISCUSSION

Physiochemical Characteristics

The water in Sheldon Reservoir was extremely clear during the prerotenone treatment year (Mean turbidity = 13.8 JTU) and water quality problems were not apparent. Aquatic vegetation (primarily *Potamogeton nodosus*) was extremely abundant in the reservoir and in many cases presented problems to fishermen. After the water level was lowered in 1972, heavy rains refilled the reservoir soon after rotenone treatment. Although the water was not turbid the few months following refilling of the reservoir, vegetation never became re-established. The effects of wave action was increased and considerable erosion to the reservoir's clay levees resulted. Water became increasingly turbid in 1972, and by 1973 and 1974 the turbidity averaged over 100 JTU. At times turbidity reached levels as high as 150 JTU.

Composition of the Fish Community

Gill net catches during 1971 indicated game fishes comprised only 17.54% (by weight) of the fish community (Table 2). The most abundant sport fishes were largemouth bass and white crappie which accounted for 5.21 and 5.52% of the total gill net catch, respectively. Channel catfish accounted for only 1.81% of the catch. Problematic fishes included spotted gar, bowfin and gizzard shad, which comprised 26.94, 19.34, and 17.61% of the annual gill net catch respectively. Carp, although not scarce in the lake, did not present a significant problem; the species accounted for only 7.22% of the total catch.

Table 2. Yearly gill net catch statistics, Sheldon Reservoir, 1971 through 1974. Six experimental gill nets (45.72 m long, 2.44 m deep multifilament) were fished overnight bimonthly.

*Species**	*Per Cent Total Number*				*Per Cent Total Weight*			
	1971	*1972*	*1973*	*1974*	*1971*	*1972*	*1973*	*1974*
Spotted gar	21.90	0.34	3.53	5.48	26.94	0.16	4.00	4.87
Bowfin	5.46	—	—	—	19.34	—	—	—
Gizzard shad	28.09	12.41	9.72	4.43	17.61	2.42	1.87	0.94
Carp	1.68	17.24	21.31	24.47	7.22	44.86	47.79	50.05
Golden shiner	0.36	—	0.15	—	0.07	—	0.02	—
Lake chubsucker	1.97	8.97	5.80	0.43	0.81	4.36	1.93	0.12
Blue catfish**	0.36	8.27	5.34	9.49	1.45	7.60	7.69	18.35
Black bullhead	0.15	4.48	2.86	0.84	0.33	1.14	0.80	0.32
Yellow bullhead	2.98	2.07	1.29	0.64	4.51	0.79	0.68	0.18
Channel catfish**	0.58	39.66	30.34	16.03	1.81	34.17	24.25	8.33
Flathead catfish**	—	—	0.08	0.84	—	—	0.21	3.80
Yellow bass	9.54	—	1.05	13.51	4.93	—	0.01	1.56
Warmouth**	0.21	—	1.66	2.53	0.03	—	0.51	0.27
Bluegill**	6.63	—	3.16	1.26	0.88	—	0.51	0.10
Longear sunfish	0.14	—	0.08	—	0.02	—	0.01	—
Redear sunfish**	4.01	—	0.15	—	0.55	—	0.02	—
Largemouth bass**	3.42	6.21	5.94	1.90	5.21	4.36	3.65	1.61
White crappie**	8.00	0.35	6.86	16.25	5.52	0.14	5.81	8.41
Black crappie**	4.37	—	0.68	1.68	2.09	—	0.24	0.76
Freshwater drum	0.15	—	—	0.22	0.68	—	—	0.33
Total desirable species	27.58	54.49	54.21	49.98	17.54	46.27	42.89	41.63
Total undesirable species	72.42	45.51	45.79	50.02	82.46	53.73	57.11	58.37

*Common names taken from Bailey, 1970.
**Desirable species.

Total game fish populations increased considerably after rotenone treatment. During 1972, game fish comprised over 46% of the total gill net catch, and their relative abundance remained above 40% throughout the study. Catches of white crappie and channel and blue catfishes increased substantially after rotenone treatment and restocking; however, largemouth bass decreased in abundance. The rough fishes that were most abundant in the reservoir before treatment became very scarce in gill net catches after the renovation. But, the incidence of carp increased to over 50% of the annual catch by the end of the study. Carp, although not present immediately after treatment, gained access to the reservoir's watershed after heavy rains created considerable flooding.

Monthly seining in 1971 revealed large numbers of stunted sunfishes. Spawning success and recruitment of largemouth bass were apparently excellent, but no evidence of channel or blue catfish reproduction was found. In the study years following the rotenone treatment, seining efforts netted considerably fewer largemouth bass fry and fingerlings. This was possibly a result of the elimination of the previously abundant vegetative cover and the resulting turbidity. Kramer and Smith (1962) found wind-swept lakes with turbid conditions limited the success of largemouth bass nesting. Seine samples in 1973 and 1974 revealed evidence of channel catfish reproduction.

Fishing Pressure

In 1971 creel survey indicated an annual fishing pressure of 223.10 man-hours/hectare before rotenone renovation. According to aerial census, the actual rotenone treatment provided recreation for 11,494 people. Almost half of the people who attended (5,109) did so in an effort to salvage usable fish. These participants spent an estimated 10,728 man-hours (22.09 man-hours/ha based on the reservoir's normal area) salvaging both sport and rough fishes. A sport fishery was re-established in Sheldon Reservoir approximately 3 months after the rotenone treatment. During the 6 months immediately after the rotenone treatment, fishing pressure dropped only to 63.50 man-hours/ha, almost 1/3 of the pressure noted during 1971. Pressure increased in 1973 to 132.44 man-hours/ha. This increase was seemingly due to the first-time returns of anglers interested in the new fishery provided by renovation and restocking efforts. But, possibly due to highly turbid water and low catch rates in 1973, many of these fishermen were dissatisfied and never returned. This was obvious in 1974 when fishing pressure dropped to 76.30 man-hours/ha. Hanson (1974) reported a similar disinterest in the fishery of Thomas Hill Reservoir, Missouri, during years of turbid conditions.

Fishing Quality

The quality of fishing in Sheldon Reservoir was low in 1971 (Table 3). This quality, in terms of fish/man-hour or kilograms/man-hour, more than doubled during the 6 months immediately following rotenone treatment. Although the fishing pressure was low, fishing provided in the treatment year showed there is not necessarily a prolonged void of recreational opportunities following a rotenone renovation. Fishing quality was low in 1973 and 1974. Since game fish populations were very large during those periods, this poor fishing quality was attributed to the turbid conditions of the reservoir.

Fisherman Harvest

Fishermen in 1971 harvested 39.02 fish/ha or 10.21 kg of fish/ha (Table 4). During the rotenone treatment, 45,057 fish (38,685 kg) were harvested by the public. Carp and spotted gar comprised 74% (by weight) of the fish salvaged. After rotenone treatment and restocking, harvest for the 6-month period surveyed in 1972 was over half of that estimated for the entire year of 1971. Therefore, harvest rates during 1972 were adversely affected for only 3 months immediately following rotenone treatment. Harvest declined in 1973 and remained small through 1974, again a possible result of turbid conditions.

Fisherman Benefit

Based only on the fish removed, the value of the fishery for the year before the rotenone treatment was $16,610. The cost of the treatment, including chemical, application and restocking, was $11,893.25. The fisherman benefit for the year of the rotenone treatment (1972), including salvage of fish during the treatment day and 6 months of sport fishing,

Table 3. Fishing quality statistics, Sheldon Reservoir, 1971 through 1974.

Species*	Number of fish/man-hour				Grams of fish/man-hour			
	1971	1972	1973	1974	1971	1972	1973	1974
Bowfin	0.018	0.014	0.009	0.022	7.71	4.53	4.53	15.88
Blue catfish	0.001	0.003	0.001	0.002	0.45	1.36	0.45	1.81
Black bullhead	0.002	0.003	0.004	0.003	1.36	0.45	0.91	0.91
Channel catfish	0.002	0.168	0.026	0.031	0.91	48.08	10.89	15.88
Green sunfish	0.001	0.001	0.001	—	0.45	0.45	0.91	—
Warmouth	0.007	0.002	0.006	0.007	0.91	0.45	0.91	0.45
Bluegill	0.058	0.043	0.027	0.006	4.53	2.72	1.81	0.45
Longear sunfish	0.003	0.006	0.003	0.002	0.45	0.45	0.45	0.45
Redear sunfish	0.026	0.008	0.004	—	1.81	0.45	0.45	—
Spotted sunfish	0.002	0.001	0.001	0.001	0.45	0.45	1.36	0.45
Largemouth bass	0.039	0.199	0.027	0.028	23.13	40.82	10.43	14.51
White crappie	0.110	0.003	0.044	0.047	4.08	0.45	0.91	12.70
Black crappie	0.007	—	0.003	0.001	1.81	—	0.45	0.45
Total	0.176	0.450	0.154	0.149	48.05	100.66	34.46	63.94

*Common names taken from Bailey, 1970.

Table 4. Estimated sportfishing harvest, Sheldon Reservoir, 1971 through 1974.

Species*	Number of fish/hectare				Kilograms of fish/hectare			
	1971	1972	1973	1974	1971	1972	1973	1974
Bowfin	3.94	0.88	1.22	1.32	1.72	0.28	0.57	0.96
Blue catfish	0.01	0.17	0.20	0.13	<0.01	0.07	0.09	0.10
Black bullhead	0.42	0.20	0.56	0.18	0.27	0.04	0.14	0.04
Channel catfish	0.40	10.70	3.41	1.86	0.16	3.04	1.44	0.95
Green sunfish	0.22	0.01	0.01	—	0.01	<0.01	<0.01	—
Warmouth	0.40	0.13	0.73	0.40	0.22	0.01	0.10	0.03
Bluegill	13.04	2.73	3.98	0.30	1.03	0.16	0.22	0.03
Longear sunfish	0.57	0.28	0.45	0.10	0.06	0.01	0.02	0.01
Redear sunfish	5.81	0.48	0.46	—	0.45	0.03	0.04	—
Spotted sunfish	0.53	0.03	<0.01	0.02	0.03	<0.01	<0.01	0.02
Largemouth bass	8.59	12.61	3.55	1.72	5.19	2.58	1.38	0.89
White crappie	2.40	0.21	0.45	2.85	0.88	0.02	0.11	0.77
Black crappie	1.49	—	0.43	0.06	0.38	—	0.06	0.02
Total	33.87	28.43	15.46	8.94	10.41	6.26	4.19	3.82

*Common names taken from Bailey, 1970.

was $46,549. This represented $29,939 of benefit over what would have been provided without rotenone treatment. The cost/benefit ratio for this first year, therefore, was 1:1.63. The benefit provided during 1972 was large enough to absorb the loss in fishing pressure during 1973 and again resulted in a favorable cumulative cost/benefit ratio of 1:1.20. During 1974 the cumulative value of the fishery after treatment was still slightly greater than that which would have been provided without the treatment. However, the added cost of the rotenone treatment resulted in an unfavorable cumulative cost/benefit ratio for that year of 1:0.93.

CONCLUSIONS

Cost of rotenone renovation and restocking can be greatly overshadowed by the immediate fisherman benefits provided by the treatment. This value may be so great that

long-term favorable cost/benefit ratios can be achieved with little or no improvement in fishing pressure or harvest.

A prolonged void in fish harvest after rotenone renovation is not a problem. Stocked fishes quickly enter the fishery in fertile lakes of south Texas.

Recommendations for rotenone renovation by the fishery manager should only be made after examination of possible detrimental effects. Aquatic vegetation may be eradicated or "set back" by lowering a reservoir's water level. The absence of vegetation in a shallow reservoir may indirectly be responsible for decreases in number of certain sport fishes and increases in water turbidity. Turbid conditions may be aggravated by activities of "rough" fishes, such as carp, that sometime become abundant after rotenone treatments. Decreases in fishing pressure and fisherman harvest can be directly linked to turbid conditions.

LITERATURE CITED

American Fisheries Society, Pollution Committee. 1970. Monetary values of fish. 15 p.

Anderson, D. 1970. Summary of fish toxicant use in Minnesota. Minn. Dep. Cons., Div. Game and Fish, Section of Fisheries. July 28, 1970. 7 p.

Bailey, R. M., ed. 1970. A list of common and scientific names of fishes from the United States and Canada (Third Ed.). Amer. Fish. Soc., Spec. Publ. 6:1-149.

Ball, R. C. 1948. A summary of experiments in Michigan lakes on the elimination of fish populations with rotenone, 1934-1942. Trans. Amer. Fish. Soc. 75:139-146.

Clemens, H. P., and M. Martin. 1953. Effectiveness of rotenone in pond reclamation. Trans. Amer. Fish Soc. 82:166-177.

Gerking, S. D. 1950. A carp removal experiment at Oliver Lake, Indiana. Investigations of Indiana Lakes and Streams. 3(10):373-388.

Hanson, W. D. 1974. The fishery of a Missouri reservoir receiving thermal effluent. Proc. Southeastern Assoc. Game and Fish Comm. 27:722-734.

Kramer, R. H., and L. E. Smith, Jr. 1962. Formation of year classes in largemouth bass. Trans. Amer. Fish. Soc. 91(1):29-41.

Lambou, V. W. 1961. Determination of fishing pressure from fishermen or party counts with a discussion of sampling problems. Proc. Southeastern Assoc. Game and Fish Comm. 14:380-400.

Schnick, R. A. 1974. A review of the literature on the use of rotenone in fisheries. U. S. Dept. Int. Fish and Wildlife Ser., Fish Cont. Lab. La Crosse, Wisc. 130 p.

Wegener, W., and D. Holcomb. 1973. An economic evaluation of the 1970 fishery in Lake Tohepekaliga, Florida. Proc. Southeastern Assoc. Game and Fish Comm. 26:628-634.