BARKLEY LAKE SYMPOSIUM

RECOVERY OF TAGGED FISH DURING THE CROOKED CREEK BAY ROTENONE STUDY AT BARKELY LAKE, KENTUCKY

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Abstract: Recovery rates were determined for marked fish released into 10 of 15 cove areas and 2 of 6 open water areas during the cove rotenone study at Crooked Creek Bay, an 85 ha arm of Barkley Lake, Kentucky. Fish were tagged with a Floy FD-68B dart tag and either released back into the same study area or introduced from an outside area. Of 986 fish tagged in the embayment, 89% were recaptured. Seventy-five percent of the marked fish were recovered in 9 cove areas, where marked fish were released back into the same cove section. Only 32% were recovered from a back-cove area in which marked fish were introduced from an open water area. Sixty percent were recovered outside this area, indicating a strong tendency for displaced fish to escape. Percentage escapement of marked fish from the other 9 cove areas was only 16%. Escapement increased in each cove section that was progressively farther from open water. Escapement also decreased as mean depth of coves increased. This relationship, when expressed in a multiple regression, was significant ($P>0.04$). The marking and release of fish taken from within a study cove is recommended versus displacement to achieve a higher percent recovery. Selection of cove areas having a mean depth resembling that of adjacent open water habitat is also suggested to minimize escapement and obtain a more representative sample of the reservoir fish population.

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The cove rotenone technique has been the most preferred method for describing fish populations quantitatively in reservoirs in the southern U.S. since 1941 (Hall 1962, Chance 1958). Fish and wildlife agencies in the South have had to rely more on this technique since the early 1960's when reservoirs were being created rapidly. Although rotenone sampling procedures had been standardized by Surber (1960), the Reservoir Committee of the Southern Division, American Fisheries Society, recognized limitations to using cove samples as an inclusive representation of the reservoir fish population. In 1965, a study of the cove rotenone technique was conducted under the guidance of the Committee in a 47 ha arm of Douglas Lake, a storage reservoir in Tennessee (Hayne et al. 1968). Of primary concern was the accuracy of cove samples in describing the fish population of the entire arm.

One inadequacy of cove rotenone sampling not evaluated at Douglas Lake is incomplete recovery of fish. The earliest mention of incomplete fish recovery in coves was by Ball (1948) and Krumholtz (1950). In these studies, fish from outside cove sampling areas were marked and released into the coves prior to applying rotenone. Recovery rates of 23 to 91% were documented. Henley (1967) reported a mean recovery rate of 74% of the numbers and 95% of the weight of fish collected in 11 coves based on observations of SCUBA divers. This procedure did not account for fish that had escaped from the cove area or those lost to predators and scavengers.

One of the first intensive studies directed toward measuring fish recovery rates was conducted as part of the Reservoir Committee's Predator Stocking Evaluation (PSE) Project in 1972-1973. Approximately 100 fish from outside each study cove were marked by clipping the under lobe of the caudal fin and then released into the cove. The recovery rate for all marked fish released into coves of 20 PSE reservoirs was 56.6% (Grinstead et al. 1978). Percent recovery for various tagged species ranged from 20% for bowfin to 79%

for flathead catfish. Standing crop data from 23 PSE reservoirs was adjusted by using factors derived from the Douglas Lake Study for differences in distribution of fish in cove versus open water areas and by applying recovery rates determined from the PSE study.

The Texas Parks and Wildlife Department carried out a statewide effort to determine recovery rates for fish collected during cove rotenone studies in each of their reservoirs in 1976-1978. The mean recovery rate for all fish tagged in 40 reservoirs was 77% and varied from 54 to 96% (Provine personal communication 1979).

A long term study on recovery rates was conducted by Tennessee Valley Authority between 1961 and 1974 (Barr and McDonough 1978). In this study, fish were either fin clipped or dart tagged and recoveries of fish marked by each method were compared. The recovery of fin clipped fish was 52% versus 72% for tagged fish. Inference was made toward using the tagging method versus fin clipping to minimize the problem of marked fish not being identified during the rotenone study.

One of the conclusions of the PSE project was the need for another study similar to the evaluation of the cove rotenone technique at Douglas Lake, but on a different type of reservoir. In September 1978, an extensive field study designed by the Reservoir Committee was conducted in an 85 ha arm of Barkley Lake, Kentucky, to evaluate the cove rotenone sampling technique on a mainstream reservoir. Part of the field operation included a concentrated effort to evaluate recovery rates in cove and open water areas.

Recovery rate data presented in this paper were also used by Aggus et al. (1979) to adjust standing crops of fish, by Jenkins et al. (1979) in determining prey-predator relations, and by Harris et al. (1979) in comparing mark recapture techniques for estimating the number of largemouth bass in Crooked Creek Bay.

METHODS

On 25 September 1978, block nets were set in Crooked Creek embayment of Barkley Lake, Kentucky. SCUBA divers inspected each net to be sure there were no openings where fish could escape. Following the positioning of nets, electrofishing crews collected, tagged, and released all black bass (*Micropterus* sp.) greater than 15 cm and all other fish, except shad (*Dorosoma* sp.), greater than 10 cm. Numbered Floy tags (FD-68B) were inserted below the left posterior dorsal area at the base of the dorsal fin with the monofilament anchor placed through the pterygiophores.

Fish from 12 of the 24 study areas were tagged. The areas designated for the study and the number of tagged fish in each are as follows:

Cove area	Number of tagged fish
C1	101
C2	100
C3	95
C4	100
D	20
F	100
G1	108
G2	101
G3	104
G4	29
Open water area	
OW3	129
BN2	1

Although the study was designed to tag and release 100 fish in each study area, collecting difficulties prevented total completion of this goal. The 100 tagged fish in area C4 were displaced from area OW3.

On 26 September the entire 85 ha embayment was treated with 1 ppm emulsifiable rotenone. Each of the 24 sample areas had individual data collectors who were responsible for locating and recording tag recoveries. A more detailed description of the rotenone study is discussed by Summers and Axon (1979). Fishes are listed by common name in Tables 1-4 and Table 6 according to the list of common names accepted by the American Fisheries Society.

RESULTS AND DISCUSSION

During the 25 September shocking in Crooked Creek Bay, 12 electrofishing crews tagged 986 fish representing 23 different types (Table 1) in 10 cove areas and 2 open water

TABLE 1. Fish recovery by species in Crooked Creek Bay during the Barkley Lake Rotenone Study.

	Tagged	Recovered	Percent
Gars	2	2	100
Bowfin	2	2	100
River carpsucker	1	1	100
Spotted sucker	52	47	90
Smallmouth buffalo	14	14	100
Yellow bullhead	7	5	71
Channel catfish	7	7	100
White bass	54	49	91
Yellow bass	3	3	100
Bluegill	238	217	91
Longear sunfish	317	281	89
Redear sunfish	2	2	100
Green sunfish	1	1	100
Warmouth	8	6	75
Largemouth bass	128	112	88
Spotted bass	3	3	100
White crappie	13	11	85
Black crappie	2	2	100
Sauger	2	2	100
Logperch	1	1	100
Freshwater drum	72	60	83
Carp	54	50	93
Golden shiner	3	2	67
Total	986	880	
Weighed mean			89

areas. Eighty-nine percent of all fish marked were recovered during the rotenone study. A high recovery rate was expected because of the shallow nature of the bay, which had a mean depth of 2.1 m during the study. This depth was similar to the mean depth (2.9 m) of Barkley Lake. Recovery rates varied from 67% for golden shiner to 100% for 12 other fish types. Forty-nine percent of the fish were collected during the second day of the study compared to 40% the first day and 11% the third day.

The percent recovery improved with size of fish for each type (Table 1). This relationship was not evident, however, when comparing percent recovery for each size range within each taxon due to the small number of fish in each length class (Tables 2-4).

TABLE 2. Percent recovery per millimeter class for game fish from Crooked Creek Bay, Barkley Lake. Number of fish tagged in each millimeter class are in parentheses.

Size range (mm)	White bass	Black bass	Crappie	Sauger
114-139	0 (1)	100 (1)		
140-164	100 (1)	89 (27)	100(1)	
165-189	87 (15)	89 (55)	100(4)	
190-215	87 (15)	91 (11)	100 (1)	
216-240	67 (3)	67 (3)	67 (3)	
241-266		75 (4)	67 (3)	100 (1)
267-291	100 (1)	75 (8)	100 (3)	
292-317	100 (7)	100 (6)	100 (1)	100 (1)
318-342	100 (6)	100 (2)		
343-367	100 (1)	100 (2)		
368-393	100 (1)			
394-418		80 (5)		
419-443		100 (2)		
444-469		100 (3)		
470-494		100 (1)		
495-520		100 (1)		

Although emphasis was placed on determining recovery of fish in coves, fish also were tagged and released in a 19.2 ha open water area (OW3) and a 0.4 ha open water area (BN2). cove area C4 was the only area where marked fish were displaced from another area (OW3). Recovery was 78% for fish in OW3; whereas, 92% of the fish in C4 and 91% in 9 other cove areas were collected in the entire embayment (Table 5).

Percentage recovery of marked fish displaced into area C4 and recovered throughout the bay was nearly identical to the combined recovery rate of marked fish not displaced in the 9 remaining coves. Rate of escapement, however, was considerably greater from C4 than in the other cove areas. Sixty percent of the fish in C4 were recovered outside the area, while only 32% were collected in C4. Less escapement occurred in the other 9 cove areas where tagged fish were not displaced. The mean escapement from these areas was 16%; 75% were recovered. The capture and marking of fish in the same cove area to be sampled resulted in greater recovery and lower escapement, thereby making it a more desirable method of determining recovery rates. Recovery and escapement were less for fish tagged in OW3 than in the 9 cove areas.

Certain kinds of fish escaped from coves more frequently than others. Seven of 21 species tagged in 9 cove sections, excluding C4, were marked in adequate numbers (>43) to compare percentage escapement with the mean rate of 16% escapement for all fish (Table 6). White bass, bluegill, and common carp were the only fish of the 7 species that escaped at a greater rate than the mean. Percentage escapement for bluegill was slightly greater than the mean; whereas, escapement rate for white bass and carp was more than twice the mean.

TABLE 3. Percent recovery for each millimeter class of predatory and non-predatory food fish in Crooked Creek Bay, Barkley Lake. Number of fish tagged in each millimeter class are in parentheses.

Size range (mm)	Predatory food fish			Non-predatory food fish			
	Channel catfish	Gar	Bowfin	Carp	Drum	Castostomids	Yellow bullhead
114-139					100 (1)		.0 (1)
140-164	100 (1)				80 (25)	100 (1)	50 (2)
165-189	100 (2)				85 (26)		100 (2)
190-215	100 (1)				100 (10)	100 (1)	
216-240				100 (1)	86 (7)	75 (12)	100 (2)
241-266	100 (1)				100 (1)	91 (22)	0 (1)
267-291					100 (1)	100 (5)	
292-317	100 (1)				100 (1)	100 (5)	
318-342						100 (7)	
343-367						100 (2)	
368-393				100 (1)		100 (1)	
394-418		100 (2)		100 (2)		100 (1)	
419-443				100 (9)		100 (3)	
444-469				89 (9)		100 (3)	
470-494				89 (9)		100 (2)	
495-520				100 (7)		100 (1)	
521-545				75 (4)			
546-571				100 (1)		100 (1)	
572-596				75 (4)			
597-621				100 (3)			
622-647				100 (1)			
648-672							
673-697							
698-723							
724-748			100 (1)				

TABLE 4. Percent recovery for each millimeter class of prey fish in Crooked Bay, Barkely Lake. Number of fish tagged in each millimeter class are in parentheses.

Size range (mm)	Golden shiner	Yellow bass	Sunfish	Logperch
64- 88	0 (1)		100 (1)	
89-113			87 (165)	
114-139			90 (255)	100 (1)
140-164		100 (1)	93 (100)	
165-189		50 (2)	82 (39)	
190-215	100 (1)		100 (1)	
216-240	100 (1)		100 (1)	

TABLE 5. Fish recovery of marked fish in cove and open water areas in Crooked Creek Bay.

Area	Tagged	Percent recovery: Within each area	Outside each area	Total
9 cove areas excluding C4	757	75	16	91
Cove area C4[a]	100	32	60	92
Open water area OW3	129	68	10	78

[a]Fish were displaced from OW3

TABLE 6. Recovery of tagged fish in 9 cove areas, excluding area C4 where fish were displaced, in Crooked Creek Bay.

Species	Tagged	Percent recovered: in area	outside area
Gars	2		100
Bowfin	2	100	
Spotted sucker	44	86	11
Smallmouth buffalo	14	93	7
Yellow bullhead	1	100	
Channel catfish	4	50	50
White bass	47	53	38
Yellow bass	3	67	33
Bluegill	170	71	19
Longear sunfish	222	84	9
Redear sunfish	2	100	
Warmouth	7	43	43
Largemouth bass	102	81	6
Spotted bass	3	67	33
White crappie	11	73	9
Black crappie	2	100	
Sauger	1	100	
Logperch	1		100
Freshwater drum	63	67	16
Carp	53	58	34
Golden shiner	3	67	
Total	757		
Weighed mean		75	16

Escapement was never mentioned as a factor of incomplete recovery in the literature reviewed. The Barkley Lake rotenone study was a rare opportunity to document this type of behavior. Percentage escapement was much higher than anticipated and may have been exaggerated because of the longer than ususal period (almost a day) between the time block nets were set and the beginning of the rotenone study. During this time, fish exhibited a tendency to move toward open water (Table 7). Percentage of fish recovered outside their area of release increased progressively in each cove area located farther away from open water in the C and G coves except for G4. The sample of marked fish was too small in G4 to provide a reliable comparison. The percentage of fish crossing 1 block net

TABLE 7. Fish recovery for each sample area in Crooked Creek Bay.

Area	Size (hectares)	Tagged	mean depth (m)	Percent within area	recovered outside area
Coves					
C1	1.60	101	0.98	89	6
C2	0.62	100	0.94	76	17
C3	0.41	95	0.58	63	27
C4[a]	0.44	100	0.43	32	60
D	0.40	20	1.01	80	20
F	0.38	100	1.62	88	7
G1	5.39	108	1.77	70	6
G2	0.61	101	1.16	74	22
G3	0.28	104	0.94	55	23
G4	0.41	29	0.61	83	7
Open water					
OW3	19.21	129	2.04	68	10
BN2	0.35	1	2.13	0	100

[a]Fish were displaced from OW3.

was 17%; 33% crossed 2 nets; less than 1% crossed 3, 4, or 5 block nets. Percentage escapement varied from 7% in cove area F to 60% in C4.

As mean depth increased in coves and became similar to that in the adjacent open water area, escapement declined. A regression fitting mean depth to percentage escapement, when areas C4 and G4 were deleted, was significant ($p>0.04$). This suggests that a large enough cove area should be selected for sampling so that its mean depth resembles mean depth of adjacent open water as nearly as possible. Preferably, the study cove should be sampled out to its mouth. This will provide a more complete recovery and a better representation of the reservoir fish population.

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