Differences in Estimates Generated by Two Tag Types

Lee C. Keefer, *Georgia Department of Natural Resources, Game and Fish Division, 2024 Newton Rd., Albany, GA 31708*

Howard L. Wilson, *Georgia Department of Natural Resources, Game and Fish Division, 2024 Newton Rd., Albany, GA 31708*

Abstract: During 1978–1991, Floy FD-68B "T bar" type tags and Floy internal anchor tags were used on Lake Walter F. George to estimate exploitation of the largemouth bass population. Tag loss and non-reporting of tags by anglers were calculated in an attempt to adjust exploitation and total catch estimates. Over the 5-year period, tag loss averaged 20% per year for Floy FD-68B tag and <1% for the Floy internal anchor tag. Non-reporting of tags by anglers was estimated to be 33%. Based on tag returns, exploitation was estimated to be 23% for fish tagged with FD-68B tags and 28% for fish tagged with internal anchor tags. Estimates of the total catch of tagged bass were 48% and 58% for FD-68B and internal anchor tags, respectively. These estimates differed significantly by tag type used, even when adjusted for tag loss.

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The largemouth bass (*Micropterus salmoides*) is the most popular and economically important game fish in the Southeastern United States. Millions of dollars are spent annually by anglers fishing specifically for this species. Fishing pressure, particularly for largemouth bass, has increased steadily nationwide, and fisheries managers and anglers alike are expressing concerns about potential overharvest. As a result, a number of tagging studies were conducted in the Southeast in an attempt to estimate largemouth bass exploitation (Ager 1978, Yaeger and Van Den Avyle 1978, Folmar et al. 1979, Reed and Davies 1980, Coomer and Holder 1981, Keefer 1988). The results of these studies varied widely and were complicated by tag loss, tagging mortality, and non-reporting of tagged fish by anglers. Failure to compensate for these factors can result in a serious underestimation of the harvest of fish (Ebner and Copes 1982, Muoneke 1992).

During 1987–1991, a tagging study was conducted on Lake Walter F. George to estimate angler exploitation of the largemouth bass population using both Floy FD-68B "T bar" type tags (Dell 1968) and Floy internal anchor tags. The FD-68B type tag is widely used to mark a variety of fish species, due to its ease of use and

moderate cost. The FD-68B comes in a convenient clip of 25 tags that can be rapidly inserted using a self feeding tagging gun. In contrast, the internal anchor tag is more costly and must be implanted through a small incision in the abdominal cavity. In addition, each tag must be handled individually, resulting in a marked increase in processing time.

The purpose of this paper is to discuss differences in tag loss, tag return, exploitation, and total catch rate estimates generated by the 2 different tag types. This project was funded in part by the Federal Aid in Sport Fish Restoration Project F-28, Georgia.

Methods

Lake Walter F. George, a 17,600-ha reservoir, is located on the Chattahoochee River between Fort Gaines and Columbus, Georgia. This reservoir, created in 1962 by the U.S. Army Corps of Engineers for navigation and power generation, is 137 km long and over 3.2 km wide at its widest point. It has approximately 1,030 km of shoreline. The total drainage area of the reservoir is 1,932,955 ha (U.S. Army Corps Eng. 1974). This lake is a mainstream impoundment that floods onto the old river flood plain in the lower part of the reservoir (Keefer 1988).

During February and March of each year, largemouth bass ≥305 mm were collected by electrofishing, tagged with either a single FD-68B "T bar" tag, double FD-68B tags, or 1 FD-68B tag and 1 internal anchor tag. The lake shoreline was divided into 20 areas approximately equal in length to provide replicate samples. Bass were not tagged in each area each year, but a minimum of 6 replicates per year were used for each tag type. FD-68B tags were placed through the pterygiophores at the rear of the soft dorsal fin (Wydoski and Emory 1983). Single tags were placed on the left side of the fish, and the second tag was placed on the right side of the fish, just anterior to the insertion of the first tag. All tags were individually numbered and contained the legend "Reward Georgia DNR 912-430-4256." (DNR is the Department of Natural Resources.) Internal anchor tags had the legend printed on the external vinyl tubing and the 13-mm oval disk that was inserted into each fish's abdomen. Internal anchor tags were inserted on the left side of the fish in the posterior part of the abdominal cavity through a vertical incision 6–8 mm long.

A $5.00 reward was offered for each returned tag with an additional incentive of an annual drawing for a $100–$500 prize. Posters were placed at all boat ramps and at bait and convenience stores around the reservoir informing the public of the reward system. News releases were prepared for local newspapers and talks were given to local sportsman's groups to inform the angling public about the tagging study. Pre-printed, postage paid envelopes were placed at all bait and tackle stores around the reservoir so that anglers could return their tags with a minimum of inconvenience. Information requested on each return envelope included the angler's name, address and phone number, the date the fish was captured, and whether or not the fish was released. This last question was added to avoid the catch/release bias discussed by Garner et al. (1984).

Anglers were instructed to remove all tags upon catching a fish, whether they planned to release it or not, to provide a better estimate of total catch. A weakness of this method is that fish caught by anglers and released were not counted as harvested and were still vulnerable to future exploitation. Some of these fish were harvested at a later date and were not counted as harvested since the tags were removed by the previous angler. As a result, exploitation and catch were underestimated to some degree. Fortunately, the effect of subsequent capture of released fish should be independent of tag type and should not bias the comparison of tag types.

Data from each fish tagged was entered into a computer database file, and when a tag was returned, all information about that fish's capture was entered into the file. When a tag was received without an envelope or with an incompletely filled out envelope, a follow-up letter was sent to that angler which requested the required information. If this failed to produce a response, a second follow-up letter was sent, and if necessary, a telephone call was placed to obtain the needed information. Fish that were still lacking some information after these efforts failed were assigned a "?" for the missing data. When calculations were made requiring the use of a data set containing missing data, values were apportioned based on the proportion of answers in the data set with complete answers.

Tag Loss

In order to evaluate tag loss, most previous investigators (Pitlo 1992, Ager 1978, Wilbur and Duchrow 1972, Latapie 1968) have marked and released fish, recaptured them after a preplanned time period had elapsed, and then reported tag loss as the percent of tags lost after X months (years, days, etc.) at large. Attempting to use this rate in an exploitation study based on angler returns raises some problems, since tags are being returned by anglers during the entire time period and at a non-linear rate (since fishing pressure and harvest vary greatly by season), and the tag loss estimate is based on a mass recapture by the investigator at a fixed point in time. The adjustment of exploitation rates from this data requires some mathematical manipulation to accommodate the non-point, non-linear nature of angler harvest. To do this, a number of assumptions have to be made concerning the comparability of the point estimate of tag loss as measured by the investigators to the non-linear tag loss experienced by angler caught fish.

To avoid these problems in our study, tag loss was evaluated by monitoring the returns of double tagged fish by anglers. When an envelope was received containing only 1 tag from a double-tagged fish, an inquiry letter was sent to that angler. This letter informed the angler that the fish had 2 tags when it was released and asked if it still had both tags when captured. If this letter was not answered, a second follow-up letter was sent and, if necessary, the angler was contacted by telephone to determine the status of each double-tagged fish when a single tag was returned.

Tag loss was, then, estimated to be the percent of returns for double-tagged fish during the 12 months following tagging that had lost 1 tag. Since fish subject to tag loss were theoretically returned at the same rate as all tagged fish and were

assumed to be subject to the same rates of disappearance from the population, a simple tag loss correction factor was determined from the equation: C = 1/(1–(L/R)), where C = the correction factor, L = the number of double-tagged fish that lost a tag, and R = the total number of double-tagged fish reported captured by anglers during the 12-month period following tagging.

Non-reporting

A file was maintained of all telephone inquiries received at the Albany or Dawson offices concerning the return of fish tags. Whenever possible, the person's name and address, phone number, and the tag number were recorded during the initial phone call. Inquiries were then compared to actual tag returns at the end of the year to estimate the percentage of non-reporting. A second estimate of non-reporting was obtained by asking the creel clerks to record tag numbers of any fish they observed in an angler's creel, but not to alert the angler to the presence of the tagged fish. This information was then compared with known returns of tags to provide a second estimate of non-reporting. A tag loss correction factor was then calculated using the formula: C = 1/(1–(*N*/I)), where C = the correction factor, *N* = the number of fish not reported, and I = the total number of inquiries or creel clerk observations.

Exploitation

Exploitation rates were calculated using the equation: E = (H/M)C, where E = exploitation, H = number of tagged bass harvested (caught and kept) during the 12 months following each year's tagging, M = total number of largemouth bass tagged, C = correction factor for non-reporting and tag loss. Total catch rate was calculated in a similar fashion substituting the total number of tagged fish caught (including those released by anglers) for the total number of bass harvested.

Statistical Analysis

Exploitation and total catch were estimated each year for each tag type for each of the 20 possible shoreline replicates that were sampled. Sample size (number of replicates sampled) varied from year to year because fish were not tagged in all areas every year, due to logistic and budgetary considerations. The overall annual rates of exploitation and catch were calculated using all replicates for all years for each tag type, and the Mann Whitney U test was used to evaluate for significant differences between tag types. (Statistix 4.0, Anal. Software, St. Paul, Minn.).

Results

Tag Loss

Angler reported tag loss for FD-68B tags ranged from 7.8% in 1990 to 25.2% in 1988 and averaged 20.0% for the 5-year study (Table 1). Because of the high variation in tag loss, different correction factors for each year were used for FD-

Table 1. Tag loss of Floy FD-68B and internal anchor tags from largemouth bass of Lake Walter F. George, Georgia. Data represents angler tag returns up to 1 year after tagging. FD-68B loss is shown for fish tagged with the FD-68B/internal anchor tag combination, double FD-68B tags, and a weighted average based on both tag combinations.

	1987		1988		1989	1990		1991	Totals	
	FD-68B + Internal anchor	Double FD-68B	FD-68B + Internal anchor	Double FD-68B	Internal anchor	FD-68B + Internal anchor	Double FD-68B	FD-68B + Internal anchor	FD-68B + Internal anchor	Double FD-68B
Number tagged	289	466	361	381	491	495	59	574	2,210	906
Total *N* caught	134	170	144	114	218	225	19	199	920	303
Number FD-68B lost	11	19	35	30	41	14	5	36	191	54
Percent FD-68B loss	8.2%	11.2%	24.3%	26.3%	18.8%	6.2%	26.3%	18.1%	20.8%	17.8%
95% CI	4.9–11.5%	7.4–15.0%	19.7–28.9%	21.7–30.9%	15.2–22.4%	4.0–8.4%	14.1–38.5%	14.9–21.3%	19.1–22.5%	15.3–20.3%
Wtd. avg. FD-68B loss	9.9%		25.2%		18.8%	7.8%		18.1%	20.0%	
95% CI	7.7–12.1%		22.0–28.4%		15.2–22.4%	5.5–10.1%		14.9–21.3%	18.6–21.4%	
Correction factor	1.11		1.34		1.23	1.08		1.22	1.25	
N Int. anch. lost	0		1		2	1	2	6		
% Int. anch. loss	0%		<1%		<1%	<1%	1%	<1%		

68B tags. Tag loss for the internal anchor tag ranged from 0% in 1987 to 1.0% in 1991 with an average rate of loss of <1%. Because of the low rate of tag loss, no correction factor was deemed necessary for internal anchor tags.

Non-reporting

A total of 575 telephone inquiries from anglers requesting information about tagged fish were received in the Albany and Dawson offices over the course of the 5-year study. Of these 575 inquiries, 131 anglers failed to return the tag after receiving instructions on how to do so, for a non-reporting rate of 23%. Another estimate of non-reporting was obtained from creel clerk observations of tagged fish. Clerks observed a total of 86 tagged bass during the 5-year study, 37 marked with internal anchor tags and 49 marked with FD-68B tags. Thirteen (35%) of the fish marked with internal anchor tags were not returned and 15 (31%) of the fish marked with the FD-68B tags were not returned. If data from both tag types are pooled together, the overall rate of non-reporting was 33%.

Exploitation

Estimates of exploitation were calculated for each year and for each tag type. Exploitation of FD-68B tagged fish ranged from a low of 16% in 1991 to a high of 31% in 1988 (Table 2). Estimates for exploitation of fish marked with internal anchor tags ranged from 22% in 1991 to 35% in 1987. The overall rate of exploitation was 23% for FD-68B tagged fish and 28% for internal anchor tagged fish. This difference was significant at the 0.05 level with the Mann Whitney U test.

Total Catch of Tagged Bass

Estimates of the total catch of tagged bass ranged from 43% in 1991 to 57% in 1988 for FD-68B tagged fish and 48% in 1991 to 68% in 1987 for fish marked with internal anchor tags. The overall total catch rate estimate was 48% for FD-68B tags and 58% for internal anchor tagged fish. This difference was significant at the 0.001 level with the Mann Whitney U test. Estimates of catch rates for fish tagged with internal anchor tags were higher for all years than fish tagged with FD-68B tags. Exploitation estimates for fish tagged with internal anchor tags were also higher for all years except for 1988. This single incidence of a high exploitation rate for FD-68B tagged fish may have been the result of the higher tag loss correction factor that was used that year. Raw exploitation, not corrected for tag loss or non-reporting, was also higher for fish tagged with internal anchor tags for all years.

Discussion

The differences observed in the estimate of non-reporting generated by telephone inquiries and creel clerk observations were probably due to a difference in what each technique was measuring. Non-reporting can be broken into 2 distinct components. One component is non-recognition, where the angler does not see the

Table 2. Exploitation and total catch of tagged largemouth bass in Lake Walter F. George, 1987–91. Estimates are given for 2 different tag types and are adjusted for tag loss and non-reporting. In 1991, a total of 426 bass were tagged with only an internal anchor tag and 574 with both an internal anchor and a FD-68B tag, for a total of 1,000. During all other years bass tagged with internal anchor tags were also tagged with a FD-68B tag.

	1987		1988		1989		1990		1991		Totals	
	Internal anchor	Single FD-68B	Internal anchor	Single FD-68B	Internal anchor	Single FD-68B	Internal anchor	Single FD-68B	Internal anchor	Single FD-68B	Internal anchor	Single FD-68B
N tagged	289	530	361	1,077	491	897	495	787	1,000	564	2,636	3,855
N kept	65	78	64	161	105	89	102	80	142	49	478	457
N released	61	54	72	134	100	115	106	114	172	81	511	498
N caught twice	2	0	4	0	2	0	5	0	2	0	15	0
Status unknown	6	3	4	18	11	17	12	6	11	7	44	51
% released	48.4%	40.9%	52.9%	45.4%	48.8%	56.4%	51.0%	58.8%	54.8%	62.3%	51.7%	52.1%
Total kept	70	80	70	171	113	96	113	82	149	52	514	481
Raw exploitation	24%	15%	19%	16%	23%	11%	23%	10%	15%	9%	20%	12%
Non-reporting factor	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46
Tag loss factor	1	1.11	1	1.34	1	1.23	1	1.08	1	1.22	1	1.25
Adjust. exploitation	35%	24%	28%	31%	33%	19%	33%	17%	22%	16%	28%	23%
95% CI	30–41%	21–28%	24–33%	28–34%	29–38%	17–22%	29–38%	14–19%	19–24%	13–19%	27–30%	22–24%
Total catch	68%	41%	58%	57%	65%	44%	66%	40%	48%	43%	58%	48%
95% CI	62–73%	37–46%	53–63%	54–60%	61–69%	41–48%	62–71%	37–44%	45–51%	39–48%	56–60%	46–49%

tag in the fish or does not recognize it as a tag. The other component of non-reporting is non-response, where the angler recognizes the tag and either does not understand that the tag should be sent to the proper authorities, or is not sufficiently motivated to follow through.

Monitoring of telephone inquiries failed to measure non-recognition, because the angler must have already recognized the tag in order to inquire about it, while tag observations by the creel clerks measured both components, and probably provided the best estimate of non-reporting. This method still probably underestimated non-recognition, since the additional handling of tagged fish by the angler passing them to the creel clerk would increase the chances that the anglers would notice the tag.

Fish caught and released immediately by anglers were not seen by the clerks, and these fish would no doubt be subject to a higher rate of non-recognition than fish held in coolers or live wells, due to the limited amount of handling by the angler. Since anglers released an average of 52% of all tagged bass caught, underestimating non-recognition could result in a significant underestimate of the total catch of tagged bass. Because creel clerk observations of tagged fish provided the best estimate of non-reporting, the correction factor generated from this method was used for correcting exploitation and total catch of tagged bass estimates.

Other investigators have reported relatively high tag loss with FD-68B type tags from largemouth bass and other species. Pitlo (1992) reported an annual loss rate of 39% for Floy tags (presumably FD-68B type) based on the recapture of fin clipped and tagged largemouth bass 1 year after tagging. Wilbur and Duchrow (1973) observed a tag loss of 12% after 3 months for largemouth bass held in hatchery ponds. Dunning et al. (1987) observed results similar to the present study with a double tagging experiment on striped bass in the Hudson River, where loss of internal anchor tags was 2% after 1 year, compared to 58% for FD-68B tags. Waldman et al. (1991), in a follow up study, found that tag loss for the 2nd through 6th recapture years was 2% and 98% for internal anchor and FD-68B tags, respectively. These estimates are not directly comparable to the tag loss estimates of the current study, because they are point estimates based on mass recaptures at fixed points in time and not based on tag loss as tags were being returned by anglers. However, they do indicate a relatively high loss rate for FD-68B tags.

Other investigators have also reported observing lower return rates for fish marked with FD-68B type tags. Data presented by Hammond and Ager (1975) indicates a relatively low return rate for largemouth bass tagged with FD-68B tags (18 of 322, or 3.6%) over a 15-week creel survey, compared to the return rate for fish tagged with monel strap tags (10 of 150, or 6.7%). They do not discuss this difference or offer any possible explanation, however.

There are several potential causes for the differences in observed exploitation and total catch rates for the 2 tag types. One possibility is that the fish are actually being exploited at a higher rate because of the internal anchor tag. Another possibility is that the different tag types are causing differential tagging mortality, resulting in fewer FD-68B tagged individuals being in the population available for recapture than the number tagged would indicate. Both of these possibilities seem

to be unlikely causes for the observed results. It seems doubtful that differences in the type of tag made bass more or less vulnerable to angling. The possibility of differential tagging mortality also seems unlikely since tagging mortality with tags placed similarly to the FD-68B tags has been reported to be relatively low (Kirkland 1962, Folmar et al. 1979). It might be expected that the internal anchor tag would be more likely to cause higher mortalities than the FD-68B, due to the more invasive surgery required to implant it; however, Weathers et al. (1990) found tag induced mortality to be negligible for largemouth bass tagged with internal anchor tags, and the higher exploitation and catch rates observed for this type of tag in the current study also support this conclusion.

Another explanation for the difference in estimates produced by the 2 tag types is the possibility that the estimates of tag loss and non-reporting were somehow biased to produce lower estimates for FD-68B tagged fish. Both methods of estimating non-reporting (telephone inquiries and creel clerk observations) seemed to measure non-reporting adequately, but may have provided an underestimate of non-recognition. Creel clerk observations probably provided the best estimate of total non-reporting since anglers had to both recognize the tag and then return it for the reward. Examination by fisheries section personnel and by anglers of recaptured fish that had been at large for a number of months indicated that the FD-68B tags become discolored with algal growths similar to the discoloration and growths observed by Hedgepeth et al. (1978) and Pitlo (1992). FD-68B tags also tended to lay closely along the dorsal surface of the fish, making them less visible to anglers. Because of the semi-rigid tubing, the internal anchor tag tended to protrude at right angles from the fish's abdomen and appeared to be much more visible to the casual observer than the FD-68B. The internal anchor also seemed less likely to become incrusted with algal growth. As a result, this tag was probably much more apparent to the angler and this could have contributed to the higher estimates of exploitation and total catch observed for fish tagged with it. The non-reporting rates observed by the creel clerks (35% for internal anchor tags, compared to 31% for FD-68B tags), however, do not support that assumption. Because the differences were not statistically significant (probably due to the small sample sizes involved) the possible impact of differences in non-recognition should not be dismissed without further investigation.

From our experience, internal anchor tags will provide a more reliable estimate of the true level of largemouth bass exploitation than the FD-68B type tag. The methods used to adjust exploitation rates for non-reporting and tag loss apparently did not adequately correct the estimates obtained with the FD-68B tag. The lower visibility to anglers of FD-68B tag and the high and variable rates of tag loss observed for this type of tag are sources of sampling variability that would be desirable to avoid. The consistently lower estimates of exploitation and total catch of tagged bass generated by the FD-68B tag also seem to be serious drawbacks that should be considered when a tag is selected for research purposes.

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