Movements, Home Range, and Survival Estimation of Largemouth Bass following Displacement

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Abstract.- The fate of largemouth bass Micropterus salmoides displaced in tournaments can be defined in terms of whether or not fish return to previously held home ranges at the site of capture, as well as their survival following displacement. A biotelemetry experiment on displaced largemouth bass that addresses both of these issues in a northern site, Rideau Lake, Ontario, Canada is summarized. Largemouth bass were displaced over a range of distances (1.5-16.5 km) and their movements and home range characteristics were compared to fish that were not displaced. Disp laced largemouth were followed for a year after displacement to determine if they returned close to their site of capture. Disappearance of radio-tagged bass was used to determine seasonal patterns in survival following displacement. It took approximately two weeks for displaced bass to move more than 400 m from the release site. The overall rate of return was 37 percent (7 of 19 fish), with three of the seven bass returning in the spring of the year following displacement. No fish displaced greater than 8 km from their capture site returned to their home range. There was no difference in the home range area of displaced and nondisplaced bass. Survival over the fishing season was based on the disappearance of radio tags and was estimated by the known fate model of survival analysis. This estimate of survival (Mean S = 0.587; se = 0.099), when combined with estimates of natural mortality for the nonfishing season, points to an apparent improvement in the overall survival rate of largemouth bass in Rideau Lake, relative to data collected twenty years ago.

Introduction

Ecological issues surrounding bass tournaments focus largely on the fate of displaced fish, whether defined in terms of mortality or a return to previously held home ranges (Schramm et al. 1991). Despite a generally sharper focus on mortality and displacement issues related to bass tournaments, the attitude of nontournament anglers remains skeptical, with respect to the survival chances of tournament caught fish (Wilde et al. 1998). In part, the skepticism seems justified. A recent summary of mortality in black bass tournaments has demonstrated some reduction in mortality over the last 30 years, with implementation of better handling procedures (Wilde 1998). Despite increased attention, however, the interaction between water temperature and handling procedures continues to be a persistent challenge in reducing tournamentrelated mortality. This challenge seems to stem from the exponential relationship between water temperature and mortality (initial and delayed) in tournaments (Wilde 1998). Since many tournaments are held in locations with very high summer temperatures, the temperaturemortality relationship may represent a barrier through which current tournament practices cannot significantly improve survival.

Displacement in bass tournaments occurs following handling, when fish are not returned to sites of capture. There appears to be differences in return rates between smallmouth bass Micropterus dolomieu and largemouth bass Micropterus salmoides in biotelemetry studies that displace fish. In an Ontario, Canada study (Ridgway and Shuter 1996), 15 out of 18 (83%) displaced smallmouth bass, fitted with ultrasonic transmitters, returned to previously held home ranges. Home range size and seasonal patterns of use did not differ between displaced and control bass in the Ontario study. In New York, the average percent return of largemouth bass to capture sites in three tournament locations was 26 percent (Cayuga Lake, Saratoga Lake [after removing dead or lost radiotagged fish], Hudson River; Stang et al. 1996). In the upper Chesapeake Bay region, 43 percent and 33 percent of displaced largemouth bass returned to the Susquehanna and Northeast Rivers, respectively, after displacement (Richardson-Heft et al. 2000).

Mortality in bass tournaments occurs following handling (initial mortality) and after fish are returned to the water (delayed mortality). The survival of bass continues with the dominating question of the fate of tournament-caught fish. A recent summary on the mortality of bass in 130 tournaments has demonstrated some reduction in mortality over the last 30 years, with the implementation of better handling procedures (Wilde 1998). All of the tournaments, however, held fish in some kind of enclosure as a means of assessing survival, with less than six percent of the tournaments reporting survival estimates for fish held for more than one week (Wilde 1998). Two assessments of tournament related mortality in northern sites demonstrated that cooler temperatures helped lower initial and delayed mortality for fish held in enclosures (Kwak and Henry 1995; Hartley and Moring 1995).

The objective of this study is to determine the effects of displacement on the movements, home range, and survival of largemouth bass fitted with radio and ultrasonic tags in a northern lake, Rideau Lake, Ontario. Largemouth bass were displaced in a tournament fashion to determine if they returned to previously held home ranges. Survival was estimated over the summer and fall following displacement, using the disappearance of radio tags as a means of calculating seasonal patterns of survival (White and Garrott 1990).

Methods

Study Site

Data were collected on the movements of 55 largemouth bass from early June through October in 1996,1997, and 1998 in Rideau Lake (44°46'15" N; $76^{\circ}12'46''$ W) in eastern Ontario. Rideau Lake (area = 5.761 ha: mean depth = 13.3 m) is a complex system that stretches 35 km, with the portion south of the Rideau Ferry bridge known as "Big Rideau," and to the north of the bridge known as "Lower Rideau." The lake contains both an oligotrophic cold water fish community, with lake trout Sa/velinus namaycush as the top predator, and a warm water fish community dominated by centrarchid species occupying broad shallow areas (> 10 m depth) of the lake. In this study, efforts were largely restricted to the shallow warm water areas of the lake, because competitive fishing tournaments focusing on bass occur in the summer months (21 tournaments, 1996-2000).

Biotelemetry Implants

Fish were located using either ultrasonic or radio tags surgically implanted in the body cavity (Winters 1996; Ridgway and Shuter 1996). Ultrasonic tags (Sonotronics, Inc., CTT-83 tag: 60 mm long x 16 mm diameter, 8 g in water) were used in 1996 to determine if largemouth bass occupied depths beyond the general detection range of radio receivers (generally below 10 m depth) at any time in the season. This is particularly relevant during the fall, when bass may move to deeper depths prior to the winter period, as we found for smallmouth bass (Ridgway and Shuter 1996). We found that large mouth bass in Rideau Lake rarely went below 10 m in depth throughout their active foraging season. Following the 1996 field season, radio tags (Loteck Inc.) were used for purposes of greater range in locating individual animals. All fish used in this study were angled in late June and early July, and implanted with an ultrasonic (1996) or radio tags (1997 and 1998). Their position was determined using triangulation. GPS positioning (50 m accuracy) when sound was omnidirectional or for positioning fish when associated with obvious landmarks nearshore (points, embayments) on detailed topographic maps. A minimum of three or four days per week were spent searching for fish implanted with tags. Fish ranged in size from 36.0 to 46.0 cm forklength, and ranged in age from 6 to 13 years. All fish were of a size that is routinely kept by tournament anglers.

Natural Movements (1996, 1998)

Movements and home range area were determined for a set of reference fish, for the purpose of comparison to displaced fish. In a previous study, focusing on smallmouth bass (Ridgway and Shuter 1996), reference and displaced fish were followed in the same year after home range area was determined for both groups of bass. In that study, after home ranges became apparent in the early summer, specific freeranging smallmouth bass fitted with ultrasonic transmitters were targeted for displacement. In this study, data from nondisplaced large mouth bass were collected in the year preceding (1996) and following (1998) the displacement experiment (1997) in large part because of the logistical difficulty in targeting and capturing specific fish.

Twenty ultrasonic tags and twelve radio tags were implanted into largemouth bass in 1996 and 1998, respectively. Thirteen ultrasonic and eight radio tags provided adequate data to estimate home range area (N= 21 fish; median number of fixes per fish = 53; range of fixes per fish = 27-70; total number of fixes = 1,048). The remainder of the tags did not provide adequate data for area calculations. Data on movements and home range from nondisplaced largemouth bass were used in comparison with displaced largemouth bass.

Displacement Experiment (1997)

In the third week of June 1997, 27 largemouth bass from a variety of locatibns in Rideau Lake were captured by a group of volunteer anglers, then surgically implanted with radio tags, and displaced to predetermined locations. Anglers marked capture and release locations on maps. They were assigned predetermined release locations (bays and points of land) to ensure a range in displacement distances. Exact locations of release within predetermined sites were left to the discretion of the anglers. Data collected in 1996 and 1998 indicated that largemouth bass remained in restricted home ranges into the fall of each year (see Results). This information on movements in an undisturbed state (1996 and 1998) was used in 1997 to assign the capture location of largemouth bass as being within their home range. Thirteen displaced largemouth bass had sufficient data to calculate home range (median number of fixes per fish = 32; range in fixes per fish = 20-43; total number of fixes = 401).

Movement Analysis

Fixes from fish in the field were positioned on maps using UTM coordinates. The grid cell method (50 x 50 m), including "influence cells" (i.e., all eight cells surrounding a single cell containing observations), was used to calculate the area of the home range (e.g., Voigt and Tinline 1980; Miller and Menzel 1986; Doncaster and MacDonald 1991; Zoellick and Smith 1992; Ridgway and Shuter 1996). This basic perimeter summary was chosen over other methods, such as the minimum convex polygon, because the latter approach incorporated large areas of home range that never contained fixes (i.e., deeper water and land). In addition to estimating home range area for reference and displaced fish, distance moved one

month after release was compared between the two groups of fish. Distance data were log transformed to stabilize variances (F = 1.853; P = 0.183).

Survival Analysis (1997)

The sixteen week period from 29 June 1997 to 18 October 1997 was divided into eight, two-week long periods. The potential disappearance of the 27 displaced largemouth bass implanted with radio tags, in each of the eight time periods, was used to determine seasonal patterns of survival of this group of fish. Program MARK (White and Burnham 1999) was used to estimate survival under the "known fate model". This model of survival estimation is a special case of the CormackJolly-Seber method, where recapture probability for each fish is known with certainty (Le., 1.0). Use of radio tagged animals can be used to estimate survival, since the fates of individuals are presumably known, and a time period associated with any death or disappearance can be assigned. In this study, disappearance of largemouth bass was assessed in two ways. First, 6 of the 27 bass were caught and kept by anglers based on a return of the radio tag or information provided by anglers and observers (four fish) or by locating the bass in a holding tank (one fish) or on a stringer (one fish). Second, 4 of the 27 bass disappeared in midsummer after following their movements and fixing their locations continuously for a number of weeks. This kind of disappearance was unusual since all nondisplaced bass (1996 and 1998) had never made moves of a magnitude that could lead to a disappearance. When these fish disappeared, lakewide searches were undertaken repeatedly in an attempt to locate the missing fish. Searches included capture sites and all possible routes of return from release sites. Searches also included areas of the lake beyond the limits of the displacement experiment. We concluded that these fish were either captured by anglers or died and settled into deeper areas of the lake that were inaccessible for detection using radio technology. In one case, a displaced largemouth bass disappeared in mid-September and was not located again. Some largemouth bass in our set of nondisplaced fish (1996 and 1998) did move away from their home range as the lake cooled at this time of the year. It was possible that this fish moved away, and was neither caught nor died in the lake during our observation period. For these reasons, I did not include this fish in the estimate of survival. The survival analysis was, therefore, based on the loss of 10 fish out of a set of 26 fish.

The survival analysis of radio-tagged large mouth bass provided an estimate of survival (5) during the 112 day fishing season. This estimate was converted to an instantaneous rate of total mortality (2; Ricker 1974) for the fishing season. An estimate of instantaneous natural mortality (M = 0.303; se = 0.073, with tag loss accounted for; Shuter 1971) from Nogies Creek, Ontario, Canada approximately 250 km west of Rideau Lake, was used to obtain, by difference, the instantaneous rate of fishing mortality (F = 2 - M) after pro-rating M to the 112 day fishing season. The estimate of M (0.303) for the year is within the 25th (M = 0.24) and 75th (M = 0.63) percentiles of instantaneous natural mortality for largemouth bass in North America (Beamesderfer and North 1995). Based on the review of North American da ta, an equation predicting M from latitudinal position provided an es

timate for Nogies Creek of M = 0.42. This estimate is within the 95 percent CI (0.16--0.45) for the estimate of M, based on Jolly-Seber mark-recapture methods (Shuter 1971). Therefore, M = 0.303 was used to examine further instantaneous rates of mortality.

In addition to estimates of survival and mortality available from the radio-tagged bass, age frequency data were available for estimating mortality from trapnet sampling in Rideau Lake in 1981 (MacLean and Clayton 1981), and from the age distribution of radio-tagged fish in this study. The Robson-Chapman estimator of total survival (5) was used to estimate mortality for these age frequency data (Robson and Chapman 1961).

Results

Movements and Home Range

Largemouth bass were displaced over a range of 1.5 krn to 16.5 krn from their capture site (Figure 1). Of the 27 fish displaced, 8 were captured by anglers or disappeared in the weeks following displacement and, therefore, were not included in the pool of the 19 remaining largemouth bass that could return to capture sites. Of these 19 largemouth bass, 4 returned approximately three to four weeks after displacement in the summer of 1997, and 3 returned in the spring of 1998. Overall, 37 percent of displaced large mouth bass returned to their capture site. All fish that returned were displaced within 8 km of their capture site (Figure 1). In general, over one week passed (mean =8.6 days) for fish to move approximately 200 m (mean = 185 m; 95% confidence interval = 114-297 m) for those largemouth bass that eventually moved more that one kilometer from their release site (N = 8 fish). Over two weeks passed (mean = 15 days) prior to fish moving more than 400 m (mean = 458 m; 95% confidence interval = 230-914 m) from the release site for the same group of largemouth bass. Overall, after one month, dis placed largemouth bass moved a further distance from the release site than reference fish moved in their home ranges over the same one month period (Figure 2; chi-square = 29.3; P < 0.001).

The estimates of home range area did not differ between largemouth bass displaced from capture sites in 1997 (mean = 16.7 ha), relative to those released at capture sites back into their home range in 1996 and 1998 (mean = 17.6 ha; Table 1).

Survival

The fishing season was divided into eight, two-week long periods (112 days) beginning on 29 June and



Figure L The frequency distribution of displacement distances for largemouth bass. Asterisks indicate the number of fish in each displacement interval that returned to previously held home ranges.



Figure 2. The net distance (meters) moved for reference (1996, 1998) and displaced (1997) largemouth bass one month after release.

ending 18 October. Based on the known fate model, the overall survival estimate for the fishing season was 0.587 (Lower 95% CI = 0.390; Upper 95% CI = 0.760; Table 2). Late in the fishing season bass with telemetry tags were not removed from the population for a period of time after the weekend holiday, during Labor Day, in early September. Prior to this period, the two lowest estimates of mean survival occurred in the period at the start of the fishing season (29 June-12 July; 5 = 0.850; se = 0.080) and in the period that included the Labor Day weekend (24 August-6 September; 5 = 0.889; se = 0.074). Time periods where one might expect brief increases in fishing effort (opening weekend and holidays) appear to correspond to some decline in fish survival.

The survival estimate can be converted to instantaneous rates to determine the relative contributions of fishing and natural mortality (Table 3). The probability of surviving the fishing season (5 = 0.587) represents an instantaneous total mortality rate (Z) for thi6 period of 0.533 (Ricker 1974). The Jolly-Seber estimate for natural mortality in a sanctuary population provides an annual estimate of instantaneous natural mortality rate, M = 0.303 (se = 0.073) (Shuter 1971). Using Z for the fishing season and pro-rating M for the nonfishing season (253 days; M = 0.210) provides an annual estimate of instantaneous total mortality (Z = 0.743). Subtracting the instantaneous natural mortality rate for the nonfishing season (M = 0.210), from the annual estimate (M = 0.303), provides an estimate of instantaneous natural mortality for the fishing season (M = 0.093). The instantaneous fishing mortality for the fishing season in 1997 was, therefore, 0.440 (F = Z - Z)M). Based on these values, it appears that 71.7 percent of all annual mortality in Rideau Lake occurs in the fishing season. Within the fishing season, 82.5 percent of the instantaneous total mortality is attributable to anglers ($F/Z = 0.440/0.533 \times 100$). On an annual basis, this represents 59.2 percent of annual instantaneous total mortality that can be attributed to anglers.

The estimate of annual survival (5), can be compared to estimates of 5 based on age frequency distributions from trapnet catches of largemouth bass made in 1981 (MacLean and Clayton 1981), and from angler-caught bass used for radio-tracking in 1997 (Table 4). Based on the Robson Chapman estimator of annual survival from catch curves (Robson and Chapman 1961), the estimate of 5 based on age frequency data from radio tagged bass (mean 5 = 0.474) closely matches the annual estimate based on radiotracking data (mean S, 0.478; Table 4). The point estimate for 1981 (mean 5 = 0.426) was below the 1997 estimates for both radio-tracking and age distribution of radio-tagged bass. Although the confidence intervals largely overlap among the estimates, the upward shift in the estimates for 1997, relative to 1981 data, suggests that survival may be higher now than in the past.

To further explore this possible shift in survival, mean values of annual survival (Table 4) were used as point estimates and converted to instantaneous rates (Table 3; Ricker 1974). The instantaneous rate of natural mortality was based on Shuter (1971) and partitioned into fishing and nonfishing seasons as above. Converting to an instantaneous total mortality rate (Z = 0.853), fishing mortality (F = Z - M) for this earlier period was higher (F = 0.550; Table 3b) than in 1997 (F = 0.440; Table 3a).

This represents a reduction of approximately 20 percent in the instantaneous fishing mortality rate from 1981 to 1997.

Discussion

The results of this study address two important questions concerning the fate of largemouth bass displaced in a tournament fashion: First, most largemouth bass displaced in this study did not return to areas of initial capture. Only fish within 8 km of their original capture site returned (7 of 15 bass displaced within 8 km; Figure 1) with three fish not returning until the following spring. Overall, 37 percent of displaced largemouth bass in this study returned to original capture areas. Despite the low fidelity to original home ranges once displaced, the home ranges of largemouth bass in this study did not differ between reference and displaced fish (Table 1). Second, this study provided a survival estimate of largemouth bass following displacement that represented the duration of the fishing season (5 = 0.587). Incorporating natural mortality, based on an earlier tagging study of a sanctuary population of largemouth bass (Shuter 1971), the annual estimate of survival in this study is higher than an estimate from 1981 in Rideau Lake (MacLean and Clayton 1981).

There appear to be clear differences between largemouth and smallmouth bass in their movements. In an earlier study, a high percentage of smallmouth bass returned to previously held home ranges when displaced over a range of distances used in this study (Ridgway and Shuter 1996). In a New York study, 26 percent of largemouth bass returned to previous capture locations when all sites were combined. In this study, 37 percent of large mouth bass returned, with some taking up to a year to return. These observations are similar to return rates observed in the upper Chesapeake Bay (33% and 43%; Richardson-Heft et al. 2000). Similarities between this study and the New York study also included fish that returned relatively quickly, while others required months. Largemouth bass that require months to return to capture sites appear to be present, along with fish that take only a few days to weeks after displacement. With the exception of two largemouth bass that returned 18 km to capture sites in New York, data from Ontario and New York indicate that few, if any, fish return from displacement greater than 8 km from the site of original capture. Despite this lack of a high return rate, however, home ranges of displaced and control fish are similar in size for largemouth bass in Rideau

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Table 1. Home range areas of displaced and reference largemouth bass in Rideau Lake.

	Home range area		Number of fixes	
		(hectares)	per fish	
	Reference	Displaced	Reference	Displaced
Mean	17.55	16.65	50	31
'15% CI	12.06-23.04	11.06-22.24	45-56	27-35

Lake. A similar conclusion was reached for displaced smallmouth bass in Lake Opeongo (Ridgway and Shuter 1996).

The apparent reduction in fishing mortality observed in this study, relative to samples in 1981, may be due to a number of factors. Certainly, different gear types can sample different size distributions of a fish population that in turn can lead to different estimates of population parameters. In this case, catches from trap nets under-represent small fish (Hamley and Howley 1985), which in bass tends to be fish less than 25 em in length (personal observation). However, data used in this study to estimate total mortality twenty-years ago was based on fish ages 8-11. Based on the size at age observed in this study, largemouth bass at these ages are vulnerable to both trapnets and tournament anglers.

A more likely interpretation of the decline in fishing mortality is the current prevalence of catchandrelease practices relative to twenty years ago. An important component of catch-and-release seems to be an increased interest in minimizing stress in fish, among most bass anglers and angling associations. In this study, volunteer bass anglers displaced the fish to preselected sites for release, although the exact location of release in these sites was left to the discretion of the anglers. Large mouth bass were kept in livewells and transported following normal handling procedures. Based on the estimate of survival from radio-tagged bass and the role of volunteer anglers in this study, it is pos sible to achieve minimal effects of tournaments on the survival of largemouth bass over the course of a fishing season.

This conclusion must come with two caveats: First, this study displaced single fish and not large groups of bass that normally occur in most post tournament releases. In the latter case, many fish are typically released in relatively few locations so post release movements away from these sites may differ from what was observed in the Rideau Lake study. Furthermore, because multiple tournaments can occur on a lake, these releases can occur multiple times in a fishing season although not neces sarily at the same location each time. Second, this study occurred near the northern distribution of largemouth bass where relatively moderate water temperatures are known to be beneficial for survival in the short term (Kwak and Henry 1995: Hartley and Moring 1995; Wilde 1998). The density of released largemouth bass and the frequency of tournaments on a water body under normal tournament scenarios, as well as the generally sub-lethal water temperatures that occur in northern sites, are important considerations when interpreting the results of this study. The effects of multiple captures and repeatedly releasing high densities of bass in limited locations are important issues for future work. For example, the vulnerability of largemouth bass to angling when released in large groups may differ from what was occurring in the Rideau Lake study where individual fish were released at different sites. Increasing or decreasing catchability

Table 2. Estimates of survival (5) for two week periods for displaced largemouth bass in Rideau Lake. The period covers the start of the fishing season through to 16 October.

			Lower	Upper
Date	Survival (5)	se	95% CI	95% CI
29 June-12 July	0.850	0.0798	0.624	0.958
13-26 July	0.909	0.0613	0.700	0.977
27 July-9 Aug	0.950	0.0487	0.718	0.993
10-23 Aug	0.900	0.0671	0.676	0.975
24 Aug-6 Sept	0.889	0.0741	0.648	0.972
7-20 Sept	1.0			
21 Sept-4 Oct	1.0		-	
5-18 Oct	1.0			
Total	0.587	0.0991	0.390	0.760

Table 3. Instantaneous annual (Z), fishing(F), and natural(M) mortality rates for radio-tagged largemouth bass in 1997, and for trapnet sample of largemouth bass in 1981.

	Point		Percent of total	
	estimate	Source	annual mortality	
1997 Radio-Tagged Largemouth Bass				
Z for fishing season	0.533	5 = 0.587	71.7	
M for fishing season	0.093	M = 0.303*	12.5	
F for fishing season M for non-fishing season Z annual	0.440 0.210 0.743	0.533-0.093 M = 0.303** 0.511 + 0.210	59.2 28.3	
1981 Trapnet Sample of Largemouth Bass	0.745	0.511 + 0.210		
Z for fishing season	0.643	0.853-0.210	75.4	
M for fishing season	0.093	M = 0.303*	10.9	
F for fishing season	0.550	0.643-0.093	64.5	
M for non-fishing season	0.210	M = 0.303**	24.9	
Z, annual	0.853	5 = 0.426		
*M pro-rated for 112 day fishing season **M pro-				

rated for 253 day non-fishing season

will have a direct effect on survival estimates.

One interesting result to emerge from this work is the high level of exploitation that occurs in the first half of the bass fishing season relative to the second half (Table 2). A similar finding occurred in Saratoga Lake, New York (Stang et al. 1996). The number of days after release (release day = 23 June 1991) until harvest were provided for 10 radiotagged largemouth bass in Saratoga Lake following a tournament weigh-in. I applied the known fate analysis to the schedule of loss as described by Stang et al. (1996) to cover a 112 day fishing period as occurred in Rideau Lake. Five of nine radiotagged largemouth bass in Saratoga Lake were eventually harvested over the 112 days. The first two months after release on Saratoga Lake revealed a survival estimate (S = 0.555) lower but similar to the survival estimate over a similar two month period (largely July and August) in Rideau Lake (S = 0.661). The second half of the fishing period (largely September and October) revealed similar survival estimates for both sites (S = 0.800 for Saratoga Lake;

S = 0.889 for Rideau Lake) that were clearly higher than survival estimated in the first two months. This shift may reflect seasonal changes in angling effort and harvest, vulnerability of bass to capture or both. It would require an approximate three-fold reduction in instantaneous fishing mortality for a change in harvest alone to account for this observed increase in survival. A large decline in fishing effort is clearly possible in late summer and early fall (September-October), after the summer holiday period, relative to early summer Oune-July). However, bass undertake movements in the September-October period that represent a shift from summer horne ranges to overwinter sites (Ridgway and Shuter 1996). This behavioral shift may be the basis for any decrease in vulnerability of largemouth bass to angling at this particular time. It seems reasonable to conclude that a change in vulnerability and a decline in fishing effort both contribute to the seasonal increase in survival that was observed in Rideau Lake as well as Saratoga Lake (Stang et al. 1996). This is an important issue for future research.

Table 4. Estimates of annual survival (5) for largemouth bass in Rideau Lake from various data sources. The 1981 trapnet sample and 1997 angler sample are based on age frequency distributions. The 1997 radio-tag sample is based on the seasonal loss of radio-tags combined with M = 0.210 for the non-fishing season.

	1981 trap net	1997 radio-tag	1997 angler
	sample*	sample**	sample*
Survival, 5	0.426	0.478	0.474
Lower 95% CI	0.290	0.316	0.313
Upper 95% CI	0.562	0.616	0.635

*based on the Robson-Chapman (1961) estimator

**based on known fate model of surviv al (White and Burnham 1999)

The improvement in survival in 1997 relative to 1981 was also evident in the estimate of annual survival based on the age distribution of radiotagged bass. Indeed, the estimates of annual survival in 1997 utilizing two different methods were closely matched. A full examination of the effects of tournament handling on survival of bass would require tracking the fates of individuals in two groups of radio-tagged bass, one handled in tournament fashion and the other released at site of capture, to tease apart any possible effects of toumaments on seasonal survival.

Nontournament anglers tend to believe that most fish released at tournaments do not survive (Wilde et al. 1998). This perception seems to be general among people independent of latitude and known effects of temperature on post tournament survival (personal observation). Despite a sharper focus on the operation of mortality in bass tournaments, there is clearly a need to continue to investigate the survival of bass caught in tournaments in a variety of formats. The most important need may be to repeat this season-long approach at other sites where the fates of displaced fish are followed for many weeks. This approach would certainly extend the question of survival beyond the current focus of research on the fates of fish held in enclosures spanning approximately one week after capture (Wilde 1998). There is a need to operate such survival experiments at scales that match the spatial scale of tournaments themselves and in a fashion that closely matches the operation of tournament release. This would include survival of fish released in large groups at limited sites after weigh-in.

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