Derby-Determined Vital Statistics and Trends of the Smallmouth Bass, *Micropterus dolomieu*, Recreational Fishery in the Middle Reaches of the Grand River, Ontario

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Data from Grand River Bass Derbies (1988-1997) documents trends in relative abundance and provides information on vital statistics of Smallmouth Bass (*Micropterus dolomieu*) in the recreational fishery on the Grand River, Ontario. The length-weight relationship for all fish entered in the derby was described as weight (g) = $(2 \times 10^5) \times$ total length $(mm)^{2.95}$. A significant declining trend in mean fish length existed for the 10 longest fish entered in the derby each year over the 10 year period ($r^2 = 0.071$, $p < 0.05$). Relative weights observed were consistently below the length specific standard of 100, similar to other riverine Smallmouth Bass populations. Age and growth rates were similar to other northern riverine Smallmouth Bass populations, and the oldest fish observed was 16 + (441 mm TL). Trends in the middle Grand River Catch Per Unit Effort (CPUE) data suggest that the relative abundance of Smallmouth Bass has decreased significantly since 1988 ($r^2 = 0.552$, $p < 0.05$), although the 10-year derby CPUE (0.36) is similar to CPUE from other riverine populations. The derby data indicates that the population size and structure require further investigations to determine exactly where problems and management opportunities exist.

Key Words: Smallmouth Bass, *Micropterus dolomieu*, relative abundance, Derby data, Grand River, Ontario.

Smallmouth Bass (*Micropterus dolomieu*) are an important game fish in North America (Coble 1975; Scott and Crossman 1973; Edwards et al. 1983). Despite this, very little information exists about the ecology of riverine populations in Canada. One of the most popular riverine Smallmouth Bass fisheries in Canada exists in the middle reaches of the Grand River in southwestern Ontario. This fishery has been poorly studied, largely as a result of its disturbed nature (Mackay 1995) and the difficulties involved in studying fish in large lotic systems (Hendricks et al. 1980; Bunt et al. 1998).

Analysis of tournament fishing results is a relatively inexpensive and simple method for collecting biological data from large rivers (Willis and Hartmann 1986; Ebbers 1987). Rupp (1961) indicated that tournament records based on Catch Per Unit Effort (CPUE) afford valid comparisons of fishing quality because only the efforts of the most skilled anglers are considered. The Grand River Bass Derby is a family event which has been held for 10 years (1988-1997) leading to participation by anglers with a wide range of skills. Although not limited to the most skilled anglers, the Grand River Bass Derby data may still be useful if the general composition of anglers providing data is similar between years. Although competitive angling event data are not appropriate for answering questions relating to population structure, the data may provide the most accurate assessment of fishing quality over long periods of time (Quertermus 1991).

The only data currently available to assess the quality of Smallmouth Bass fishing in the middle reaches of the Grand River are from derby creel cards. Biological data from fish entered in the derby also provide the opportunity to determine the vital statistics of fish.

We report the vital statistics and relative abundance of Smallmouth Bass in the middle Grand River, Ontario, including growth rates, indices of condition, and CPUE determined from data collected at the Grand River Bass Derby 1988-1997. We also describe applications, opportunities and biases associated with the use of derby data. This information will be useful for comparison in investigation of other riverine Smallmouth Bass populations in the northern portion of their range.

Methods

Study Area

The Grand River watershed is located in southern Ontario and covers an area of 6734 km^2. The Grand River extends 297 km from Dundalk in the north to Port Maitland at Lake Erie. The middle Grand River is an arbitrary title often used to describe the section between West Montrose (43°34′ N, 80°26′ W) and Parkhill Dam in Cambridge (43°22′ N, 80°19′ W). Parkhill dam forms a downstream barrier and has no fish passage devices. The Mannheim Weir (43°25′ N, 80°25′ W), located 17 km upstream from the Parkhill Dam, forms the only other barrier in the study area. The Mannheim Weir has two Denil fishways as described by Bunt et al. (1998) that pass Smallmouth Bass. Two major tributaries join the Grand River in the study site. Little is known about the fish community in the lower Conestoga River or lower Speed River, although Smallmouth Bass have been documented in both. The topography of the middle Grand River can be characterized by rolling and undulating hills and valleys. Mean daily discharges (1989-1995) at Doon (43°24′N, 80°23′W) were 33.19 m^3/s^{-1} (John Bartlett, Grand River Conservation Authority, unpublished data). Fish community structure, aquatic macrophyte distribution and physical parameters in the middle Grand River are discussed in Coleman (1991). Although the study area is restricted to the middle Grand River, Smallmouth Bass have been documented throughout the Grand River.

Vital Statistics

The Grand River Bass Derby is a family event that has been operated by the Stanley Park Optimists since 1988. The annual two-day event is held during the first weekend in July. After arriving at the weigh-in site in bags or coolers, fish are measured (TL, mm) and weighed (g). Smallmouth Bass are then held in a large aerated cooler for at least five hours prior to being transported and released at common access sites throughout the middle Grand River. Water temperatures during the derby ranged from 18°C to 26°C. Prizes were awarded based on longest total length. Fish entered in the derby were, therefore, not representative of the entire fish population in the middle Grand River. However, they represent the longest smallmouth angled during the two-day event.

Ten years of derby data (1988-1997) containing information on total length (mm) and weight (g) were entered into a database. Condition factors were calculated for each fish using the relative weight (W_r) equation:

$$W_r = (W/W_s) \times 100,$$

where W is the weight of an individual fish (g) and W_s is a length-specific standard weight.

The form of the W_s equation is

$$\log_{10}(W_s) = a' + b \times \log_{10}(L),$$

where a= is the intercept value and b is the slope of the $\log_{10}$(weight)-$\log_{10}$(length) regression equation and L is the maximum total length of the fish.

The RLP technique provided the following 75th percentile W_s equation (Kolander et al. 1993) for fish 150 mm and longer:

$$\log_{10}W_s = -5.329 + 3.200 \log_{10}L.$$

A length-weight regression was generated for all fish entered in the derby using a quadratic model. The 10 largest individuals in total length for each year were extracted from the database. Because some anglers entered fish in the derby which were small (i.e., less than 400 mm TL), it was not possible to make comparisons of mean length for all fish entered. By using only the 10 longest individual fish from each year, we were assured that they are useful in documenting trends in mean length of the fish entered in the derby each year.

A model one fixed-effect, one way ANOVA was used to test the null hypothesis of no differences among means for length of the 10 longest individuals among each of the 10 years. When means are tested for pairwise differences the probability of finding one significant difference by chance alone increases rapidly with the number of pairs, so the Tukey-Kraemer HSD test was used, as recommended by Day and Quinn (1989). All tests were calculated using SYSTAT V. Linear regression analysis was used to determine if relationships existed between variables. A loess plot (smoothing parameter 0.5) was used to determine if there was an overall linear trend prior to fitting a line. All tests were performed using an alpha level of 0.05.

In 1996, scales were taken laterally from just posterior to the relaxed pectoral fin (n = 61). Scales were cleaned and random scales for each fish were displayed on a microprojector to determine annuli (Reynolds 1965; Robbins and MacCrimmon 1977). A card strip was laid along the nucleus midpoint and the anterior median scale margin and each annulus and the scale margin was marked (Bagenal and Tesch 1978).

Since annulus formation occurred almost simultaneously with the timing of the derby (i.e., late June), ages were interpreted as being one year greater than the number of annuli unless the new annulus had just formed (Beckman 1942; Robbins and MacCrimmon 1977). Mean lengths of the various year classes were determined by back-calculation using scale annuli (Everhart 1950). Length-at-age up to the time of capture was estimated with the Fraser-Lee rectilinear body-scale regression method developed by Carlander (1982) using DisBCal89 (Missouri Department of Conservation, Version 1989). We assumed that the length of fish before scale formation was 35 mm, thereby ensuring that the intercept (a) in the rectilinear body-scale regression was constant, as used by Weathers and Bain (1992).

Relative Abundance

Creel cards were distributed and collected at the Grand River Bass Derby as draw prizes to encourage cooperation with the provision of CPUE data. Every angler in the derby received a card which asked basic questions including duration of angling, location and catch. CPUE for derby participants is calculated for each year. Linear regression analysis was used to examine the relationship between derby

CPUE and the year of the derby. Responses to the number of days spent angling in the Grand River over the period of a year were used to assess the abilities of anglers. This served as a standardized measure of sampling efficiency and the relationship was examined using linear regression analysis.

Results

Vital Statistics

In total, 514 Smallmouth Bass were entered in the Grand River Bass Derby from 1988 to 1997. The length-weight regression for all fish entered in the derby over 10 years (Figure 1) can be described as weight (g) = $(2 \times 10^5) \times$ total length (mm)$^{2.95}$. The largest fish (531 mm TL) was entered in the derby in 1988.

There was a trend toward decreasing sizes of fish being caught. The mean lengths for the 10 longest fish in each of the derby years (1988-1997) differed significantly (ANOVA $F = 3.507$, $p = 0.001$) among years. Mean lengths from 1996 were significantly lower (Tukey-Kraemer HSD) than mean lengths of fish from 1989 ($p = 0.010$) and 1992 ($p = 0.003$), lengths from 1995 were less than those from 1992 ($p = 0.032$) and fish caught during 1997 were smaller than those caught in 1992 ($p = 0.024$). The mean lengths of fish did not differ significantly among other years ($p > 0.05$). The regression (Figure 2) was negatively correlated ($r^2 = 0.071$) and highly significant ($F = 7.441$, $p = 0.008$).

Relative weights for all fish entered in the derby from 1988 to 1997 were low (Figure 3). Less than 5% of the W_r values were greater than the length specific standard of 100. The regression was negatively correlated ($r^2 = 0.071$), highly significant ($F = 39.018$, $p < 0.001$), and declined with increases in fish length.

The oldest Smallmouth Bass entered in the Grand River Bass Derby was 16 years of age. Due to scale degeneration, the first annulus was difficult to identify in almost all samples, resulting in the provision of growth information for age classes 2 and older (Table 1). Most of the fish entered in the derby were between 7 and 14 years old. Growth was most rapid during the first 6 years. After attaining ages greater than 6 years, growth rates declined as evidenced by reduced average annual growth increments.

Relative Abundance

Between 1988 and 1997, 3314 creel cards were submitted, reflecting 37 553.85 hours of effort and 13678 Smallmouth Bass angled. The total derby CPUE over the 10-year period was 0.364 Smallmouth Bass per hour. The highest CPUEs were reported in the first two years of the derby (Table 2).

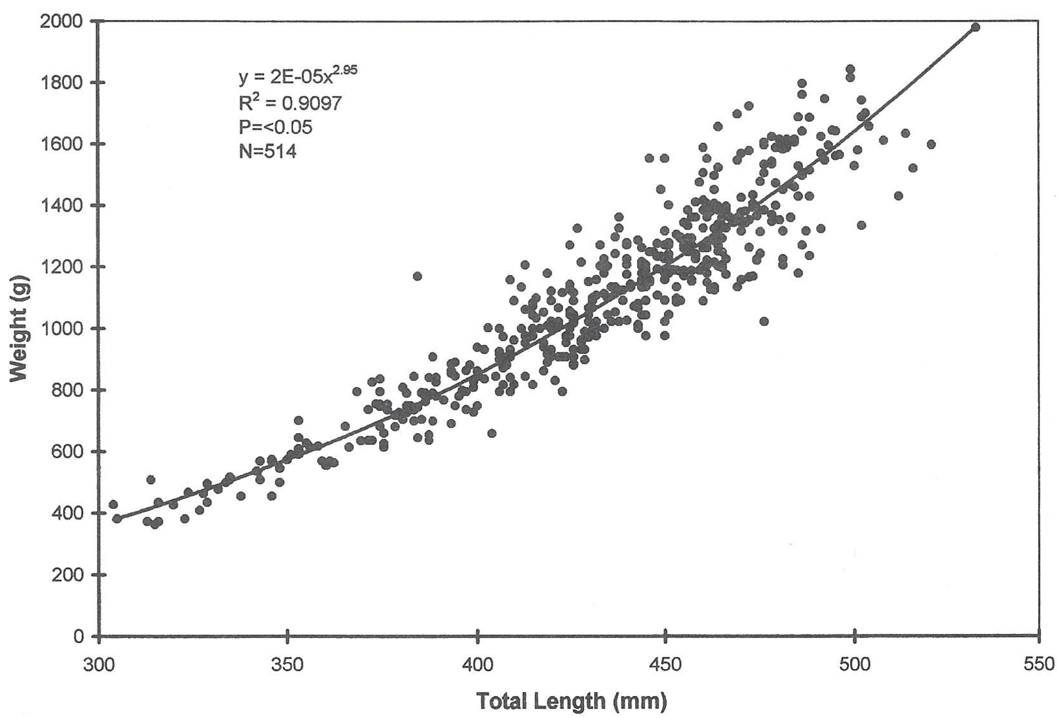

FIGURE 1. Length-weight regression for Smallmouth Bass entered in the Grand River Bass Derby from 1988 to 1997. The relationship is defined as weight (g) = $(2 \times 10^5) \times$ total length (mm)$^{2.9464}$.

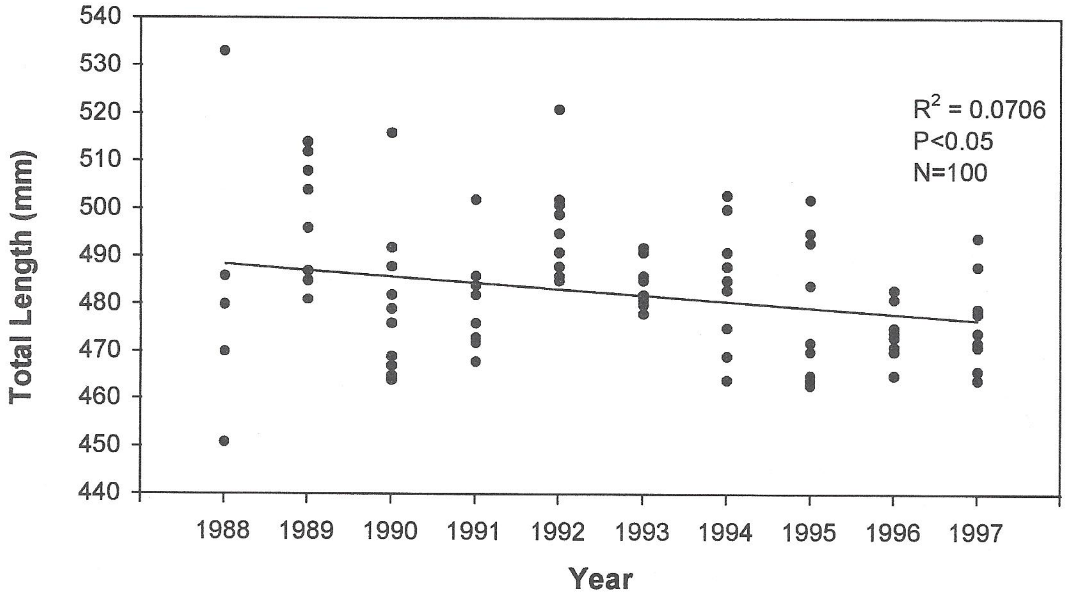

FIGURE 2. The ten longest (TL, mm) Smallmouth Bass entered in the Grand River Bass Derby each year (1988-1997).

The lowest CPUEs were observed in 1991, 1994, 1996, and 1997.

The relationship between derby CPUE and time (Figure 4) was negatively correlated (r^2 = 0.552) and significant over the 10-year period (F = 9.876, p = 0.014). There appeared to be no difference in the expertise of anglers because the mean number of days spent angling the Grand River by derby participants was similar between years. There was no significant relationship between mean number of days fished on the Grand River and CPUE (F = 0.673, p = 0.436).

Discussion

Difficulties arise when attempting to obtain an unbiased sample of any population under study (Pope and Willis 1996). Angling, like most sampling methods, is size selective, usually towards the faster-growing segment of a given year-class (Miranda et al. 1987). Miranda et al. (1987) reported that fish collected by anglers misrepresented the growth rate of a population, especially at younger ages. Such biases in growth estimates derived from fish collected by anglers can be eliminated if year-classes that are not fully recruited into the fishery are excluded from analysis, as we did here. This was an intrinsic property of the derby method of fish collection since that anglers only entered fish that were potentially large enough to qualify for prizes.

Additional biases exist with regards to individual variation in catchability (Martin 1958; Burkett et al. 1986). However, this is still poorly understood for Smallmouth Bass and deserves further attention. Nonrandom sampling of the stock probably selected larger and more aggressive members of younger ages-classes (Bagenal and Tesch 1978). This is an inherent bias when analyzing data from angler-caught fish (Miranda et al. 1987). For these reasons, the information presented here can be used only for relative comparisons and for documenting trends through time.

The low relative weights observed from the Grand River derby fish are consistent with many other riverine populations. Weiss-Glanz and Stanley (1984) reported that almost all relative weight values in the Penobscot River, Maine, were below 100 and that the variation in relative weight increased with fish size. The low relative weights suggest slow growth, but could also indicate that riverine Smallmouth Bass are slimmer than those dwelling in lakes (Weiss-Glanz and Stanley 1984). For this reason, a standard weight equation for both lentic and lotic populations of Smallmouth Bass should be generated.

The standard weight equation we used (Kolander et al. 1993) was derived from 50 data-sets representing 6731 fish. Although attempts were made to obtain Canadian data-sets, none were submitted. Smallmouth Bass in the northern part of their range may also exhibit reduced growth due to the shorter growing season. However, Kolander et al. (1993) found no geographic pattern in relative weight values for Smallmouth Bass, as had been previously noted for Yellow Perch, *Perca flavescens* (Willis et al. 1991).

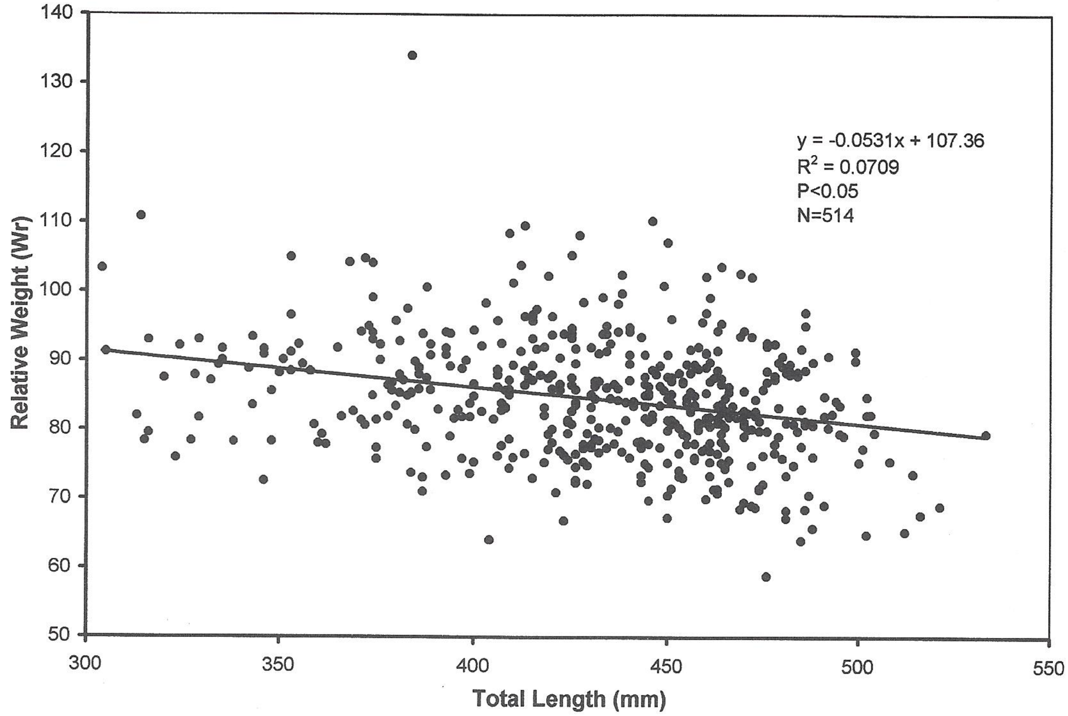

FIGURE 3. Relationship between relative weight (W_r) and total length (mm) for all Smallmouth Bass entered in the Grand River Bass Derby (1988-1997).

Because of the potential variability of relative weight as a function of season and size of fish, it is not a particularly accurate predictor of growth rate (Anderson and Neuman 1996). However, low values, such as those found in the present study, may indicate both problems and management opportunities. Variability in condition factor was minimized by consistently sampling fish on the same weekend every year. However, if fish were caught prior to spawning, the relative weight values would be inflated. This is one of the major problems when biologists investigate relative weight since the standard weight equations are not time specific and disregard gonadal condition.

TABLE 1. Average back-calculated total lengths (mm) for each age class from Grand River Smallmouth Bass. Standard errors are presented below each calculated length. Scales were collected from 61 fish during the 1996 Grand River Derby.

Back calculation age	All classes (mean TL mm)	SEM	N
2	182.87	3.659	61
3	226.96	4.099	61
4	267.40	4.313	61
5	302.04	4.579	61
6	329.71	4.427	60
7	352.75	4.557	56
8	375.53	4.379	50
9	393.45	4.727	43
10	406.86	5.006	36
11	416.83	5.175	30
12	423.62	5.570	21
13	436.28	6.323	13
14	436.13	5.865	8
15	442.05	13.289	3
16	441.38	0	1

Caution must be used when interpreting age and growth results presented here due to the biases associated with the sampling method and the difficulties involved with the accurate aging of scale samples from old Smallmouth Bass. Robbins and MacCrimmon (1977) validated the scale method for aging Smallmouth Bass by removing and sectioning the pelvic spine. They reported that age estimates based upon scale and finray methods were in agreement. The removal of scales from fish entered in the Grand River Bass Derby is a quick and relatively non-invasive technique for obtaining age and growth data. The removal of otoliths was precluded by our reluctance to sacrifice large individuals among the population of angler-caught fish.

Smallmouth Bass achieved a maximum observed age of 16 years in the Grand River. Previously reported maximum ages for Smallmouth Bass are generally 15 years, and most have been from lacustrine popula-

TABLE 2. Summary information derived from 3314 Grand River Bass Derby creel cards submitted from 1988-1997.

Year	Total number creel cards submitted	Total number of bass caught	Derby CPUE (bass/hour)	Mean number of days angler per year*
1988	238	1061	0.480	16.0
1989	237	2108	0.785	18.3
1990	440	1856	0.403	15.3
1991	523	1446	0.298	18.6
1992	410	2052	0.416	19.6
1993	423	1805	0.358	16.7
1994	320	915	0.246	18.3
1995	247	1007	0.313	13.3
1996	247	711	0.207	16.9
1997	229	717	0.250	12.5

*By Derby participants on the Grand River.

tions in Ontario (Stone et al. 1954; Scott and Crossman 1973). Carlander (1977) reported that the maximum life span of Smallmouth Bass is about 18 years. Riverine populations in Ontario or other northern parts of their range have not been studied extensively. Growth of Smallmouth Bass entered in the Grand River Bass Derby is slower than other riverine fish populations (Coble 1967; Carlander 1977).

The growth season in Ontario is limited by short periods of warm water, generally resulting in small average annual growth increments (Carlander 1977). Variable growth rates have also been attributed to differences in food supply (Coble 1975). The Grand River has many species of forage fish, as well as crayfish, which likely comprise the majority of the food consumed. In a fluvial system, fish must often expend energy to maintain position in the flow or to accomplish upstream migrations. Such energy expenditures are reduced in lentic populations, resulting in increased opportunities for growth. Heavy parasite burdens may also restrict growth of Smallmouth Bass (Hunter and Hunter 1938). Cestodes were common in the digestive tracts of Smallmouth Bass from the middle Grand River.

CPUE determined from derby data is an effective measure of fishing quality and relative abundance (Quertermus 1991). The CPUE for Smallmouth Bass in rivers and streams without harvest regulations across North America is highly variable (Weathers and Bain 1992), and CPUE data from the middle Grand River is similar to the median from other data sets. Trends in the middle Grand River CUE data suggest that the relative abundance of Smallmouth Bass has decreased since the derby's inception.

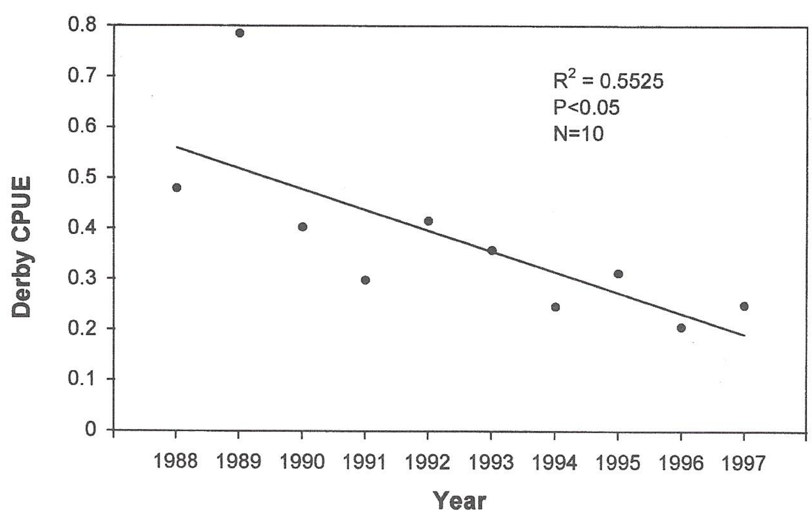

FIGURE 4. CPUE for anglers who targeted Smallmouth Bass during the Grand River Bass Derby (1988-1997). Data were derived from creel cards submitted by participating anglers.

Concerns have been raised about increased pressure, over-harvest, habitat degradation and the impacts of the Grand River Bass derby. Access to the river has improved and several companies offer canoe rentals that previously were not present, enabling more anglers to reach areas which previously received little fishing pressure. The derby has also provided increased exposure for the Smallmouth Bass fishery, perhaps stimulating further interest in angling for Smallmouth Bass in the middle Grand River.

Since no estimates of population size or structure exist from the middle Grand River, the use of derby data to document changes in relative abundance of Smallmouth Bass becomes a viable alternative. The Grand River Bass derby was repeated annually and attracted participants with similar angling patterns. This standardized format provided an opportunity to document trends in the vital statistics and relative abundance of the Smallmouth Bass fishery of the middle reaches of the Grand River. However, angler provided data is only useful if all potential biases are identified, and if possible, controlled.

Collection of meristic information from individual fish and CPUE data provides an opportunity for anglers to participate in key aspects of fisheries assessment and management. When anglers feel that they are contributing to the protection and enhancement of the resource, the opportunity to obtain accurate and complete data increases (Pollock et al. 1994).

The Grand River Bass Derby data indicated that the population size and structure require further investigations to determine exactly where problems and management opportunities exist. Electrofishing surveys would complement the angler-provided data by providing information on population structure and biomass. Similar to Quertermus (1991) we agree that derby data cannot be used to assess population structure and are, therefore, insufficient to serve as the sole source of data to determine management opportunities.

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