Tournament-Associated Mortality and the Effects of Culling in Wisconsin Black Bass (*Micropterus* spp.) Tournaments

Craig W. Williamson
Michael A. Bozek

Wisconsin Cooperative Fishery Research Unit
University of Wisconsin-Stevens Point, Wisconsin 54481

Final Report
December 31, 2006

Funding provided by
Wisconsin Department of Natural Resources

Executive Summary

The Wisconsin Cooperative Fishery Research Unit was contracted by the Wisconsin Department of Natural Resources (WDNR) to evaluate the mortality associated with culling in bass tournaments. The objective of this study was to quantify mortality rates of largemouth bass (*Micropterus salmoides*) (LMB) and smallmouth bass (*M. dolomieu*) (SMB) occurring as a result of tournament-induced stress, and in particular culling. Two parallel studies were conducted. The first study quantified general characteristics of tournament angling where culling is allowed, including the degree of culling, water temperature, pathogens, weigh-in procedures, and subsequent mortality in selected bass tournaments in Wisconsin. This provided background information on the extent to which tournaments that allow culling affect black bass mortality in general. The second study directly targeted the effects of culling on mortality rates. This aspect of the project was evaluated using controlled angling and culling activities by volunteer anglers simulating culling that occurs during a real tournament. The culled treatment fish were evaluated for five days to assess mortality. At the six professional bass tournaments studied, total mortality rates ranged from 0% to 77.4% for LMB and 0% to 54.6% for SMB. When adjusted for reference fish mortalities, total mortality rates of LMB ranged from 0% to 43.9%, and SMB from 0% to 55.5%. Initial mortality rates which occur at the time of weigh-in and reflect what anglers and the public actually see drastically under represents the true effects of angling on bass mortality during tournaments. The adjusted delayed mortality rates ranged from 0% to 43.2% for LMB and 0% to 52.2% for SMB whereas the initial mortality rates for LMB and SMB ranged from just 0% to 2.4%. Across these tournaments, mortality rates were higher when water temperatures were high and when largemouth bass virus (LMBV) (Iridoviridae) was present. Our data also reflect results seen in other bass tournament angling studies that

considered the effects of water temperature and LMBV on bass mortality, and when combined with those study results, the impacts of water temperature and the presence of LMBV on tournament-associated mortality of bass are amplified. At the two simulated tournaments, mortality rates were 0% and 16.0%. Largemouth bass virus was absent at both tournaments and warm water temperatures were present at the tournament with higher mortality. Culling in the simulated tournament did not appear to increase mortality rates relative to what was seen at the professional bass tournaments These data suggest culling does not significantly increase mortality at tournaments, but the sample size was small. However, there was no mortality in one simulated tournament and no clear trend in increasing mortality with increasing time held in live wells among culled fish in the tournament that had higher mortality. Our results support other studies that indicate tournament-associated mortality dramatically increases when water temperatures exceed 25°C where LMB are the primary target species and 20°C where SMB are the primary target species, and that strict regulation of bass tournaments under such conditions may be warranted (Neal and Lopez-Clayton 2001, Schramm et al. 1987, Edwards et al. 2004, Weathers and Newman 1997, Meals and Miranda 1994, Schramm et al. 2004). We would recommend conducting further studies to determine the precise threshold for water temperature effects on tournament-associated mortality of bass. Further, we recommend the WDNR conduct an ongoing investigation into the current and projected future distribution of LMBV throughout Wisconsin and its effects on tournament angling and catch-and-release fishing in general.

Introduction

Continuing to fish after reaching a daily creel limit is common practice in bass fishing tournaments in other states where anglers are allowed to replace previously caught smaller fish in their livewell with newly caught larger fish (Staggs 2005). This process is known as culling. Current Wisconsin fishing regulations state "any fish taken into an angler's possession and not immediately returned must be considered part of that angler's daily creel limit", thus culling is prohibited (Staggs 2005). No known previous study has researched the mortality rates of culled bass in tournaments, in particular. Moreover, few studies have evaluated tournament-associated mortality rates in the northern United States (see Perry 2002, Kwak and Henry 1995, Edwards et al. 2004, and Hartley and Moring 1995 (Appendix A)) and no tournament-associated mortality study has been conducted on black bass in Wisconsin. An understanding of the mortality rates sustained by tournament-caught and tournament-culled bass is prerequisite to considering and implementing changes in Wisconsin fishing regulations.

In 2004, the Wisconsin legislature passed Act 249 which required the Wisconsin Department of Natural Resources (WDNR) to establish a bass fishing tournament pilot program and evaluate its impacts . This evaluation includes assessment of economic, social, and biological impacts (Staggs 2005). The Wisconsin Cooperative Fishery Research Unit was charged with evaluating the biological impacts. Biological impacts of culling, specifically, and bass tournament angling in general, may include physiological stress responses of individuals ultimately terminating with mortality, and population-level effects that consider the relative effect mortality has in a given water body. Other potential biological impacts, including the effect of displacement of tournament caught bass, were beyond the scope of this study.

Objectives

The objectives of this study were to (1) quantify initial, delayed, and total mortality rates of largemouth bass (*M. salmoides*) and smallmouth bass (*M. dolomieu*) weighed in at professional black bass tournaments in Wisconsin and (2) quantify the mortality rates (5-day delayed) of largemouth bass and smallmouth bass which have been culled at simulated tournaments in Wisconsin.

Methods

Two sets of information are necessary to obtain a realistic and complete evaluation of the effects of tournament angling and culling on bass in Wisconsin. An assessment of the effects of tournament angling proper is prerequisite to providing context for understanding effects of culling. Thus, the first set of information collected quantifies mortality of tournament-caught bass at professional black bass tournaments. The second set of information aimed to quantify the mortality rates of culled bass. This was done in simulated tournaments, where culling effects could be sufficiently isolated to assess the magnitude of the effects. We used methods for evaluating black bass tournaments that are relatively standardized in studies of this type.

For the first portion of the study, which evaluated professional black bass tournaments, mortality rates included initial mortality of weighed fish (proportion of fish that die before or during weigh-in), delayed mortality of weighed fish (proportion of fish that die sometime after being released as a result of tournament handling, up to 5 days post-catch), and total mortality of weighed fish (combination of initial and delayed mortality). For the second portion of the study, which evaluated simulated tournaments, the mortality rate was 5-day delayed mortality of culled fish in two hour increments (proportion of fish that die sometime after being culled as a result of being captured and handled).

The first portion of the project was achieved by monitoring six professional bass tournaments that allowed culling during 2005 and 2006, whereas the second portion of the study was achieved by monitoring three simulated tournaments during 2006.

Professional bass tournaments were evaluated on rivers, lakes and reservoirs throughout Wisconsin (Table 1). Tournaments were evaluated from late spring to early fall and covered a range of water temperatures. The simulated tournaments were conducted on lakes from late spring to late summer and also covered a range of water temperatures (Table 1).

Methods for Professional Bass Tournaments

During evaluations of professional bass tournaments, a subset of tournament-caught largemouth and smallmouth bass were placed in holding pens to serve as the "treatment" in mortality experiments. Holding pen fish densities have varied greatly among previous studies, ranging from 0.6 fish/m^3 to 50.0 fish/m^3 (Table 2). To assess pen size on mortality prior to the actual evaluations we conducted a preliminary study by holding bass in a holding pen for 5 days where no fish died, suggesting mortality was not caused by the holding pens. Moreover, pre-tournament holding of bass in 3 lakes in central and southern Maine by Hartley and Moring (1995) also showed no mortality caused by the holding pens. Depending on the expected catch of the tournament, we placed up to 50 bass in each half of the holding pens (3.1 fish/m^3). The exact number of fish in each side of the holding pens varied among tournaments since catch rates varied among tournaments. "Control" fish (see Wilde et al. 2003 for discussion on lack of true controls and its consequences), herein referred to as reference fish, were obtained by boat electrofishing with pulsed direct current, or by fyke netting 1-2 days prior to each tournament to compare with the mortality rates of treatment fish (i.e., tournament-caught fish).

Table 1. Professional black bass tournaments and simulated tournaments evaluated during this study.

Waterbody	County	Dates	Abbreviation
	Professional Bass Tournaments		
Mississippi River	LaCrosse	August 3-6, 2005	LC05
Shawano Lake	Shawano	September 24-25, 2005	SH05
Green Bay	Door County	May 20-21, 2006	SB06
Mississippi River	LaCrosse	July 12-15, 2006	LC06
Wolf River Chain	Winnebago	July 30, 2006	WC06
Madison Lake Chain	Dane	September 23-24, 2006	MA06
	Simulated Tournaments		
Balsam Lake	Polk	June 23, 2006	BA06
Madison Lake Chain	Dane	August 26, 2006	MAS06
Minocqua Lake Chain	Oneida	September 9, 2006	MI06

Table 2. Examples of holding pens volumes in previous tournament-associated mortality studies.

Holding Pen Volume	Max. Pen Density	Citation
31.1 m^3	0.6 fish/m^3	Schramm et al.(1987)
28.2 m^3	1.2 fish/m^3	Weathers and Newman (1997)
32.7 m^3	**3.1 fish/m^3**	**This study**
4.6 m^3	9.8 fish/m^3	Neal and Lopez-Clayton (2001)
1.7 m^3	17.6 fish/m^3	Kwak and Henry (1995)
1 m^3	50.0 fish/m^3	Hartley and Moring (1995)

The reference fish remained separate from treatment fish and the treatment fish were separated by day of capture to evaluate daily mortality rates.

Monitoring Bass at Professional Tournaments and Simulated Tournaments

All fish assessed for delayed mortality were held for 5 days in rectangular, floating, holding pens and evaluated for mortality each day. The holding pens were located as close as possible to the weigh-in location on the same body of water in which the tournament was held. The holding pens measured 3.66 m in length by 3.66 m in width by 2.44 m in depth for a total volume of 32.7 m^3 with 2.54 cm square knotted nylon mesh. The pens were placed in water with a minimum depth of 2.5 m to accommodate the maximum depth of pens. The holding pens had a vertical net divider in the middle of the frame; consequently dividing the holding pens into two 16.35 m^3 areas. The frame was constructed of polyvinyl chloride pipe. The cross-sectional diameter of the top floating portion of the frame was 7.62 cm in diameter while the bottom sinking portion of the frame was 5.08 cm in diameter. Expanding spray foam was placed in the top floating pipes to aid in buoyancy, while re-bar was placed in the bottom pipes to eliminate buoyancy. The frame was free floating and had no pipes connecting the top frame to the bottom frame; only the net extended between them. The netting was attached to the top and bottom frame with zip ties. The holding pen was covered in netting on all six sides. The portion of the netting that covered the top of the holding pen was sewn to the pen on one side. Once fish were placed in the holding pen, the top cover was tied with string to the frame on the remaining three sides to seal it shut and prevent escape.

Dead bass (no opercular movement) were removed, recorded, measured (TL), and discarded daily at a standardized time (1000) during each tournament. On the morning of the fifth day of confinement, the reference and treatment fish were removed from the holding pens, counted, measured (TL), identified by species, and released. Subsets of treatment fish (≈ 30) from each tournament were sent to a United States Fish and Wildlife Service (USFWS) pathologist in LaCrosse, Wisconsin to be necropsied and tested for largemouth bass virus (Iridoviridae).

Because "reference" fish were subjected to the physiological stress of electrofishing and hence were not true "controls", they were used as another treatment from which to compare delayed mortality from angling (i.e., a reference). Incidentally, both reference fish and treatment fish were affected to some degree by capture, thus adjusted mortality rates of treatment fish are conservative, as more reference fish may have survived if not subjected to electrofishing or fyke netting. Because environmental conditions among days of a tournament can vary, total mortality and total delayed mortality was also evaluated among days, (by keeping fish caught each day in separate pens), to elucidate a day effect.

Water temperature (°C) and dissolved oxygen (mg/l) were recorded every 15 min at the water surface and 2.5 m deep with two Aqua 2002™ dissolved oxygen and temperature data loggers from BioDevices in Aimes, IA, USA near the holding pens. Water temperature and dissolved oxygen profiles were also recorded twice a day with a YSI 95© temperature and dissolved oxygen meter from YSI Incorporated in Yellow Springs, OH, USA adjacent to pens as a backup system. Water temperatures were recorded every 0.5 m from the surface to 2.5 m deep once each morning and evening. The profiles were taken next to the holding pen nearest shore and at the holding pen farthest from shore.

Simulated Tournaments

The second objective of the study was designed to assess the effects of culling. This aspect of the project was evaluated using simulated (i.e., controlled) angling and culling activities using volunteer anglers executing actual angling and culling that would occur during a tournament. Actual tournaments were not used in this experiment so as to not interfere with the tournament proper. In addition we wanted to ensure that live well holding time and number of fish in the live well could controlled.

Methods for Simulated Tournaments

Fish used in this portion of the study were obtained by electrofishing and held for a minimum of one day in holding pens to assess pre-tournament mortality and to determine physiological suitability for the simulation. At the start of the experiment, five individual bass were removed from the holding pens, and then hooked with a single hook through the upper mandible. Next, the fish were placed in the water so a volunteer angler, who were in his/her boat approximately 10 m from the holding pen, could "angle" or reel the fish in, unhook the fish, and place the angled fish into a livewell until five angled fish had been placed into an angler's livewell. The anglers were assigned a standardized return time in 2-hour intervals at which time he/she returned and "culled" an individual treatment bass at each of the four pre-selected time intervals. One fish per time period, per boat was "culled". Each designated "culled" fish (treatment fish) was placed in an individually marked holding pen based on the length of time (e.g., 2 hour intervals) they were assigned to be held for evaluation. As each culled fish was removed from a livewell, a "new" marked fish was angled and added to the livewell to ensure five fish remained in the livewell (Figure 1). New fish were marked with X-Tools™ culling clips, which are numbered clips placed on the lower mandible of bass for quick identification, to distinguish them from fish already in the livewell. The numbered clips also allowed us to know how long each fish had been in the livewell. Anglers returned to fish in the lakes as they would in a real tournament with a full livewell. They never placed additional fish caught during the simulated tournament in the livewells. Electrofished bass not held in livewells were used as reference fish. Once anglers had placed the last treatment bass (8-hour treatment bass) into the 8-hour holding pen, they still had four marked fish (new fish added during culling) remaining in their livewell.

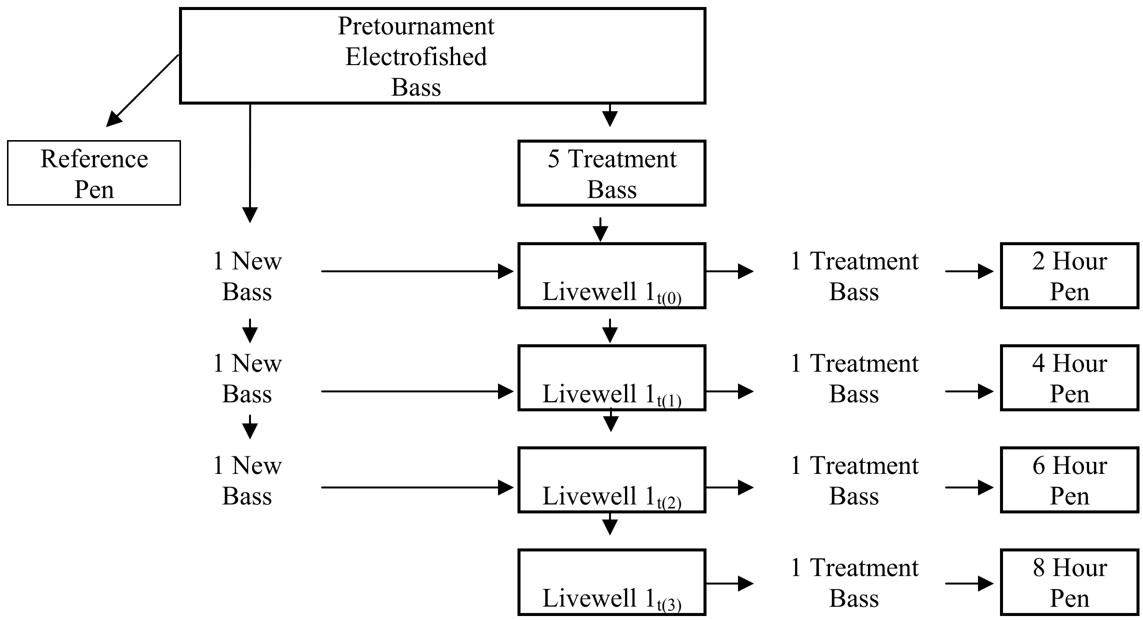

Figure 1. Diagram of how simulated tournaments were handled. Culled bass were held in holding pens based on how long they were held in livewells. As a bass was removed from a livewell to be placed in a holding pen, a new bass (marked with a culling clip) was placed in the livewell. Bass not held in livewells served as reference bass.

These marked fish were then placed in holding pens based on the length of time they had been in the angler's livewell. At all times, five fish (maximum creel limit) were in livewells during the simulated tournaments. So each angler had placed two treatment fish into each of the four 2-hour interval holding pens. The remaining reference fish were removed from the reference pen and placed in a 0-hour holding pen to serve as the reference. At the end of the simulated tournament, five holding pens contained fish culled at each of the time intervals, 0-hours, 2-hours, 4-hours, 6-hours, and 8-hours.

Data Analysis for Professional Bass Tournaments

Procedures used to evaluate mortality closely follow those of previous researchers; especially Wilde et al. (2003), which have become standardized nationwide (see Kwak and Henry 1995, Schramm et al. 1987, Wilde et al. 2003). At professional bass tournaments, fish were judged dead or alive by tournament officials at weigh-in. The ratio of fish brought to weigh-in dead $n_{I,i}$, versus the total number of fish weighed in $N_{I,i}$ for any given day *i* were our initial mortality rate $M_{I,i}$ (Wilde et al. 2003). The initial mortality rate used the function:

$$M_{I,i} = \frac{n_{I,i}}{N_{I,i}}$$

Where:

$M_{I,i}$ = initial mortality rate on day *i*

$n_{I,i}$ = total number of that die before or during weigh-in on day *i*

$N_{I,i}$ = total number of fish weighed in on day *i*

To quantify delayed mortality a subset of tournament-caught fish that are weighed in alive were held in holding pens for five days. The ratio of held tournament-caught fish that die after weigh-in $n_{T,i}$ versus the total number of tournament-caught fish held $N_{T,i}$ for any given day *i* was the delayed mortality rate $M_{T,i}$. The delayed mortality rate used the function:

$$M_{T,i} = \frac{n_{I,i}}{N_{I,i}}$$

Where:

$M_{T,i}$ = delayed mortality rate on day *i*

$n_{T,i}$ = total number of tournament-caught fish that die after weigh-in (5 days) on day *i*

$N_{T,i}$ = total number of tournament-caught fish held for evaluation (5 days) on day *i*

The reference mortality rate was $M_{R,i}$, where $n_{R,i}$ is the number of reference fish that died on any given day *i*, and $N_{R,i}$ is the number of reference fish held. The reference mortality rate used the function:

$$M_{R,i} = \frac{n_{R,i}}{N_{R,i}}$$

Where:

$M_{R,i}$ = reference mortality rate on day *i*

$n_{R,i}$ = total number of reference fish that die on day *i*

$N_{R,i}$ = total number of reference fish held for evaluation (5 days) on day *i*

To adjust the delayed mortality rate for pen mortalities we subtracted the reference mortality rate from the delayed mortality rate to obtain an adjusted delayed mortality rate $M_{D,i}$. The adjusted delayed mortality rate used the function:

$$M_{D,i} = M_{T,i} - M_{R,i}$$

Where:

$M_{D,i}$ = adjusted delayed mortality rate on day *i*

$M_{T,i}$ = delayed mortality rate on day *i*

$M_{R,i}$ = reference mortality rate on day *i*

Total mortality M_i for any given day *i* used the function:

$$M_i = M_{I,i} + \left\{ \left(\frac{n_{I,i}}{N_{I,i}} \right) * M_{D,i} \right\}$$

Where:

M_i = total mortality rate on day *i*

$M_{I,i}$ = initial mortality rate on day *i*

$n_{I,i}$ = total number of that die before or during weigh-in on day *i*

$N_{I,i}$ = total number of fish weighed in on day *i*

$M_{D,i}$ = adjusted delayed mortality rate on day *i*

where $M_{I,i}$ is initial mortality on the *i*th day, $M_{D,i}$ is delayed mortality of fish captured on the *i*th day, $n_{L,i}$ is the number of fish brought to weigh-in alive, and $N_{I,i}$ is the total number of fish live or dead that are captured and brought to weigh-in.

Data Analysis for Simulated Tournaments

To quantify the mortality rate, "culled" fish were held in holding pens for 5 days. The ratio of held "culled" dead fish $n_{T,i}$ versus the total number of "culled" fish held $N_{T,i}$ for any given day *i* is the mortality rate $M_{T,i}$. The mortality rate for "culled" fish used the function:

$$M_{T,i} = \frac{n_{T,i}}{N_{T,i}}$$

Where:

$M_{T,i}$ = mortality rate of "culled" fish on day *i*

$n_{T,i}$ = total number of "culled" fish that die on day *i*

$N_{T,i}$ = total number of "culled" fish held for evaluation (5 days) on day *i*

The reference mortality rate is $M_{R,i}$, where $n_{R,i}$ is the number of reference fish that died on any given day i, and $N_{R,i}$ is the number of reference fish held. The reference mortality rate used the function:

$$M_{R,i} = \frac{n_{R,i}}{N_{R,i}}$$

Where:

$M_{R,i}$ = reference mortality rate on day i

$n_{R,i}$ = total number of reference fish that die on day i

$N_{R,i}$ = total number of reference fish held for evaluation (5 days) on day i

To adjust the mortality rate for pen mortalities we subtracted the reference mortalities from the mortalities of "culled" fish to obtain an adjusted mortality rate M_i. The adjusted mortality rate used the function:

$$M_i = M_{T,i} - M_{R,i}$$

Where:

M_i = adjusted mortality rate of "culled fish" on day i

$M_{T,i}$ = delayed mortality rate of "culled" fish on day i

$M_{R,i}$ = reference mortality rate on day i

Results

Professional Bass Tournaments

Mortality rates varied greatly among the professional black bass tournaments selected as part of the bass fishing tournament pilot program in 2005 and 2006. Unadjusted total mortality rates ranged from 0% to 77.4% for LMB and 0% to 54.6% for SMB. Total mortality rates of

LMB ranged from 0% to 43.9%, and SMB from 0% to 55.5% when adjusted for reference fish mortalities. Combined LMB and SMB delayed mortality rates ranged from 0 to 66.0%. Adjusted delayed mortality rates ranged from 0% to 43.2% for LMB and 0% to 52.2% for SMB (Figures 3 & 4). LMB had higher delayed mortality rates than SMB in four out of five tournaments. Combined initial mortality rates for LMB and SMB ranged 0% to 2.4% (Figure 5). SMB suffered greater initial mortality rates than LMB, with SMB initial mortality rates ranging from 0% to 3.3%, while LMB initial mortality rates ranged from 0% to 1.2%. (See table 3). The highest mortality rates occurred at WC06 where the data was compromised. Chi square analysis showed a significant difference ($p < 0.05$) in mortality between treatment and reference fish and LC05, LC06, and WC06. (See table 3). LMBV was present in four of the six tournament fisheries (LC05, LC06, WC06, and MA06, see table 3). Tournaments taking place in fisheries where LMBV was present had greater mortality rates for LMB than tournaments taking place in fisheries where LMBV was absent especially when the water temperature was above 25°C (Table 3). Mean surface water temperatures ranged from15.2°C to 27.9°C at all six tournaments. The three tournaments that had high mortality rates all took place in fisheries where the mean surface water temperature was > 25°C and LMBV was present. Mortality at MA06 was very low despite the presence of LMBV, because the mean surface water temperature was 16.7°C. Dissolved oxygen was only an issue at WC06 where dissolved oxygen levels occasionally dropped to very low levels (≈ 3.5 mg/l) which could have added to the mortality rates. There were sufficient dissolved oxygen levels (> 5 mg/l) at the holding pens during rest of the tournaments. (See table 3).

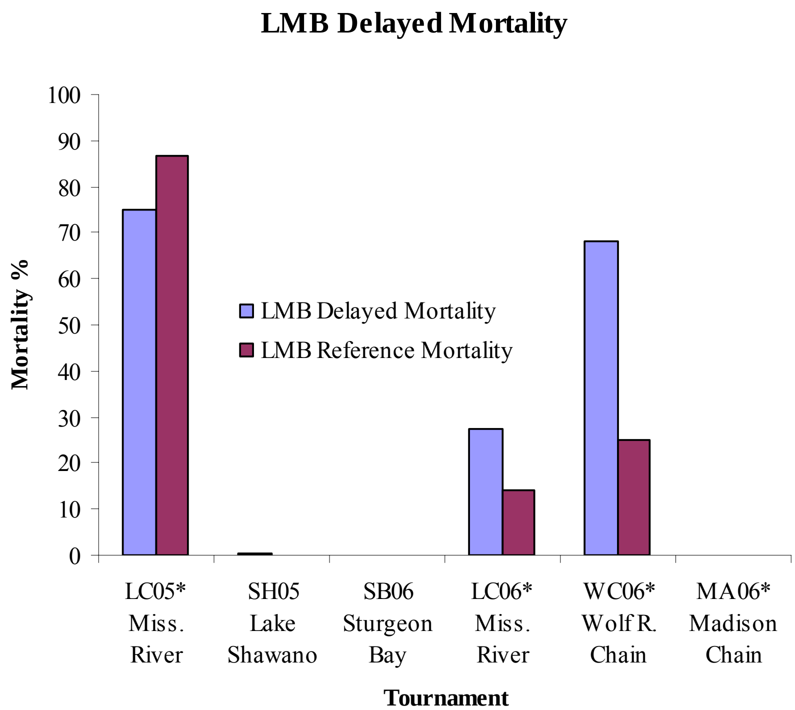

Figure 3. Delayed mortality rates of treatment and reference largemouth bass (LMB) at professional bass tournaments (* largemouth bass virus present).

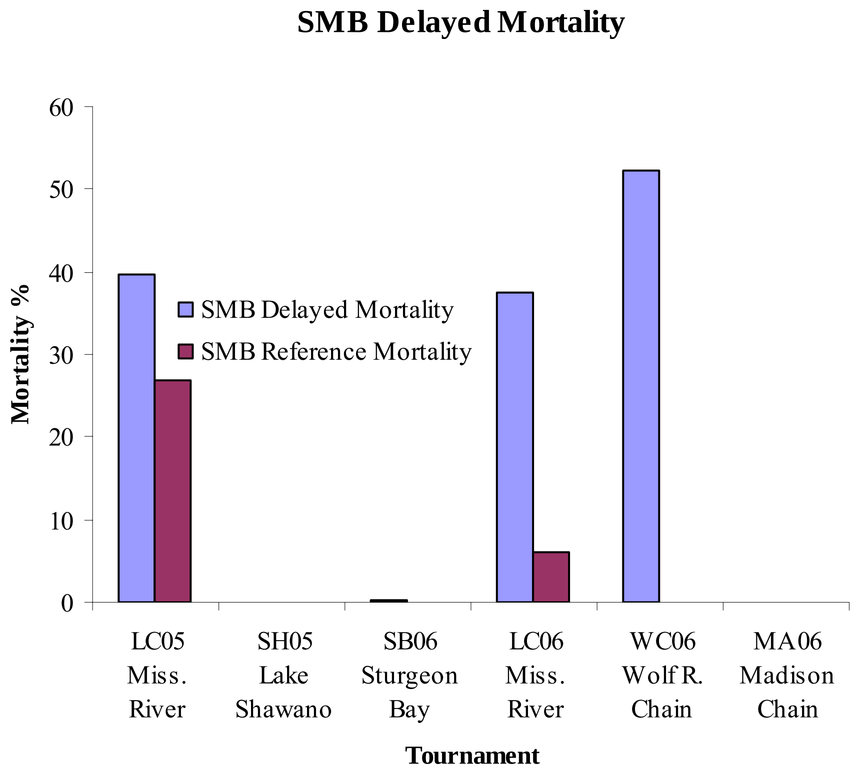

Figure 4. Delayed mortality rates of treatment and reference smallmouth bass (SMB) at professional bass tournaments.

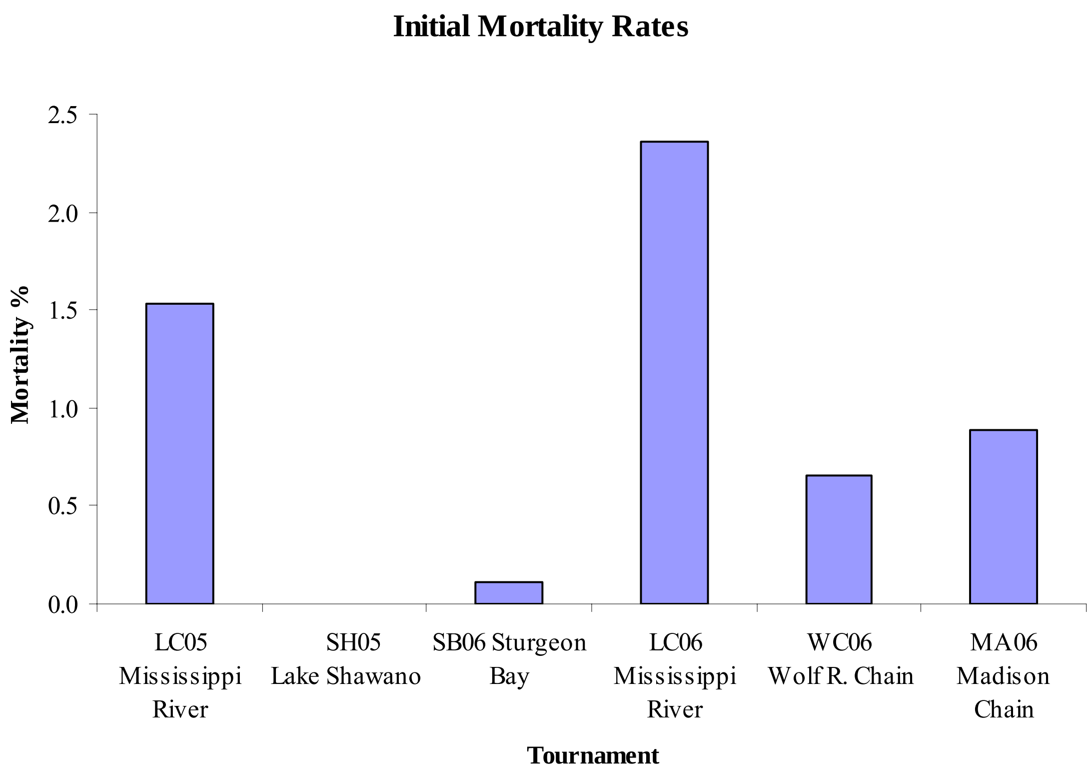

Figure 5. Initial mortality rates at professional bass tournaments.

Table 3. Summary of professional bass tournaments studied during 2005 and 2006. [1] Combined largemouth and smallmouth bass initial mortality. [2] Adjusted mortalities compromised due to problems with reference fish. [3] No fish used in study.

	Tournament					
	LC05	SH05	SB06	LC06	WC06	MA06
	Miss. River	Lake Shawano	Sturgeon Bay	Miss. River	Wolf R. Chain	Madison Chain
Date	8/3-8/6/2005	9/24-9/25/2005	5/20-5/21/2006	7/12-7/15/2006	7/30/2006	9/23-9/24/2006
Mean Surface Water Temp (°C)	27.2 ± 0.01458	16.5 ± 0.29991	14.6 ± 0.05239	27.3 ± 0.05289	27.8 ± 0.03912	16.7 ± 0.03427
Surface Water Temp Range (°C)	26.4 - 28.2	12.7 - 18.6	11.9 - 17.5	24.8 - 30.9	24.5 - 29.2	12.9 -17.8
LMBV Presence/Absence	Present	Absent	Absent	Present	Present	Present
Mean Surface D.O. (mg/l) at Pens	9.6 ± 0.43604	12.5 ± 0.29759	11.9 ± 0.03908	10.5 ± 0.08313	7.3 ± 0.06077	10.6 ± 0.03351
Mean Surface D.O. (mg/l) Range	6.1 - 13.3	8.9 - 14.4	8.5 - 13.7	7.1 - 17.0	3.8 - 9.5	8.8 - 12.6
Mean Bottom D.O. (mg/l) at Pens	8.3 ± 0.22434	12.3 ± 0.28670	12.3 ± 0.10348	7.3 ± 0.02898	7.0 ± 0.06651	9.9 ± 0.03191
Mean Bottom D.O. (mg/l) Range	5.91 - 9.77	8.9 - 14.0	7.7 - 18.9	4.8 - 9.6	3.4 - 9.7	8.1 - 11.9
LMB Total Mortality Rate (%)	-10.7	0.6	0	15.6	43.9	0
SMB Total Mortality Rate (%)	15.3	0	0.4	33.9	55.5	0
LMB Delayed Mortality Rate (%)	75.0	0.6	0	27.2	68.2	0
SMB Delayed Mortality Rate (%)	39.7	0	0.3	37.5	52.2	0
LMB Reference Mortality Rate (%)	86.8	0	NA[3]	14.0	25.0	0
SMB Reference Mortality Rate (%)	26.9	NA[3]	0	6.0	NA[3]	NA[3]
Adjusted LMB Delayed Mortality (%)	-11.8[2]	0.6	0	13.2	43.2[2]	0
Adjusted SMB Delayed Mortality (%)	12.8[2]	0	0.3	31.5	52.2[2]	0
LMB Initial Mortality Rate (%)	1.2	0	0	2.4[1]	0.7	0.9
SMB Initial Mortality Rate (%)	2.6	0	0.1	NA[3]	3.3	0
Total # LMB Weighed In	1551	275	16	2498	271	220
Total # SMB Weighed In	540	42	1741	634	30	6
Total # Treatment SMB	242	28	398	32	23	4
Total # Treatment LMB	711	172	2	180	173	183
Total # Ref LMB	106	91	0	50	8	100
Total # Ref SMB	26	0	101	50	0	0
Chi X^2	4.2519	0.4566	0.253	13.6242	5.7481	NA
p - value	0.0392	0.4992	0.6150	0.0002	0.0165	NA
Total # LMB Culled	286	1	6	924	43	6
Total # SMB Culled	149	0	1113	247	5	0
Reference Fish Compromised?	Yes	No	No	No	Yes	No

Simulated Tournaments

Three simulated tournaments were conducted resulting in varying mortality rates ranging from 0% to 43%. BA06 showed the highest adjusted mortality rate of 16%, while MI06 had a 0% mortality rate and much cooler water temperatures (Table 4). LMBV was absent at BA06 and MI06 (Table 4). The data from MAS06 was compromised because muskrats chewed many holes in the holding pens which consequently let most reference and treatment fish escape. BA06 was the only tournament we were able to evaluate mortality by hour at since MAS06 was compromised and no fish died at MI06 (Figure 6, Table 5). Dissolved oxygen levels were not an issue at any of the three simulated tournaments since the levels remained above 7.6 mg/l throughout the experiments. (See table 4).

Table 4. Summary statistics simulated tournaments bass tournaments in Wisconsin.

[1] Data compromised due to escape of reference and treatment fish.

	Tournament		
	BA06 Balsam Lake	MAS06 Madison Chain	MI06 Minocqua Chain
Date	6/17/2006	8/25/2006	9/8/2006
LMBV Presence/Absence	Absent	Present	Absent
Mean Surface Water Temp (°C)	23.1 ± 0.01734	24.2 ± 0.02139	20.0 ± 0.33473
Surface Water Temp Range (°C)	22.2 - 24.3	21.9 - 26.0	18.5 - 21.9
Mean Surface D.O. (mg/l) at Pens	8.5 ± 0.01693	9.6 ± 0.03045	9.9 ± 0.03271
Mean Surface D.O. (mg/l) Range	7.7 - 9.3	8.2 - 12.3	7.6 - 12.1
Mean Bottom D.O. (mg/l) at Pens	8.6 ± 0.01898	8.0 ± 0.02736	8.3 ± 0.01023
Mean Bottom D.O. (mg/l) Range	7.6 - 9.5	6.6 - 10.3	7.8 - 9.0
Mortality Rate (%)	43%	NA[1]	0%
Adjusted LMB Mortality Rate	16%	NA[1]	0%
Total # Treatment LMB	111	44	71
Total # Treatment SMB	0	0	0
Total # Ref LMB	59	8	41
Total # Ref SMB	0	0	0
Chi X^2	7.47	NA	NA
p - value	0.0583	NA	NA
Reference Fish Compromised?	No	Yes	No

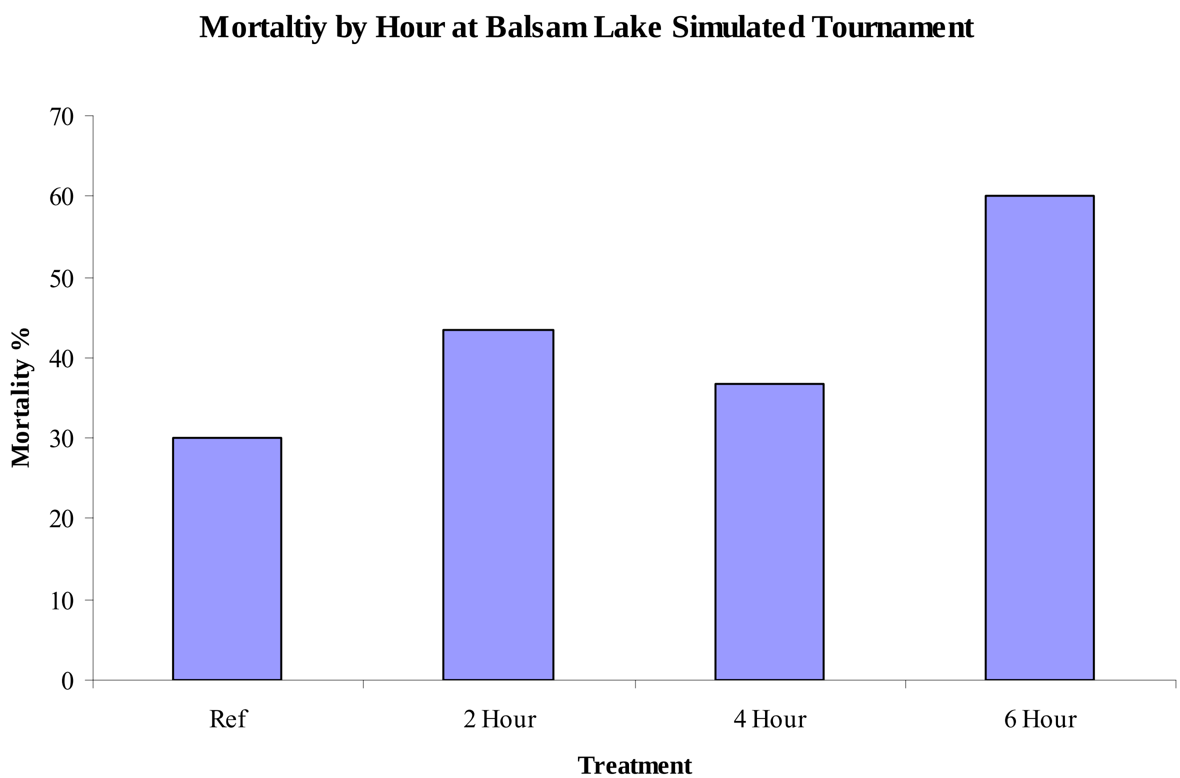

Figure 6. Mortality by treatment at BA06.

Table 5. Mortality by length of time fish were held until culled at Balsam Lake simulated tournament. Note, no fish died at Minocqua simulated tournament and the Madison simulated tournament could not be evaluated due to loss of fish from pens.

	Ref	2 Hour	4 Hour	6 Hour
	Balsam Lake			
Mortality %	30.0	43.3	33.7	60.0
Adjusted Mortality %	NA	13.3	6.7	30.0
	Minocqua Chain			
Mortality %	0	0	0	0
Adjusted Mortality %	NA	0	0	0

Discussion

Professional Tournaments

In general our findings concurred with the findings of previous studies (Neal and Lopez-Clayton 2001, Hartley and Moring 1995, Kwak and Henry 1995, Schramm et al. 1987, Edwards et al. 2004, Weathers and Newman 1997, Meals and Miranda 1994, Schramm et al. 2004). We found that high water temperatures combined with the presence of LMBV leads to high mortality rates, Similar to previous research that indicates high mortality rates for LMB when water temperatures exceed 25°C, especially when LMBV is present, and SMB when temperatures exceed 20°C (Figure 6) (see Edwards et al. 2004). In addition, a study conducted in the southeastern United States on fisheries that had largemouth bass virus found an average delayed mortality rate of approximately 76% for largemouth bass (Schramm et al. 2004). The study was conducted during the summer while average surface water temperatures ranged from 27.8-32.8°C (Table 6). The combination of largemouth bass virus and warm water temperatures played a significant role in the high mortality rates sustained by the largemouth bass. Smallmouth bass mortality rates were generally unaffected by largemouth bass virus presence or absence, because smallmouth bass are capable of carrying largemouth bass virus, but do not suffer any harmful effects from the virus. Initial mortality rates were lower than delayed mortality rates, especially when largemouth bass virus was present since largemouth bass mortalities are delayed 1-5 days while the fish succumb to the virus.

It is important to point out the technical problems we had at two of the six tournaments. At the Mississippi River tournament in 2005 our reference fish were held in a modified hoop net overnight prior to placement in the holding pens. This added stress to the fish by confining them in a smaller enclosure than the holding pen. The reference fish were crowded and did not have

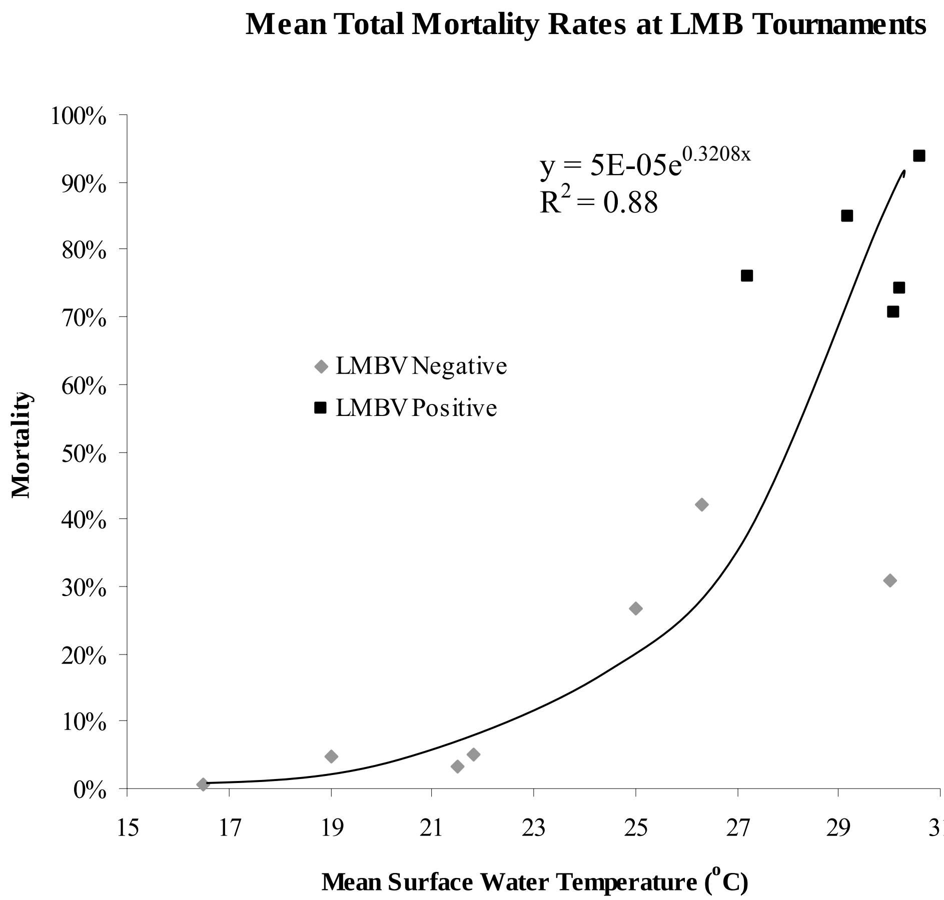

Figure 6. Mean total mortality rates for multiple LMB tournaments (including this study) throughout the United States. Each data point represents multiple studies (Neal and Lopez-Clayton 2001, Hartley and Moring 1995, Kwak and Henry 1995, Schramm et al. 1987, Edwards et al. 2004, Weathers and Newman 1997, Meals and Miranda 1994, Schramm et al. 2004). (need to add citation for the other data used in this figure).

Table 6. Selected tournament-associated mortality study results (Neal and Lopez-Clayton 2001, Hartley and Moring 1995, Kwak and Henry 1995, Schramm et al. 1987, Edwards et al. 2004, Weathers and Newman 1997, Meals and Miranda 1994, Schramm et al. 2004).

Tournament Location	Number of Tournaments Evaluated	Dates	Mean Surface Water Temperature (°C)	LMBV Presence/Absence	Mean Total Mortality Rate
		No Largemouth Bass Virus			
Wisconsin	1	Sep. 2005	16.5	Absent	0.5%
Connecticut	54	Apr. 2001- Oct. 2002	21.5	Untested	3.2%
Minnesota	2	May 1992- Sep. 1992	19.0	Untested	4.8%
Maine	9	Jun. 1989- Oct. 1989	21.8	Pre-LMBV	5.0%
Florida	11	Jul. 1984- Jun. 1985	25.0	Pre-LMBV	26.7%
Alabama	14	May 1991- Sep. 1992	30.0	Untested	30.8%
Puerto Rico	15	Apr. 1999- Mar. 2000	26.3	Untested	42.0%
		Largemouth Bass Virus Present			
Alabama	3	Jul. 2002-Aug. 2003	30.1	Present	70.7%
Mississippi	7	Jul. 2002-Sep.2003	30.2	Present	74.2%
Wisconsin	1	Aug. 2005	27.2	Present	75.0%
Missouri	1	Aug. 2002	29.2	Present	85.0%
Arkansas	1	Jul. 2002	30.6	Present	93.9%

adequate ventilation. The fish were subjected to additional stress when we removed them from the hoop net and placed into the holding pen. Consequently 75% of the reference fish died, which was 9% higher than the combined delayed mortality rate of the treatment fish.

We also had problems at the Winneconne tournament in 2006. The night after we collected reference fish, a severe thunderstorm came through, and the high winds and waves flipped the holding pen that the reference fish were in. Many of the reference fish were pinned to the surface of the pen since the net collapsed on itself. Approximately one quarter of the fish were dead when we arrived to check them the next morning. So we released the remaining reference fish and decided to try and collect more reference fish the day after the tournament. The air temperature was over 38°C the day after the tournament while we were electrofishing and subsequently we only captured eight reference bass. We are unable to get a realistic comparison of mortality with only eight reference fish. In addition to the mortality of the reference fish at Winneconne, on five separate occasions the dissolved oxygen content dipped below 5 mg/l in the holding pens during the five day observation period. We believe this contributed to the high mortality rate observed at this tournament, as dissolved oxygen contents below 5 mg/l are considered stressful to largemouth bass (Gilliland et al. 2002).

Simulated Tournaments

The results of our simulated tournaments are similar to the results of our professional bass tournaments. The Balsam Lake tournament was held under warm water conditions and had a higher mortality rate than the Minocqua Chain tournament which had cooler water temperatures. We expected increased mortality with increased retention time in livewells. However, more fish in the 2 hour treatment died than in the 4 hour treatment, but this may be a result of small sample size. It is also possible we did not see this pattern because the time the fish was held in the livewell did not cause mortality, rather mortality may have been caused by the numerous other stressors the fish endured throughout the experiment.

Conclusion

Strict regulation of bass fishing tournaments when surface water temperature exceeds 25°C if LMB are the primary target species, and 20°C if SMB are the primary target species appears warranted. We recommend conducting further studies to determine the threshold for water temperatures in which no bass tournaments should be allowed. We also recommend the WDNR conduct an ongoing investigation into the present and future distribution of LMBV throughout Wisconsin's fisheries and its affect on tournament angling and catch-and-release fishing. Given our limited data, culling appeared to have a lesser impact on bass tournament mortality compared to the impacts of water temperature and LMBV.

Literature Cited

Edwards, G. P., Jr., R. M. Nuemann, R. P. Jacobs, and E. B. O'Donnell. 2004. Factors related to mortality of black bass caught during small club tournaments in Connecticut. North American Journal of Fisheries Management 24: 801-810.

Gilliland, E. R., H. L., Schramm Jr. 2002. Keeping bass alive: a guide book for anglers and tournament organizers. Bass Angler Sportsman Society, Montgomery Alabama. 44 p.

Hartley, R. A., and J. R. Moring. 1995. Differences in mortality between largemouth and smallmouth bass caught in tournaments. North American Journal of Fisheries Management 15: 666–670.

Kwak, T. J., and M. G. Henry. 1995. Largemouth bass mortality and related causal factors during live-release fishing tournaments on a large Minnesota lake. North American Journal of Fisheries Management 15: 621–630.

Meals, K. O., and L. E. Miranda. 1994. Size-related mortality of tournament-caught largemouth bass. North American Journal of Fisheries Management 14: 460– 463.

Neal, J. W., and D. Lopez-Clayton. 2001. Mortality of largemouth bass during catch-and-release tournaments in a Puerto Rico reservoir. North American Journal of Fisheries Management 21: 834–842.

Perry, S. G. 2002. Initial mortality in New Hampshire black bass fishing tournaments, 1997-2001. New Hampshire Fish and Game Department, internal agency report Concord, New Hampshire. 12 p.

Schramm, H. L., Jr., P. J. Haydt, and K. M. Porter. 1987. Evaluation of prerelease, postrelease, and total mortality of largemouth bass caught during tournaments in two Florida lakes. North American Journal of Fisheries Management 7: 394–402.

Schramm, H. L., Jr., J. Grizzle, L. Hanson, G. Gilliland. 2004. Improving survival of tournament-caught bass and the effects of tournament handling on largemouth bass virus disease. Internal Agency Completion Report. Mississippi Cooperative Fish and Wildlife Research Unit, Mississippi State University, Mississippi State, Mississippi. 120 p.

Staggs, M. 2005. Bass fishing tournament pilot program evaluation plan. Internal Agency Report. Wisconsin Department of Natural Resources. 5 p.

Weathers, K. C., and M. J. Newman. 1997. Effects of organizational procedures on mortality of largemouth bass during summer tournaments. North American Journal of Fisheries Management 17: 131–135.

Wilde, G. R., K. L. Pope, and R. E. Strauss. 2003. Estimation of tournament mortality and its sampling variance. North American Journal of Fisheries Management 23: 779–786.

Appendix

Literature Review

Background and Origin of Black Bass Tournaments

Wisconsin has two black bass species, largemouth bass and smallmouth bass both of which play an integral role in Wisconsin fisheries (Simonson 2001). Adult largemouth and smallmouth bass are among the top predators in Wisconsin fisheries while young smallmouth and largemouth bass serve as prey for older centrarchids, esocids, and percids, as well as crayfish, birds, frogs, and snakes (Becker 1983).

Largemouth bass and smallmouth bass are two of the most popular sport fish in North America (Hartley et al. 1995). According to the Bass Angler Sportsman Society (B.A.S.S.) over 30 million people fished for bass in 2002 (Suski et al. 2004). In 1985, black bass overtook panfish as America's most popular sportfish (Suski et al. 2004). Black bass (*Micropterus* spp.) tournaments are a popular and increasingly important use of Wisconsin's fisheries resources. Under the current format of the vast majority of bass fishing tournaments (e.g. total-weight tournaments), fish are held in boat live wells until the end of the fishing day (Staggs 2005). They are then brought to a common location where each angler's daily creel is weighed (Staggs 2005). Anglers are penalized for weighing in dead fish as an incentive to keep fish alive; live fish are then released after being weighed (Staggs 2005). The angler with the highest weight of captured fish wins one or a combination of prizes, trophies, and/or money.

Tournament angling has increased concurrently with the increase in bass angling. Bass tournaments originated in the southern states; in 1955, the first organized bass tournament was held on Lake Whitney, Texas with seventy-three anglers participating in the tournament (Suski et al. 2004). By the 1970's, tournaments were being held across the Midwest and parts of the western United States (Ostrand et al. 1999). In the north-central United States, the number of waters on which black bass tournaments occurred doubled from 161 in 1978 to 330 in 1983 (Kwak et al. 1995). At least 30,000 competitive fishing tournaments now occur annually across North America (Suski et al. 2004).

Organized bass associations became established as black bass tournaments became more popular. Ray Scott founded B.A.S.S. in 1968 in Alabama to organize American bass anglers, promote bass tournaments, support fisheries management, and elevate the sport (Suski et al. 2004). Since the organization was founded, membership has increased from 100 anglers to over 600,000 anglers in 2003 (Suski et al. 2004).

During early days of competitive black bass tournaments (1950's - 1970's), mortality rates were high due to generous size and catch limits and high retention rates (i.e., keeping fish) (Ostrand et al. 1999). Therefore, in 1972, Ray Scott started the "Don't Kill Your Catch" program in an effort to reduce tournament-associated mortality (Suski et al. 2004). Improvements were made in aerating live-wells and developing catch-and-release techniques that dramatically improved largemouth bass survival rates (Figure 1) (Ostrand et al. 1999). These improvements were made by the late 1970's and early 1980's and subsequently reduced mortality rates (Ostrand et al. 1999).

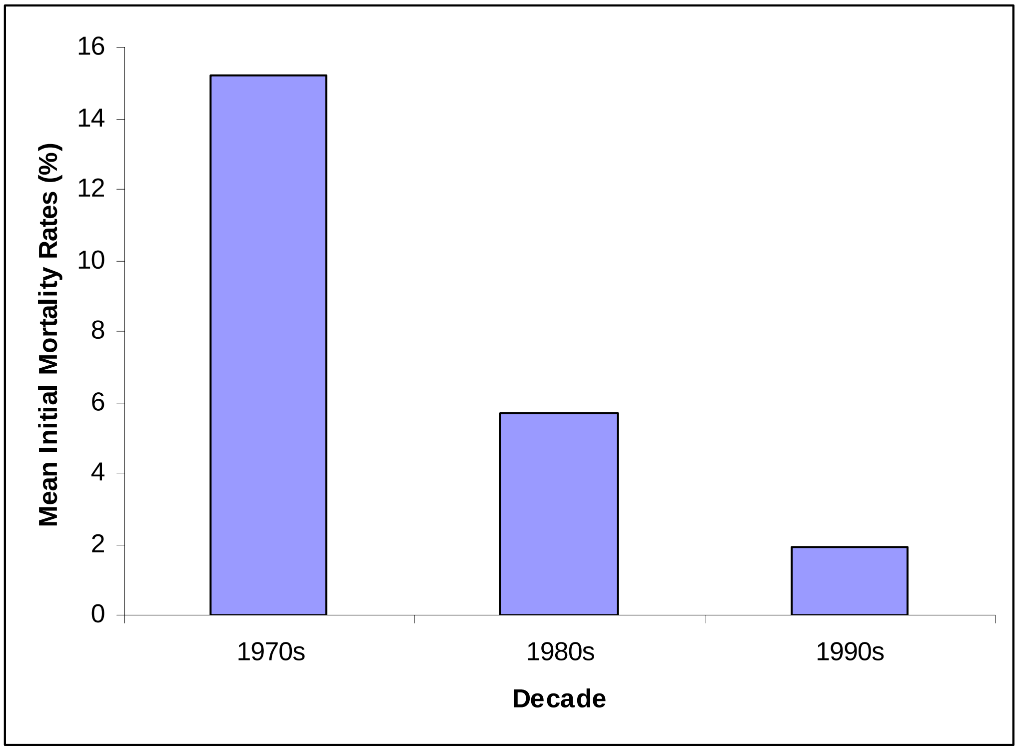

Figure 1. Mean initial mortality rates of black bass tournaments from 1970-2000 (Ostrand et al. 1999).

Problematic Issues Concerning Black Bass Tournaments

Many anglers are concerned about the potential biological and social impacts of competitive fishing (Schramm et al. 1991). The main issue of concern is the belief by many non-tournament anglers that the majority of tournament-caught fish do not survive angling, handling, confinement, weigh-in, and release (Ostrand et al. 1999). For instance, a survey conducted in Texas found 51% of black bass anglers believe tournaments harm their fishing experience by reducing their catch rates and a number of other reasons (Wilde 1998) which will be discussed later. In 1984, 32% of Indiana anglers thought tournaments hurt fishing; that number increased to 45% by 1994 due to social problems between non-tournament and tournament anglers (Pearson 2003).

Tournament and Non-Tournament Angler Attitudes

Fishery managers have become increasingly aware of the importance of managing anglers and have attempted to understand the attitudes and goals of anglers to appropriately manage fishery resources (Schramm 1991). Grouping anglers according to their type of participation in fishing provides insight to fishery managers on the diversity of motivations and fishing experiences preferred by black bass anglers that is not obtainable when anglers are lumped into one group (Wilde et al. 1998). So to further understand the issues concerning bass tournaments a mail survey of Texas black bass anglers was conducted in 1992 (Wilde et al. 1998). The survey sought to identify the motives, attitudes and demographic characteristics of tournament and non-tournament anglers (Wilde et al. 1998). The study used specific contexts of a fishing experience to help illustrate the importance in explaining a number of differences among angler groups which can help fishery managers manage for the specific fishing experiences desired by different anglers and angler groups.

The survey found differences in tournament and non-tournament demographic characteristics and fishing participation (Wilde et al. 1998). Specifically, the survey found 17.8% of Texas black bass anglers participated in tournaments (Wilde et al. 1998). The survey also found tournament anglers to be younger, fished more frequently, often male, often belong to fishing clubs, and viewed themselves as more skilled (Wilde et al. 1998). The study also found tournament anglers and non-tournament anglers have different motives for fishing (Wilde et al. 1998). For example, tournament anglers were more prone to fish for "experience, adventure, and excitement" and to "experience new and different things", while non-tournament anglers were more interested in obtaining fish for consumption (Wilde et al. 1998) (tournament anglers were found to be less interested in keeping their fish). Tournament anglers placed greater importance on developing their skills, obtaining trophy fish, winning a prize, and challenge or sport as reasons for fishing than non-tournament anglers (Wilde et al. 1998).

When compared to non-tournament anglers the tournament anglers were more heterogeneous in their attitudes toward fishing (Wilde et al. 1998). For example, tournament anglers were more concerned with catching larger trophy bass and catching specific species than non-tournament anglers (Wilde et al. 1998). Tournament anglers and non-tournament anglers also had different views about the impacts of tournament fishing on fishing quality (Wilde et al. 1998). Only 27% of tournament anglers believed tournaments harmed their fishing while 51% of non-tournament anglers believed tournaments harmed their fishing (Wilde et al. 1998). Tournament anglers were (88.3%) more likely to believe most bass survived tournament weigh-in and release than non-tournament anglers (55.8%) (Wilde et al. 1998).

The results of this study were consistent with those from previous studies comparing tournament and non-tournament anglers (Wilde et al. 1998). The study concluded tournament and non-tournament anglers do have certain fishing behaviors, motives, and attitudes in common, but also have some important differences. The study also concluded tournament anglers are more specialized than non-tournament anglers and in general have different motives for fishing (Wilde et al. 1998).

As a major and growing use of fishery resources, it is important for fishery managers to effectively integrate competitive fishing with other fishery and aquatic resource uses (Schramm et al. 1991). Fishery managers can manage fisheries more effectively when they are aware of the specific needs of the different angler groups which then allow the fisheries managers to manage for those needs. By providing a variety of different fishing experiences for different user groups, fishery managers can potentially help eliminate future conflicts among different user groups. Allocation and rulemaking by fishery managers therefore need to be especially sensitive to user group differences.

Tournament-Associated Mortality

Again, the main issue of concern and primary focus of this study is tournament-associated mortality. Subsequently, tournament-associated mortality of black bass has been studied since the early 1970s to help quantify impacts on fisheries, and results show highly varying rates of bass mortality, ranging from 0 to 98% (Wilde 1998, Neal and Lopez-Clayton 2001). In such studies, mortality is classified as either initial or delayed mortality: initial mortalities are fish which die before or during weigh-in and delayed mortalities are fish which die after being weighed-in and released (usually determined in holding pens). The data on tournament-associated mortality show that initial mortality of black bass was greatest in the 1970s ($\bar{x}$ = 15.2%), decreased in the 1980s ($\bar{x}$ = 5.7%), and decreased further in the 1990s ($\bar{x}$ = 1.9%) (Ostrand et al. 1999). As a portion of total mortality, delayed mortality rates have shown high variation among studies ranging from less than 5% to greater than 90% (Table 1) (Kwak and Henry 1995, Schramm et al. 1987, Edwards et al. 2004, and Schramm et al. 2004). Widespread adoption of live-release practices and improved procedures for handling captured bass likely reduced tournament-associated mortality.

Even though tournament-associated mortality rates have varied from 0-98%, in general, tournaments have not been considered a major factor in reducing the size of fish populations since catch-and-release procedures were established (see Table 1) (Schramm et al. 1991). This is partially because not all tournaments have high mortality rates. However, the black bass tournaments with high mortality rates can potentially have negative biological impacts on fish populations such as reducing the number of black bass over the legal length limit (Suski et al. 2004). Fishery managers are also concerned that some tournaments may harm fisheries by simply increasing and concentrating fishing effort and increasing black bass mortality (Meals and Miranda 1994). Again, the primary focus of this study will be on mortality rates sustained by tournament-caught black bass.

Table 1. Selected tournament-associated mortality study results.

Tournament Location	Number of Tournaments Evaluated	Dates	Mean Surface Water Temperature (^oC)	LMBV Presence/Absence	Mean Total Mortality Rate
		No Largemouth Bass Virus			
Wisconsin	1	Sep. 2005	16.5	Absent	0.5%
Connecticut	54	Apr. 2001- Oct. 2002	21.5	Untested	3.2%
Minnesota	2	May 1992- Sep. 1992	19.0	Untested	4.8%
Maine	9	Jun. 1989- Oct. 1989	21.8	Pre-LMBV	5.0%
Florida	11	Jul. 1984- Jun. 1985	25.0	Pre-LMBV	26.7%
Alabama	14	May 1991- Sep. 1992	30.0	Untested	30.8%
Puerto Rico	15	Apr. 1999- Mar. 2000	26.3	Untested	42.0%
		Largemouth Bass Virus Present			
Alabama	3	Jul. 2002-Aug. 2003	30.1	Present	70.7%
Mississippi	7	Jul. 2002-Sep.2003	30.2	Present	74.2%
Wisconsin	1	Aug. 2005	27.2	Present	76.0%
Missouri	1	Aug. 2002	29.2	Present	85.0%
Arkansas	1	Jul. 2002	30.6	Present	93.9%

Stressors

Variables Associated with Tournament Mortality

Many studies have assessed sources of tournament-associated mortality, physiological responses, and sublethal effects and have recommended ways of eliminating or reducing mortality (Weathers et al. 1997). These physiological stressing factors or variables have been studied to help isolate the causes of tournament-associated mortality. These factors include osmo-regulatory dysfunction (Carmichael et al. 1984), fatigue (Parker 1959), stress induced from hooking and landing (Gustaveson et al. 1978), hooking location (Pelzman 1978), live-well conditions (Plumb et al. 1988), live-well densities (Schramm et al. 1985), fish size (Meals and Miranda 1994), use of chemical water conditioners in live-wells (Carmichael et al. 1984), water temperature (Carmichael et al. 1984), time of year and geographical location of tournaments (Ostrand et al. 1999), water quality (Carmichael et al. 1984), length of confinement of fish in boat live-wells (Seidensticker 1975), length of tournament (Bennet 1989), tournament size (Schramm et al. 1985), weigh-in procedures (Hartley et al. 1995), handling procedures (Welborn et al. 1974), environmental conditions of tournament waters (Kwak et al. 1995), and bacterial and fungal infections (Welborn et al. 1973). The following pages will examine these variables to give an overview of the findings of previous studies.

Stress as an Underlying Effect

Physiological stress, from angling, confinement, handling, and weigh-in procedures, are the root causes of mortality during bass tournaments. Plasma glucose and corticosteroid levels in the blood of angled bass have been evaluated because they are good indicators of acute stressors, whereas chloride and osmolality have been studied because they are useful as good indicators of long-term stress and patterns of recovery after stressors are removed (Table 2) (Carmichael et al.

1984). Research showed short-term exposure to poor water quality alters plasma corticosteroids and glucose but has little effect on plasma chloride or osmolality (Carmichael et al. 1984). Placing a bass in water that is abruptly different in temperature causes elevations in plasma corticosteroid and glucose concentrations and reduced plasma chloride and osmolality (Carmichael et al.1984). Confinement causes elevated glucose and corticosteroid levels and reduced osmolality and chloride values (Carmichael et al. 1984). Bass require 14 days to recover normal plasma characters after being confined for 2 days (Carmichael et al. 1984). This study highlights the importance of maintaining proper live well temperatures and holding bass for as short a time as possible. These topics will be discussed in greater detail in the following pages.

Table 2. Blood-plasma characteristics of largemouth bass exposed to high and low concentrations of oxygen, high carbon dioxide concentrations, and elevated ammonia concentrations (Carmicheal et al.1984). Groups of fish were treated alone (unconfined) and with a 30-minute net stress (confined). Values represent mean ± SE; N = 6 for each treatment and 30 for control fish; meq = milliequivalents; mOsm = milliosmoles; ND = nondetectable. Astericks denote significant differences (analysis of variance; P ≤ 0.05) from control value (*) or from both control and recovery values (**).

Test Phase	Concentration (mg/liter)	Corticosteroids (µg/100 ml)		Glucose (mg/dl)	
		Unconfined	Confined	Unconfined	Confined
Control[a]		0.7 ± 0.1	8.5 ± 0.7	61 ± 3	124 ± 8
Dissolved Oxygen					
After brief exposure	<1	2.9 ± 0.8**	4.6 ± 0.8[b]	132 ± 16**	137 ± 11
After 24 hours' recovery	5-6	0.7 ± 0.1	11.9 ± 1.2[b]	42 ± 7	116 ± 13
After 24 hours' exposure	11	1.3 ± 0.4	9.5 ± 2.4	60 ± 6	116 ± 11
After 24 hours' recovery	5-6	0.8 ± 0.3	11.2 ±1.3	39 ± 11	121 ± 15
Carbon Dioxide					
After 24 hours' exposure	135	3.3 ± 1.3**	13.1 ± 2.8	289 ± 10**	194 ± 29**
After 24 hours' recovery	35	0.7 ± 0.1	12.3 ± 3.0	62 ± 6	130 ± 10
Un-iodized Ammonia					
After 24 hours' exposure	0.04	0.2 ± 0.1	6.6 ± 1.2	80 ± 11	200 ± 13*
After 24 hours' recovery	ND	0.3 ± 0.1	8.8 ± 1.4	114 ± 13*	210 ± 16*
After 24 hours' exposure	0.2	1.4 ± 0.2	7.0 ± 1.0	173 ± 8**	279 ± 52**
After 24 hours' recovery	ND	0.9 ± 0.3	6.7 ± 1.2	71 ± 6	135 ± 13

[a] Ambient concentrations of oxygen (5-6 mg/liter), carbon dioxide (35 mg/liter), and ammonia (ND) were present in control situations.
[b] Significant difference between values, but none from control.

Table 2. extended.

Chloride (meq/liter)		Osmolality mOsm/liter	
Unconfined	Confined	Unconfined	Confined
111 ± 1	109 ± 2	314 ± 4	329 ± 5
110 ± 3	115 ± 2	294 ± 8	337 ± 10
113 ± 3	115 ± 2	296 ± 3	305 ± 5
118 ± 2	116 ± 1	305 ± 4	320 ± 6
115 ± 3	119 ± 2	292 ± 7	310 ± 8
108 ± 3	105 ± 2	331 ± 4	332 ± 4
102 ± 3*	97 ± 6	317 ± 7	326 ± 8
111 ± 2	117 ± 4	304 ± 3	325 ± 3
118 ± 4	117 ± 2	310 ± 2	323 ± 7
109 ± 2	109 ± 2	301 ± 3	308 ± 4
98 ± 5*	110 ± 1	294 ± 4	309 ± 2

Hooking and Handling

Hooking and handling bass had long been believed to be associated with tournament-associated mortality (Gustaveson et al. 1991). Hooking and playing bass causes blood chemistry alterations due to a physiological stress response (Gustaveson et al. 1991). This fatigue is indicated by elevated blood lactate levels and is directly proportional to hooking time and water temperature (Gustaveson et al. 1991). Data collected on Lake Powell, Utah in March, May, and July of 1990 at different water temperatures, (11°C - 30°C), found fish hooked and played for less than one minute were well within stress tolerance limits, even when played for five minutes (Gustaveson et al. 1991). This study also showed fish played to exhaustion take longer to recover, or return to baseline blood chemistry levels, (which were determined at hatcheries with resting wild largemouth bass), than fish that are landed quickly. But in both cases elevated glucose and lactate levels are greatly reduced after 24 hours of recovery (Gustaveson et al. 1991). Researchers concluded hooking stress alone is not directly responsible for acute or delayed mortality, because the treatment fish were able to fully recover and they saw no mortalities in their experiments, especially among fish caught at water temperatures of 11-13°C (Gustaveson et al. 1991). Gustaveson et al. (1991) suggested encouraging anglers to play and land fish within 2-3 minutes; hold tournaments during seasons when water temperatures are cool and the fish are in shallower water; and require the use of aerated live wells for holding released fish in an effort to reduce stress and ultimately reduce mortality.

Hooking location has been studied to evaluate hooking mortality. An experimental study using hatchery reared fish, involved hooking by hand largemouth bass in different locations of the mouth (Pelzman 1978). The mouths of the bass' were divided into six major areas, and approximately 50 fish per area were hooked. The study only found significant mortality ($P < 0.05$) of treatment fish hooked in the esophageal area due to hemorrhaging in the pericardial cavity (Pelzman 1978). The author suggested anglers avoid using small lures and baits, as they are more prone to hooking bass in the esophageal area.

Live Well Conditions

Bass are vulnerable to stress from a number of water quality conditions which are present while they are held in live wells. These stressors will be discussed in the following sections, but first I will give you a brief overview of live wells. Live wells are portable fish tanks used to hold fish captured by anglers. Most modern bass boats have at least one live well built into the floor of the boat. Water is typically sprayed into the live wells by a pump which helps aerate the water entering the live well. Overflow valves are placed near the top of the live well which allows excess water to drain. Live wells are designed this way to allow fish to receive fresh, aerated water and to remove accumulated waste products (Suski et al. 2005).

Live Well Densities

Live well fish densities are believed by fisheries researchers to be related to tournament-associated mortality (Wilde et al. 2002; Schramm et al. 1985). So numerous studies evaluated correlations between live-well densities and tournament-associated mortality and found significant relationships (Wilde et al. 2002; Schramm et al. 1985). Increased creel limit, mean weight, and fish per angler increase live well fish densities. Initial mortality in B.A.S.S. tournaments held from 1983-1998, showed significant correlations with creel limit ($P = 0.0044$), mean weight ($P = 0.0005$), and fish per angler ($P < 0.0001$) (Wilde et al 2002). Logistic regression showed creel limit to affect initial mortality the most (Wilde et al 2002). However, another study conducted in Florida did not find a significant relationship between mean catch per team and initial, delayed, and total mortality rates (Schramm et al. 1985). To help keep mortality rates to a minimum, Gilliland et al. 2002 recommends no more than 0.45 kilograms (1 pound) of fish per 3.79 liters (1 gallon) of water should be placed in a live-well.

Fish Size

An evaluation of size related mortality on tournament-caught largemouth bass by Meals and Miranda (1994) found prerelease mortality of large fish (total length > 457.2 mm) was significantly greater ($P < 0.05$) than the average mortality of small fish. Prerelease mortality of was recorded at bass tournaments on Sardis Reservoir, Mississippi, from 1989-1991. Large fish mortality averaged 29% while small fish mortality averaged 9%. Not surprisingly, mortality increased significantly with water temperature and mean number of fish per boat in large ($P < 0.10$) and small ($P < 0.05$) fish (Meals and Miranda 1994). The authors expected this result, because increased weight of largemouth bass in a live well exerts a greater demand for available oxygen.

Water Conditioners

When bass tournaments began, live wells occasionally lacked devices to circulate or aerate water. Because harmful metabolites build up in live wells during bass tournaments, techniques for improving water quality have been sought. Initial solutions included aerating and recirculating live well water. Later, techniques for thermal regulation of live wells were developed (e.g., ice, electric coolers). As part of these potential solutions, chemical water conditioners were also evaluated in an effort in increase live well water quality. A study conducted in 1988 found the addition of water conditioners to live wells enhanced survival of largemouth bass ($P < 0.05$) (Plumb et al. 1988). In this study, the water conditioner was a mixture of sodium chloride, potassium chloride, sodium thiosulfate, pyrogenic silica, dimethylketone, alpha-methylquinoline, methylene blue, nitromersol, EDTA, triethyleneglycol, and acriflavine (Plumb et al. 1988). Bass held in live wells, with the water conditioner for 3 to 9 hours, had a 96.5% survival rate, while bass held in ponds with no water conditioner had a survival rate of 90.8% (Plumb et al. 1988). A simpler additive, non-iodized salt at a 0.5% solution is also widely accepted as a useful tool in reducing stress in live wells (Gilliland and Schramm 2002). The salt aids the bass in osmoregulation, while water conditioners aid bass in a number of ways including osmoregulation and protection against secondary infections which should help reduce stress and mortality (Gilliland and Schramm 2002).

Water Temperatures

Of all the variables related to black bass tournament-associated mortality, water temperature is consistently the most significant variable related to initial and delayed mortality (Gilliland et al. 2002); both waterbody temperatures and live well water temperatures can affect mortality. Removing fish from their aquatic habitat and placing them into a live well can potentially be lethal if there is too large of a difference in the water temperatures and/or water chemistry (Gilliland et al. 2002). Largemouth bass can survive in water from 35.6°C to 0°C (Becker 1983). Depending on weather, water temperatures can potentially change rapidly in live wells. The exact range of thermal shock that bass can survive is unknown, however, a rapid increase of 2.78°C or decrease of 5.56°C in water was shown by Gilliland et al. (2002) to immobilize, kill, or cause loss of equilibrium to some fish species (Gilliland et al. 2002). Because bass slowly acclimate to water temperature and water chemistry, live well water should come from the same habitat the angler is fishing to reduce any impacts of thermal shock or shock from changes in water chemistry (Gilliland et al. 2002). Also, bass angled from deeper cooler water are often placed into live wells containing warmer epilimnetic water from the surface. To prevent this, live well temperatures need to match the temperatures the bass are coming from or be slightly cooler to reduce stress.

Time of year and geographical location in which fishing tournaments are held are two important factors related to tournament-associated mortality, primarily due to their relation with water temperature. A compilation of eight studies by Wilde (1998) found a strong positive relation between water temperature and both initial ($r = 0.51$) and delayed mortality ($r = 0.36$). A study conducted by Schramm et al. (1987) on eleven tournaments in Florida found prerelease and total mortality rates to be significantly ($p \leq 0.05$) related to water temperature. Initial and delayed mortality rates were also found to be significantly ($p < 0.0001$) related to water temperature in Connecticut tournaments as well (Edwards et al. 2004).

Generally, northern states have lower mortality rates at tournaments than southern states. This is partially a function of cooler average water temperatures, which is why most North American tournaments today follow a south to north circuit from spring to fall (Kwak et al. 1995). Consequently, fishery managers suggest limiting tournament activity during the hottest summer months (Edwards et al. 2004). Nonetheless, the majority of bass tournaments throughout North America are held on weekends from around daybreak to early afternoon from May through October (Ostrand et al. 1999). Therefore, a study was conducted to quantify mortality rates during different seasons and after evaluating 2,072 Texas black bass tournaments, initial mortality rates in winter were found to be less than 2%, increasing in the spring and climaxing in the summer at 8% (Ostrand et al. 1999). During summer the probability of initial mortality increases exponentially at temperatures above 25 °C for largemouth bass and above 20°C for smallmouth bass (Figure 2) (Edwards et al. 2004). Neal et al. (2001) concerned with these findings, conducted a study using 15 bass tournaments on a Puerto Rican reservoir and found when mean surface water temperature was above 25 °C, total mortality rates (54.0%) were more than threefold higher than tournaments with lower mean surface temperatures (16.8%) (Neal et al. 2001).

Seasonal differences in tournament-associated mortality can sometimes be attributed to physiological condition rather than water temperature. A study conducted in Minnesota during September of 1991 and May of 1992 found all estimates of mortality to be significantly higher in the May tournament even though the surface water temperatures were on average 5°C cooler in May (Kwak et al. 1995). The higher mortality rates in May were attributed to post-spawn stresses (Kwak et al. 1995).

Dissolved Oxygen

Reduced dissolved oxygen, particularly at higher water temperatures, is believed to contribute to mortality of bass in live wells (Gilliland and Schramm 2002). Catching and handling increases the oxygen demand of bass due to increased aerobic activity, which is why it is imperative to hold bass in live wells that are properly oxygenated and thermally regulated (Gilliland et al. 2002). A dissolved oxygen level of 5 mg/l is considered stressful to black bass, whereas a dissolved oxygen level of 3 mg/l is considered lethal (Gilliland et al. 2002). In general, water temperature is inversely correlated to the dissolved oxygen content in water: the saturation point of water is 11.3 mg/l at approximately 10°C whereas the saturation point of water at 35.6°C is 6.6 mg/l (Gilliland et al. 2002). If bass are held in live wells with no aeration, the dissolved oxygen content would quickly be depleted to lethal levels.

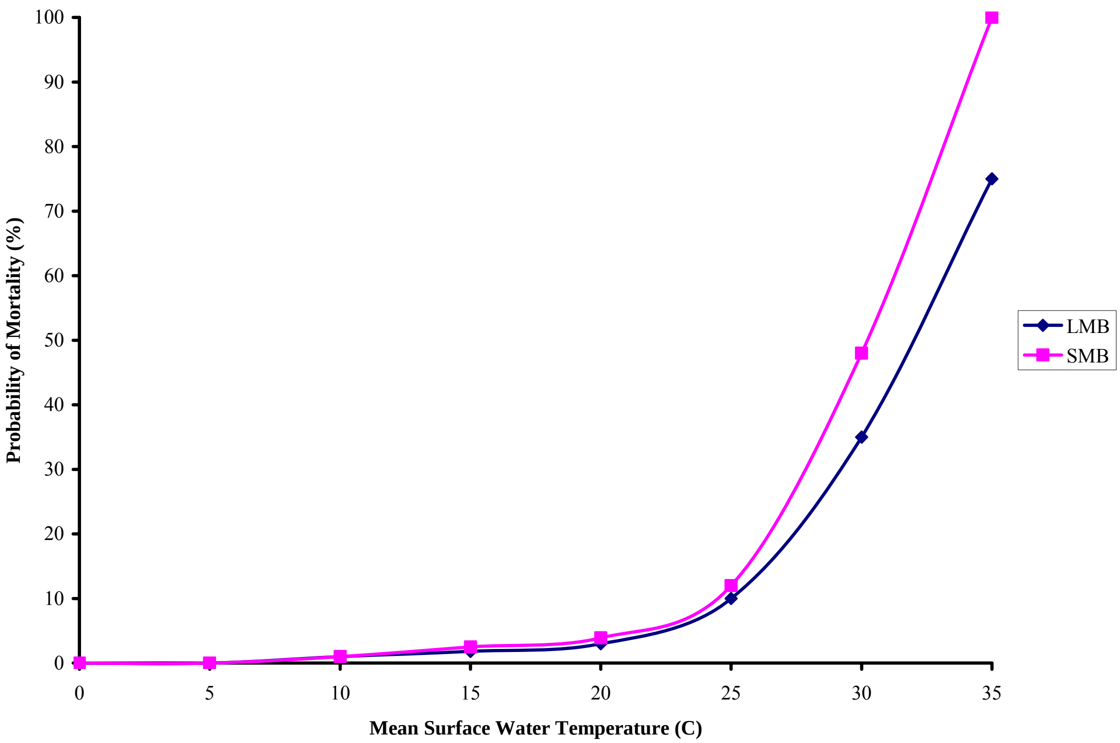

Figure 2. Initial mortality of tournament-caught largemouth bass and smallmouth bass in relation to surface water temperature (Edwards et al. 2004).

Metabolic Waste

Reduced dissolved oxygen and thermal shock are not the only problems associated with water temperature. As water temperature increases, metabolic rates of bass increase thus increasing metabolic wastes such as carbon dioxide and ammonia (Kwak and Henry 1995). A study conducted on 11 tournaments in Minnesota found the percentage of dead fish in live wells was significantly ($p < 0.05$) and inversely correlated with pH, which is a byproduct of metabolic waste (Kwak and Henry 1995). Acidity increases with high levels of dissolved carbon dioxide, and high levels of acidity, carbon dioxide, or both in live wells can cause bass mortalities (Kwak and Henry 1995). During the Minnesota tournaments, pH was found to be significantly and inversely correlated with dead bass in a live well. Another byproduct of metabolic waste, ammonia, is also toxic to bass and becomes more of a problem as water temperature increases (Gilliland et al. 2002). Problems associated with carbon dioxide or ammonia buildup can be avoided if the live-well is properly aerated (Gilliland et al. 2002).

Confinement and Handling Time

Stress caused by confinement time contributes to increased mortality rates (Carmichael et al. 1984). Confinement time can be defined as the time between catching a particular bass and weighing in that particular bass. In a compilation of data conducted on 15 bass tournaments held in Puerto Rico, confinement time showed a positive correlation with initial mortality ($r = 0.520$; $P = 0.043$) but not a significant relationship to total mortality (Neal et al. 2001). A compilation of data from 99 bass tournaments held in Connecticut used logistic regression to show positive correlations between initial mortality and total handling time (Wald $\chi^2 = 14.09$; $P = 0.0002$) and fishing day length (Wald $\chi^2 = 4.95$; $P = 0.0261$) (Edwards et al. 2004). Shorter tournament fishing days seem to improve survival of harvested bass, by reducing the amount of time in which bass are subjected to stressors (Seidensticker 1975). The Texas B.A.S.S. Federation held a bass tournament on March 30 and 31, 1974 where anglers were allowed to fish for 10 hours on the 30^{th} and 7 hours on the 31^{st}. Initial mortality was 31% on the 30^{th} and 11% on the 31^{st}; indicating shorter fishing days reduce mortality rates (Seidensticker 1975).

Environmental Conditions other than Water Quality of Tournaments

Environmental conditions such as air temperature and cumulative radiation during tournaments have been studied by fisheries researchers to assess other effects of tournament angling on mortality (Neal and Lopez-Clayton 2001, Schramm et al. 1985). Researchers presumed increased air temperature and increased cumulative radiation could increase mortality rates by increasing water temperatures and stressing bass. However, a compilation of data from multiple studies failed to find correlations between air temperature or cumulative radiation to tournament-associated mortality (Schramm et al. 1987, Neal and Lopez-Clayton 2001, Schramm et al. 1985). The attempts of many anglers to cool or maintain live well water temperatures are presumed responsible for the insignificance of air temperature and cumulative radiation on mortality (Schramm et al. 1985).

Bacterial and Fungal Infections

Studies have been conducted to see if mortality rates increase as a result of secondary bacterial and fungal infections caused by angling and weigh-in activities (Archer et al. 1975). Increased stress reduces black bass' immunosuppressant capabilities which increase the likelihood of bass suffering complications from bacterial and fungal infections. However, past failures to achieve significant improvements in post-release survival of angler-caught fish with antibiotic injections leads researchers to believe neither internal nor external bacterial disease significantly affects post-release survival of angler-caught largemouth bass (Schramm et al. 1987). For instance, in multiple experiments fish were given drugs after capture and held in holding ponds and raceways for observation with fish that had not been administered drugs and found no significant difference in mortality rates. These studies conducted in 1973 and 1974 suggested administration of Terramycin is of questionable value in the promotion of post-tournament survival of largemouth bass after failing to significantly reduce mortality when compared to untreated fish (Archer et al. 1975, Seidensticker 1975). Potassium permanganate is another oxidizing agent which has been found to have no significant impact of survival of largemouth bass (Schramm et al. 2004). Another study conducted in Mississippi suggested the administration of oxytetracycline to captured largemouth bass was not beneficial in reducing mortality of the released bass (Plumb et al. 1975). With multiple studies failing to reduce mortality rates with the use of antibiotics, bacterial and fungal infections are not considered a significant factor impacting tournament-caught bass mortality rates. Furthermore, the authors agreed that the adoption of routine antibiotic injection into released bass does not appear to be feasible either in efficacy or from a practical standpoint (Plumb et al. 1975).

Weigh-in

Weigh-in is an important factor contributing to the physiological disturbance in tournament fish (Suski et al. 2004). Two distinct components of tournaments cause severe bouts of anaerobic activity which decrease survival capabilities of tournament-caught bass: angling and weigh-in (Suski et al. 2004). A simulated study conducted at the Queen's University Biological Station on Lake Opinicon, Ontario evaluated the effects of weigh-in on largemouth bass. The results showed a 700% increase in lactate, a 75% decrease in white muscle phosphocreatine, a 46% decrease in ATP, and a 62% decrease in glycogen relative to control largemouth bass using the enzymatic assay methods of Lowry and Passonneau (1972) (Suski et al. 2004). These physiological changes result from a combination of physical activity, air exposure, and hypoxia from the use of non-aerated weigh-in bags (Suski et al. 2004). The magnitude of physiological changes caused during simulated weigh-ins were similar to those caused by simulated angling activities suggesting weigh-in is as physiologically detrimental as angling was, consequently affecting mortality (Suski et al. 2004). A study conducted in Connecticut suggested tournament-associated mortality may be reduced by increasing the efficiency of weigh-in procedures at tournaments, which reduces physiological stress (Edwards et al. 2004).

Tournament Size

Tournament size has been studied as a factor resulting in tournament-associated mortality. The size of tournaments is believed to correspond (positively) to the efficiency in which fish are weighed in and the care of the fish (Wilde 1998). In a compilation of data from 130 bass tournaments across the U.S.A., tournament size has been negatively correlated with initial mortality of tournament caught bass ($r = -0.54$), and positively correlated with delayed mortality ($r = 0.30$), suggesting large tournaments have reduced mortality rates

(Wilde 1998). Similarly, for 2,072 Texas bass tournaments, the mean initial mortality rate of 1.8% was recorded for the large tournaments, (tournaments with 50 or more boats) whereas the small tournaments had a higher rate of 4.1% (Ostrand et al. 1999). Both authors suggest larger tournaments are typically better organized and have stricter rules and procedures than smaller tournaments which reduced handling time, thus reducing mortality (Wilde 1998, Ostrand et al. 1999).

Review of Stressors

While many correlations have been found between all the variables studied and mortality, many of these factors are often inconsistent and/or statistically insignificant among tournaments. However, many of these factors are closely related to each other and thus make it difficult to identify singular causal factors of mortality. No single study can provide a definitive estimate of the magnitude of mortality or the relationship between mortality and different explanatory factors, but trends have started to emerge (see Wilde 1998). The studied variables found to be correlated with mortality include:

- Water temperature
- Dissolved oxygen
- Metabolic waste
- Handling time
- Tournament size

To briefly summarize, most tournament-associated mortality is believed to be the result of a combination of sublethal stressors in any given tournament (Wilde 1998).

Fishing Tournament Formats

Fishing tournaments are conducted using a variety of rules and formats which result in varying mean mortality rates (Ostrand et al. 1999). Researchers wished to study mortality rates at different tournaments to decide which formats had lower mean mortality rates than others. Therefore, data were collected from October 9, 1993 through June 13, 1997 by a voluntary tournament reporting program enlisted by the Texas Parks and Wildlife Department on mortality rates of 2,072 black bass tournaments (Ostrand et al. 1999). Most tournaments were "total-weight tournaments" in which prizes are awarded to the anglers who capture the greatest total weight of fish (Ostrand et al. 1999). In "total-weight tournaments" fish are kept in live-wells until the tournament is over, then they are weighed and released (Ostrand et al. 1999). This format had a mean initial mortality rate of 4.0% (Ostrand et al. 1999). Many other formats exist which include "paper tournaments" in which fish are captured, measured, recorded, and immediately released (Ostrand et al. 1999). "Paper tournaments" showed the lowest mean initial mortality rate of (1.1%), due to decreased handling time (Ostrand et al. 1999). Another common format is "big-fish tournaments", in which prizes are awarded for the heaviest individual fish weighed-in each hour (Ostrand et al. 1999). Capture and confinement are especially stressful on larger bass, but "big-fish tournaments" reduce the number of fish held in live-wells (Ostrand et al. 1999). "Big-fish tournaments" showed the highest mean mortality rates of 4.7% (Ostrand et al. 1999). However, this rate can be misleading. The number of fish per angler is one, because all smaller fish are culled out of the live well, and only the largest fish remains. The proportion of bass that die is higher in comparison with a total-weight tournament but there are fewer bass involved in the tournament (Ostrand et al. 1999). The last common format is "road-runner tournaments", in which anglers fish a number of different waters, transport their fish overland to a central weigh-in site to weigh and then release the fish (Ostrand et al. 1999). The mean mortality rate for roadrunner tournaments was 4.3% (Ostrand et al. 1999). The mortality rates in road runner tournaments are higher because fish are exposed to additional stress from being transported and confined longer (Ostrand et al. 1999).

Paper tournaments showed the lowest mean mortality rate, but are not the most common format. Total weight tournaments remain the most common format, likely due to the excitement of weigh-ins which allows spectators to watch, and sponsors to promote their products.

Species Differences

This study will also evaluate mortality by species. The following is an overview of previous research looking at species differences.

In black bass tournaments, studies have found higher mortality rates for smallmouth bass compared to largemouth bass which are much more tolerant of tournament stressors (Edwards et al. 2004). Largemouth bass and smallmouth bass are closely related, but utilize different habitat and have different physiological tolerances (Furimsky et al. 2003). Largemouth bass are typically viewed as “lie and wait” predators inhabiting shallower, warmer, weedy areas, while smallmouth bass are more “active” predators that prefer deeper and cooler open water (Furimsky et al. 2003). The preferred temperature for smallmouth bass is 20.3-21.3°C versus 27.2-30°C for largemouth bass, which is one reason smallmouth bass often inhabit deeper, cooler water than largemouth bass (Becker 1983). Because tournament anglers place both species in live wells filled with surface water (which is typically warmer than deeper water), smallmouth bass suffer greater stress and consequently higher mortality rates since the surface water temperature is warmer than the water the smallmouth bass inhabited (Edwards et al. 2004). This is especially true during the summer months when lakes are thermally stratified and the surface water being placed into the live well is warmer (Edwards et al. 2004).

Laboratory experiments conducted at Queen's University in Kingston, Ontario, tested largemouth bass and smallmouth bass arterial blood respiratory conditions, ventilation rate, and cardiac output to compare their physiological responses to graded levels of hypoxia (Furimsky et al. 2003). The study found progressive reductions in water dissolved oxygen levels had a much greater effect on blood oxygen transport properties, acid-base status, ventilation rates, and cardiac variables in smallmouth bass than largemouth bass, concluding smallmouth bass are more sensitive to hypoxia than largemouth bass (Furimsky et al. 2003). This helps explain why smallmouth bass often appear to be less tolerant of tournament procedures than largemouth bass (Furimsky et al. 2003). Unless certain precautions are made, hypoxia can easily occur in several different stages of bass tournaments, including live well holding, bag confinement, weigh-in air exposure, and the holding tanks of the release boats (Furimsky et al. 2003).

Non-lethal Tournament Effects

Tournament-associated mortality is not the only effect of tournaments concerning fishery managers and anglers. Another concern is the dispersal of tournament-caught black bass after release. In particular, fishery managers and anglers are concerned about the relocation (translocation) and concentration of fish at fishing tournament release sites (Wilde et al. 2003). Fishery researchers have studied the proportion of fish returning to their site of capture, the rate and distance dispersed by tournament-caught black bass, whether dispersal is greater among largemouth or smallmouth bass, whether dispersal differs between fish captured and released in rivers and in lakes and reservoirs, and what proportion of dispersing fish do anglers recapture (Wilde et al. 2003, Lantz and Carver 1975). A compilation of data, published and unpublished, estimations of dispersal distances by black basses captured and released alive in fishing tournaments were evaluated by Wilde et al. (2003). Data from 12 studies (36 days to 3 years in duration) in Arizona, California, Indiana, Texas, New York, Oklahoma, Utah, and Ontario (1976-1997) showed that on average, only 14% of tournament-caught largemouth bass and 32% of smallmouth bass returned to their site of capture (Wilde et al. 2003). Fifty-one percent of largemouth bass and 26% of smallmouth bass dispersed less than 1.6 km from their release sites, and on average, smallmouth bass dispersed a greater distance (7.3 km) from their release sites than largemouth bass (3.5 km) (Wilde et al. 2003). The review also showed no difference in dispersal distances for fish captured and released in rivers versus those released in lakes and reservoirs (Wilde et al. 2003). Twenty-two percent of largemouth bass and 15% of smallmouth bass caught and released in fishing tournaments were subsequently recaptured by anglers (Wilde et al. 2003).

Release boats have been recommended to help redistribute fish after weigh-in, so fish are not concentrated at weigh-in sites (Wilde 2003). This recommendation has been slow to catch on due to lack of regulatory or other incentives (Wilde 2003).

Literature Cited

Allan, R. C. 1978. A biological assessment of largemouth bass tournaments in southern Nevada. California-Nevada Wildlife; Transactions 24: 122-126.

Archer, D. L., and H. A. Layacono, Jr. 1975. Initial and delayed mortalities of largemouth bass captured in the 1973 national Keowee B.A.S.S. tournament. Proceedings of the Annual Conference Southeastern Association of Game and Fish Commissioners 28: 90-96.

Becker, G. C. 1983. Fishes of Wisconsin. The University of Wisconsin Press, Madison, Wisconsin, U.S.A. 1952 p.

Bennett, D. H., L. K. Dunsmoor, R. L. Rohrer, and B. E. Rieman. 1989. Mortality of tournament-caught largemouth and smallmouth bass in Idaho lakes and reserviors. California Fish and Game 75: 20-26.

Carmichael, G. J., J. R. Tomasso, B. A. Simco, and K. B. Davis. 1984. Confinement and water quality-induced stress in largemouth bass. Transactions of the American Fisheries Society 113: 767–777.

Edwards, G. P., Jr., R. M. Nuemann, R. P. Jacobs, and E. B. O'Donnell. 2004. Factors related to mortality of black bass caught during small club tournaments in Connecticut. North American Journal of Fisheries Management 24: 801-810.

Furimsky M., S. J. Cooke, C. D. Suski, Y. Wang., and B. L. Tufts. 2003. Respiratory and circulatory responses to hypoxia in largemouth bass and smallmouth bass: implications for "live-release" angling tournaments. Transactions of the American Fisheries Society 132: 1065-1075.

Gilliland, E. R., H. L., Schramm Jr. 2002. Keeping bass alive: a guide book for anglers and tournament organizers. Bass Angler Sportsman Society, Montgomery Alabama. 44 p.

Gustaveson, W. A., R. S. Wydoski, and G. A. Wedemeyer. 1991. Physiological response of largemouth bass to angling stress. Transactions of the American Fisheries Society 120: 629-636.

Grant, E. C., D. P. Philipp, K. R. Inendino, T. L. Goldberg. 2003. Effects of temperature on the susceptibility of largemouth bass to largemouth bass virus. Journal of Aquatic Animal Health 15: 215-220.

Hartley, R. A., and J. R. Moring. 1993. Observations of black bass (Centrarchidae) confined during angling tournaments: a cautionary note concerning dissolved oxygen. Aquaculture and Fisheries Management 24: 575–579.

Hartley, R. A., and J. R. Moring. 1995. Differences in mortality between largemouth and smallmouth bass caught in tournaments. North American Journal of Fisheries Management 15: 666–670.

Hayes, D. B., W. W. Taylor, and H. L. Schramm, Jr. 1995. Predicting the biological impact of competitive fishing. North American Journal of Fisheries Management 15: 457–472.

Jackson, J. J., and D. W. Willis. 1991. Short-term mortality of smallmouth bass caught during a live-release tournament at Lake Oahe, South Dakota. Prairie Naturalist 23: 201–204.

Kerr, S. J., and K. K. Kamke. 2003. Competitive fishing in freshwaters of North America: a survey of Canadian and U.S. jurisdictions. Fisheries 28: 26–31.

Kwak, T. J., and M. G. Henry. 1995. Largemouth bass mortality and related causal factors during live-release fishing tournaments on a large Minnesota lake. North American Journal of Fisheries Management 15: 621–630.

Lantz, K. E., and D. C. Carver. 1975. Dispersal of tournament caught bass from a central release point. Proceedings of the Annual Conference Southeastern Association of Game and Fish Commissioners 29: 115-125.

Meals, K. O., and L. E. Miranda. 1994. Size-related mortality of tournament-caught largemouth bass. North American Journal of Fisheries Management 14: 460– 463.

Neal, J. W., and D. Lopez-Clayton. 2001. Mortality of largemouth bass during catch-and-release tournaments in a Puerto Rico reservoir. North American Journal of Fisheries Management 21: 834–842.

Nielson, L. A. 1985. Public attitudes toward competitive fishing. Abstracts; American Fisheries Society 115th annual meeting, Sun Valley, Idaho. pp 62-63.

Ostrand, K. G., G. R. Wilde, D. W. Strickland, and M. I. Muoneke. 1999. Initial mortality in Texas black bass fishing tournaments. North American Journal of Fisheries Management 19: 1124–1128.

Parker, R. R., E. C. Black, and P. A. Larkin. 1959. Fatigue and mortality in troll-caught chinook salmon (*Onchorhynchus tshawytscha*). Journal of the Fisheries Research Board of Canada 16: 429-448.

Pearson, J. 2003. Largemouth bass tournament monitoring at Indiana natural Lakes. Indiana Division of Fish and Wildlife. Indianapolis, Indiana.

Pelzman, R. J. 1978. Hooking mortality of juvenile largemouth bass, *Micropterus salmoides*. California Fish and Game 64: 185-188.

Perry, S. G. 2002. Initial mortality in New Hampshire black bass fishing tournaments, 1997-2001. New Hampshire Fish and Game Department, internal agency report Concord, New Hampshire. 12 p.

Plumb, J. A., J. L. Gaines, and M. Gennings. 1975. Experimental use of antibiotics in preventing delayed mortality in a bass tournament on Lake Seminole, Georgia. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 28: 87–90.

Plumb, J. A., J. M. Grizzle, and W. A. Rogers. 1988. Survival of caught and released largemouth bass after confinement in live wells. North American Journal of Fisheries Management 8: 324–328.

Rumsey, S. 1991. The biological and social impacts of bass tournaments. Montana Department of Fish, Wildlife and Parks. Internal agency report. 6 p.

Schramm, H. L., Jr., P. J. Haydt, and N. A. Bruno. 1985. Survival of tournament-caught largemouth bass in two Florida lakes. North American Journal of Fisheries Management 5: 606–611.

Schramm, H. L., Jr., P. J. Haydt, and K. M. Porter. 1987. Evaluation of prerelease, postrelease, and total mortality of largemouth bass caught during tournaments in two Florida lakes. North American Journal of Fisheries Management 7: 394–402.

Schramm, H. L., Jr., M. L. Armstrong, A. J. Fedler, N. A. Funicelli, D. M. Green, J. L. Hahn, D. P. Lee, R. E. Manns Jr., S. P. Quinn, and S. J. Waters. 1991. Sociological, economic, and biological aspects of competitive fishing. Fisheries 16: 13-21.

Schramm, H. L., Jr., J. Grizzle, L. Hanson, G. Gilliland. 2004. Improving survival of tournament-caught bass and the effects of tournament handling on largemouth bass virus disease. Internal Agency Completion Report. Mississippi Cooperative Fish and Wildlife Research Unit, Mississippi State University, Mississippi State, Mississippi. 120 p.

Seidensticker, E. P. 1975. Mortality of largemouth bass for two tournaments utilizing a "don't kill your catch" program. Proceedings of the Annual Conference Southeastern Association of Game and Fish Commissioners 28: 83-86.

Simonson, T. 2001. Wisconsin's black bass management plan. Administrative Report Number 54. Bureau of Fisheries Management and Habitat Protection, Wisconsin Department of Natural Resources P.O. Box 7921 Madison, Wisconsin 53707.

Staggs, M. 2005. Bass fishing tournament pilot program evaluation plan. Internal Agency Report. Wisconsin Department of Natural Resources. 5 p.

Suski, C. D., S. S. Killen, S. J. Cooke, J. D. Kieffer, D. P. Phillip, and B. L. Tufts. 2004. Physiological significance of the weigh-in during live-release angling tournaments for largemouth bass. Transactions of the American Fisheries Society 133: 1291-1303.

Suski, C. D., S. J. Cooke, S. S. Killen, D. H. Wahl, D. P. Phillip, and B. L. Tufts. 2005. Behaviour of walleye, *Sander vitreus*, and largemouth bass, *Micropterus salmoides*, exposed to different wave intensities and boat operating conditions during live well confinement. Fisheries Management and Ecology 12: 19-26.

Weathers, K. C., and M. J. Newman. 1997. Effects of organizational procedures on mortality of largemouth bass during summer tournaments. North American Journal of Fisheries Management 17: 131–135.

Welborn, T. L., Jr., and J. H. Barkley. 1974. Study on the survival of tournament released bass on Ross. R. Barnett Reservoir, April 1973. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 27: 512–519.

Wilde, G. R. 1998. Tournament-associated mortality in black bass. Fisheries 23: 12–22.

Wilde, G. R., C. E. Shavlik, and K. L. Pope. 2002. Initial mortality of black bass in B.A.S.S. fishing tournaments. North American Journal of Fisheries Management 22: 950-954.

Wilde, G. R., K. L. Pope, and R. E. Strauss. 2003. Estimation of tournament mortality and its sampling variance. North American Journal of Fisheries Management 23: 779–786.

Wilde, G. R. 2003. Dispersal of tournament-caught black bass. Fisheries 28: 10-17.

Wilde, G. R. 2003. Differences in attitudes, fishing motives, and demographic characteristics between tournament and non-tournament black bass anglers in Texas. North American Journal of Fisheries Management 18: 422-431.