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

by

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Abstract

The Wisconsin Cooperative Fishery Research Unit was contracted by the Wisconsin Department of Natural Resources (WDNR) to evaluate mortality associated with culling in bass tournaments. The objectives of this study were to 1) quantify mortality rates of largemouth bass (*Micropterus salmoides*) (LMB) and smallmouth bass (*M. dolomieu*) (SMB) occurring as a result of professional black bass tournaments and 2) mortality associated with culling during those tournaments. Among six professional bass tournaments studied, total mortality rates of largemouth bass ranged from 0% to 43.9%, and smallmouth bass from 0% to 55.5% when adjusted for reference fish mortalities. During two simulated tournaments, mortality rates of culled LMB were 0% and 16.0%. Culling in simulated tournaments did not appear to increase mortality rates relative to what was seen at the professional bass tournaments. Our results support other studies that indicate tournament-associated mortality dramatically increases when water temperatures exceed 25°C (especially when largemouth bass virus is present) where largemouth bass are the primary target species and 20°C where smallmouth bass are the primary target species, and that strict regulation of bass tournaments under such conditions may be warranted.

Introduction

Continuing to fish after reaching a daily creel limit is common practice in bass fishing tournaments in other Midwestern states (other than Wisconsin) where anglers are allowed to replace or “cull” previously caught smaller fish in their live-well with newly caught larger fish (Staggs 2005). 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 nationwide study has studied the mortality rates of culled bass in tournaments, in particular. However, many studies have quantified the mortality rates of tournament-caught black bass, especially in the southern United States (Neal and Lopez-Clayton 2001, Schramm et al. 1985, Schramm et al. 1987, Weathers and Newman 1997, Meals and Miranda 1994, Schramm et al. 2004). Some researchers have also evaluated general tournament-associated black bass mortality rates in the northern United States (see Perry 2002, Kwak and Henry 1995, Edwards et al. 2004, and Hartley and Moring 1995) but no tournament-associated mortality study has been conducted on black bass in Wisconsin. Even though we expected our findings to be similar to the findings of previous researchers, the Wisconsin legislature wanted to know about tournament-associated mortality in Wisconsin. So we sought an understanding of the mortality rates sustained by tournament-caught and tournament-culled bass that is prerequisite to considering and implementing changes in Wisconsin fishing regulations.

In 2004, the Wisconsin legislature passed Act 249 that required the Wisconsin Department of Natural Resources (WDNR) to establish a bass fishing tournament “pilot” program to evaluate the economic, social, and biological impacts of allowing culling

(Staggs 2005). This project focuses on evaluating the biological impacts. Biological impacts of culling, specifically, and bass tournament angling in general, include physiological stress responses of individual bass ultimately terminating with mortality. Other potential biological impacts, including population-level effects that consider the relative effect cumulative mortalities have on a given waterbody and 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 (*Micropterus 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.

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 black bass are among the top predators in Wisconsin fisheries where as the young serve as prey for centrarchids, esocids, and percids, as well as crayfish, birds, frogs, and snakes (Becker 1983). Black bass are among 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, and 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 aspect of angling for black bass. 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, lucrative endorsements, 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 known organized bass tournament was held on Lake Whitney, Texas with 73 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). Thirty thousand competitive fishing tournaments are currently estimated to occur annually across North America (Suski et al. 2004). Organized bass associations also became established as black bass tournaments became more popular, which in turn promoted more bass tournaments. In 1968, Ray Scott founded B.A.S.S. in Alabama to organize American bass anglers, promote bass tournaments, and support fisheries management (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).

Bass tournament formats and dynamics have changed over the years (e.g. tournament size, boats, weigh-in procedures, mortality). During the 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). Realizing that high mortality affected the public's perception of bass tournaments, 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 in tournaments (Ostrand et al. 1999).

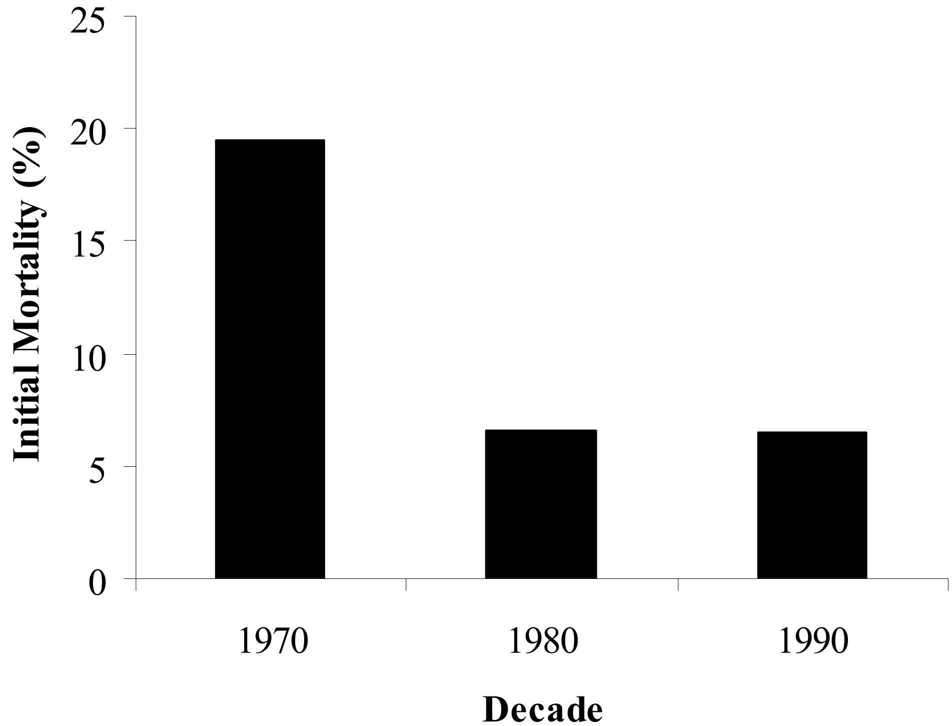

Figure 1. Mean initial mortality rates of 130 black bass tournaments from 1972-1996 (modified from Wilde 1998).

Problematic Issues Concerning Black Bass Tournaments

Tournament and Non-Tournament Angler Attitudes

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 opinion of 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 including crowding boat ramps, driving boats too fast, and displacing fish (Wilde 1998). In 1984, 32% of Indiana anglers thought tournaments hurt fishing; that number increased to 45% by 1994 because of social problems between non-tournament and tournament anglers (Pearson 2003).

Because of social issues and conflicts, fishery managers have become increasingly aware of the importance of managing anglers and have attempted to understand their attitudes and goals to appropriately manage fishery resources (Schramm 1991). Grouping anglers according to their type of participation in fishing provides insight into 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 were younger, fished more frequently, often were male, often belonged to fishing clubs, and viewed themselves as more skilled than non-tournament anglers (Wilde et al. 1998). The study also found tournament anglers had different motives for fishing than non-tournament anglers (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; tournament anglers were also found to be less interested in keeping their fish (Wilde et al. 1998). Tournament anglers placed greater importance on developing their skills, obtaining trophy fish, winning a prize, and viewed it as a 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 varied in their attitudes toward fishing in general (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 understand angler demands and motivations in order 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 help reduce 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

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 was classified as either initial or delayed mortality: initial mortalities are fish that 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 showed that initial mortality of black bass was greatest in the 1970's ($\bar{x}$ = 19.5%), decreased in the 1980's ($\bar{x}$ = 6.6%), and decreased further in the 1990's ($\bar{x}$ = 6.5%) (Wilde 1998). Delayed and total mortalities were not generally studied until the mid 1980's. As a portion of total mortality, more recent studies (since 1987) have shown that delayed mortality rates have exhibited 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).

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 (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 biological impacts on population size structure, such as reducing the number of black bass over the legal length limit (see Suski et al. 2004, Allen et al. 2004). However, this is an area in need of more study. Some researchers are also concerned that some tournaments may harm fisheries by simply increasing and concentrating fishing effort and consequently increase black bass mortality (Meals and Miranda 1994).

Table 1. Selected largemouth bass tournament-associated mortality for sites with and without largemouth bass virus (LMBV) (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 (^oC)	LMBV Presence/Absence	Mean Total Mortality Rate
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. 2002	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. 1991- Mar. 2000	26.3	Untested	42.0%
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), fish densities in live-wells (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). Physiological stress from angling, confinement, handling, and weigh-in procedures, are the primary causes of mortality during bass tournaments. The following pages will examine these variables to give an overview of the findings of previous studies.

Hooking and Handling

Hooking and handling bass had long been believed to cause tournament-associated mortality (Gustaveson et al. 1991). Hooking and playing bass caused changes in blood chemistry due to a physiological stress response (Gustaveson et al. 1991). Fatigue was 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; this was true even when played for five minutes (Gustaveson et al. 1991). This same study also showed fish played to exhaustion (i.e. no longer fighting) took 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 were greatly reduced after 24 hours of recovery (Gustaveson et al. 1991). Researchers concluded hooking stress alone was not directly responsible for all 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 in the mouth 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 categorized into six major areas, and approximately 50 fish per area were hooked. The study only found significantly higher 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 present while they are held in 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 to help aerate the water entering the live-well. Overflow valves are placed near the top of the live-well to allow 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). Because intake hoses are generally short, surface water is usually circulated through live-wells.

Fish Densities in Live-Wells

Fish densities in live-wells are believed by fisheries researchers to be related to tournament-associated mortality (Wilde et al. 2002; Schramm et al. 1985). Numerous studies evaluated by Wilde et al. 2002, and Schramm et al. 1985 found similar correlations between live-well densities and tournament-associated mortality. Increased creel limit, mean weight, and number of held fish per angler increased 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). Among these, 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).

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). To help keep mortality rates to a minimum, Gilliland et al. (2002) recommended no more than 0.45 kilograms (1 pound) of fish per 3.79 liters (1 gallon) of water should be placed into a live-well.

Confinement Time

"Stress" caused by confinement time contributes to increased mortality rates of bass in tournaments (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 collected on 15 bass tournaments held in Puerto Rico, confinement time was positively correlated with initial mortality ($r = 0.520$; $p = 0.043$) but was not significantly related to total mortality (Neal et al. 2001). Similarly, a compilation of 99 bass tournaments held in Connecticut used logistic regression to show a positive correlation between total handling time and initial mortality (Wald $\chi^2 = 14.09$; $p = 0.0002$)

(Edwards et al. 2004). Fishing day length was also positively correlated with initial mortality (Wald $\chi^2 = 4.95$; $p = 0.0261$) (Edwards et al. 2004). Shorter tournament fishing days seemed 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 30th and 7 hours on the 31st. Initial mortality was 31% on the 30th and 11% on the 31st; indicating shorter fishing days reduced mortality rates (Seidensticker 1975).

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 mortality of small fish (total length ≤ 457.2 mm). Prerelease mortality of bass on Sardis Reservoir, Mississippi, from 1989-1991 showed 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 both large ($p < 0.10$) and small ($p < 0.05$) fish (Meals and Miranda 1994). The authors suggested that the increased weight of largemouth bass in live-wells exerted a greater demand for available oxygen and caused the increased mortality.

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). Another potential solution, chemical water conditioners, was 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% (notice live-well vs. ponds) (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 that 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. 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). 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). In general, largemouth bass can survive in water from 0°C to 35.6°C (Becker 1983). Depending on weather, water temperatures can potentially change rapidly in live-wells. 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; the exact range of thermal shock that bass can survive was not determined (Gilliland et al. 2002). Because bass slowly acclimate to water temperature and water chemistry, live-well water should come from the same habitat (thermal 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 thermal shock, 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 because of their relationship 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 pre-release and total mortality rates to be significantly ($p \leq 0.05$) related to water temperature. Initial and delayed mortality rates were also significantly ($p < 0.0001$) related to water temperature in Connecticut tournaments (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. This is also why most North American tournaments today follow a south to north circuit from spring to fall (Kwak et al. 1995). Whereas fishery managers suggest limiting tournament activity during the hottest summer months because of high water temperatures, the majority of bass tournaments throughout North America are held on weekends from around daybreak to early afternoon from May through October (Edwards et al. 2004; Ostrand et al. 1999). So to evaluate effects of season on bass mortality, Ostrand et al. (1999) conducted a study to quantify mortality rates during different seasons. 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). Edwards et al. (2004) found that during the summer the probability of initial mortality increased exponentially at temperatures above 25°C for largemouth bass and above 20°C for smallmouth bass (Figure 2). Neal et al. (2001) concerned with these findings, evaluated 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).

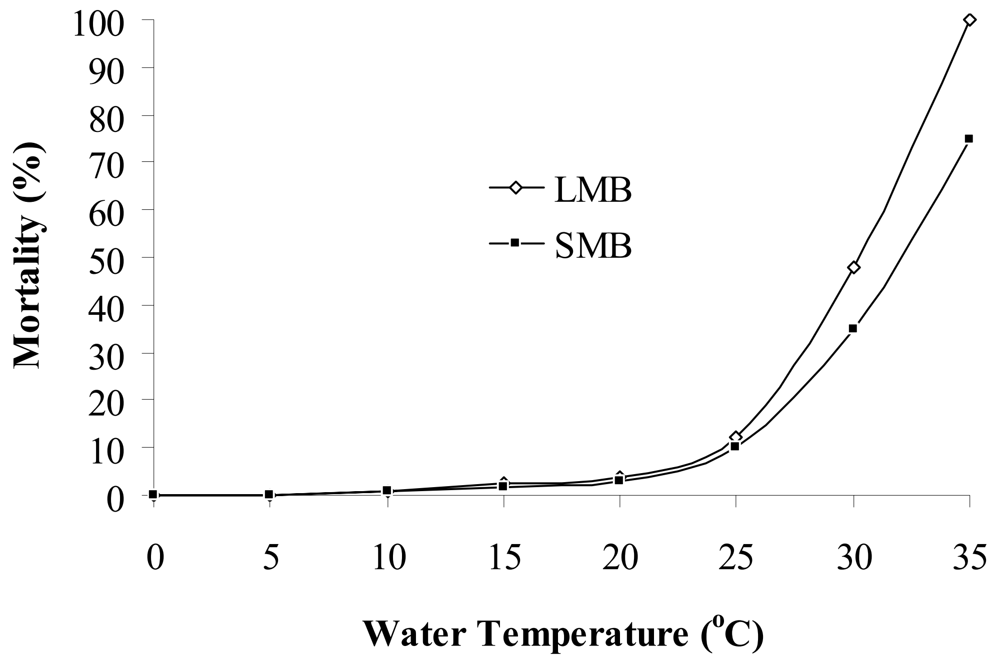

Figure 2. Mortality of tournament-caught largemouth bass (LMB) and smallmouth bass (SMB) in relation to surface water temperature (from Edwards et al. 2004).

Seasonal differences in tournament-associated mortality can also 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 than in September (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 considered a major contributor to mortality of bass in live-wells, which is why it is imperative to hold bass in live-wells that are properly oxygenated and thermally regulated (Gilliland and Schramm 2002). Angling and handling increases the oxygen demand of bass due to increased aerobic activity (Gilliland et al. 2002). A dissolved oxygen level of 5 mg/l or less is considered stressful to black bass, whereas a dissolved oxygen level of 3 mg/l or less 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 were held in live-wells with no aeration, the dissolved oxygen content would quickly be depleted to lethal levels.

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 (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 (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).

Environmental Conditions other than Water Quality of Tournaments

Fisheries researchers have studied environmental conditions at tournaments such as air temperature and cumulative solar radiation 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 and 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 were presumed responsible for the lack of impact air temperature and cumulative radiation had on mortality (Schramm et al. 1985).

Bacterial Infections

Studies have been conducted to see if mortality rates increase as a result of secondary bacterial infections caused by angling and weigh-in activities (Archer et al. 1975). Increased stress reduces black bass' immunosuppressant capabilities that increase the likelihood of bass suffering complications from bacterial infections (Archer et al. 1975). However, past failures to achieve significant improvements in post-release survival of angler-caught fish with antibiotic injections lead researchers to think neither internal nor external bacterial disease significantly affected post-release survival of angler-caught largemouth bass (Schramm et al. 1987). For instance, in multiple experiments, fish were given antibiotics after capture and held in holding ponds and raceways for observation with fish that had not been administered antibiotics and found no significant difference in mortality rates. These studies conducted in 1973 and 1974 suggested administration of oxytetracycline 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). Another study conducted in Mississippi suggested the administration of oxytetracycline to captured largemouth bass was not beneficial in reducing mortality of the released bass either (Plumb et al. 1975). Potassium permanganate is another oxidizing agent that has been found to have no significant impact of survival of largemouth bass (Schramm et al. 2004). With multiple studies failing to reduce mortality rates with the use of antibiotics, bacterial infections are no longer considered a significant factor on tournament-caught bass mortality rates (Plumb et al. 1975). 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).

Tournament Formats

Fishing Tournament Formats

Fishing tournaments are conducted using a variety of rules and formats that result in varying mean initial mortality rates (Ostrand et al. 1999). Data 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 found 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” had the lowest mean initial mortality rate of (1.1%), believed to be the result of 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 initial mortality rate of 4.7% (Ostrand et al.

1999). However, this rate can be misleading, because 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 initial mortality rate for roadrunner tournaments was 4.3% (Ostrand et al. 1999). The initial mortality rates in roadrunner tournaments are higher because fish are exposed to additional stress from being transported and confined longer (Ostrand et al. 1999).

Paper tournaments had 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 that allow spectators to watch, and sponsors to promote their products.

Tournament Size

The size of tournaments likely corresponds (positively) to the efficiency in which fish are weighed in and the care of the fish, thus reducing mortality (Wilde 1998). In a compilation of data from 130 bass tournaments across the U.S.A., tournament size was 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, among 2,072 Texas bass tournaments, the mean initial mortality rate was 1.8% for large tournaments, (tournaments with 50 or more boats) whereas 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).

Weigh-in

Weigh-in activities are 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 that 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 (Suski et al. 2004). 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 was as physiologically detrimental as angling was, consequently affecting mortality (Suski et al. 2004). A study conducted in Connecticut suggested tournament-associated mortality could be reduced by increasing the efficiency of weigh-in procedures at tournaments, which can reduce physiological stress (Edwards et al. 2004).

Species Differences

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). In black bass tournaments, studies have found higher mortality rates for smallmouth bass compared to largemouth bass that are much more tolerant of tournament stressors (Edwards et al. 2004). 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 dissolved oxygen 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).

Summary of the Effects of Stressors

Whereas many correlations have been found between nearly all variables studied and mortality in bass tournaments, many of these factors are often inconsistent and/or statistically insignificant among tournaments. Moreover, many of these factors are closely related to each other and thus make it difficult to identify singular causal factors of mortality. Wilde (1998) suggested no single study could provide a definitive estimate of the magnitude of mortality or the relationship between mortality and different explanatory factors, but trends have started to emerge. Variables correlated with mortality include: water temperature, dissolved oxygen, metabolic waste, handling time, and tournament size (Carmichael et al. 1984, Plumb et al. 1988, and Schramm et al. 1985). Most tournament-associated mortality is likely the result of a combination of these sub-lethal stressors in any given tournament (Wilde 1998).

Non-lethal Tournament Effects

Dispersal

Tournament-associated mortality is not the only effect of tournaments that concern 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).

In 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). This 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). Anglers recaptured 22% of largemouth bass and 15% of smallmouth bass caught and released in fishing tournaments (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).

Methods

Two sets of information were 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 was prerequisite to providing context for understanding effects of culling. Thus, the first set of information collected quantified mortality of tournament-caught bass at professional black bass tournaments. The second set of information quantified the mortality rates of culled bass, specifically. This was done in simulated tournaments, where culling effects could be sufficiently isolated to assess the magnitude of these effects. We used methods for evaluating black bass tournaments that were relatively standardized in studies of this type (See 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).

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 (sum of initial and delayed mortality). For the second portion of the study, which evaluated simulated tournaments, the mortality rate evaluated was the 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.

Mortality was evaluated at six professional bass tournaments on rivers, lakes and reservoirs throughout Wisconsin (Table 2). Tournaments were evaluated from late spring to early fall and covered a range of water temperatures. All six professional tournaments were "total weight tournaments" in which prizes were awarded to the angler(s) with the highest total weight of fish. Three simulated tournaments were conducted on lakes from late spring to late summer and also covered a range of water temperatures (Table 2).

Methods for Professional Bass Tournaments

Tournament officials determined initial mortalities during weigh-in. The officials looked for opercular movement on the bass. If there was any opercular movement then the bass was considered to be alive; if there was no opercular movement the bass was considered dead. The officials reported the number of dead bass and the total number of bass weighed in daily.

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; densities in this study were intermediate relative to other studies (Table 3). To assess effects of pen size on mortality prior to the actual evaluations, we conducted a preliminary study by holding 22

Table 2. 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 3. Examples of holding pens volumes in previous tournament-associated mortality studies.

Holding Pen Volume	Maximum 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)

bass in a holding pen (32.7 m^3) at McDill Pond, Plover, Wisconsin. The treatment bass were held for five days with no mortalities, suggesting mortality was not caused by the holding pens. Moreover, pre-tournament holding of bass in three lakes in central and southern Maine by Hartley and Moring (1995) also showed no mortality caused by holding pens. Depending on the expected catch of the tournament, we placed up to 50 bass in each half of the holding pens (50 fish = 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). The reference fish remained separate from treatment fish and the treatment fish were separated into pens based on the 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.

During the 2006 Mississippi River Tournament LC06 an experiment was conducted to assess delayed mortality besides the mortality experiment in holding pens. The experiment was done to evaluate the source of dead bass on the shorelines of the tournament waters. Wisconsin Department of Natural Resources biologists marked the captured bass, which were not going to serve as treatment bass in our holding pens, after they were weighed in and before they were placed into a pontoon release boat. The bass were marked with a paper hole punch in the caudal fin. Every day for seven days after the first bass were released a crew of three people monitored approximately eight kilometers of shoreline around the locations where the bass were released to search for dead bass and examine dead bass for hole punches in their caudal fin.

At the holding pens, 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 Ames, IA, USA. 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.

Once anglers had weighed their fish and handed their fish off to the release boat we interviewed the anglers to find out how many largemouth and smallmouth bass they culled, and at what time during the day they caught the fish. We also gathered information about their live-well size, aeration system, cooling system, water flow system, live-well location on the boat, and what kind, if any, of water conditioners they used (see appendix A for survey sheet).

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 be 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 was 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 live-well until five angled fish had been placed into the angler's live-well. Electrofished bass not held in live-wells were used as reference fish. 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 live-well, a "new" marked fish was angled and added to the live-well to ensure five fish remained in the live-well (Figure 3). 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 live-well. The numbered clips also allowed us to know how long each fish had been in the live-well. Anglers returned to fish in the lakes as they would in a real tournament with a full live-well. They never placed any additional fish caught during the simulated tournament in the live-wells. 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 live-well. These marked fish were then placed in holding pens based on the length of time they had been in the angler's live-well. At all times, five fish (maximum creel limit) were in live-wells during the simulated tournaments. So in the end, 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,

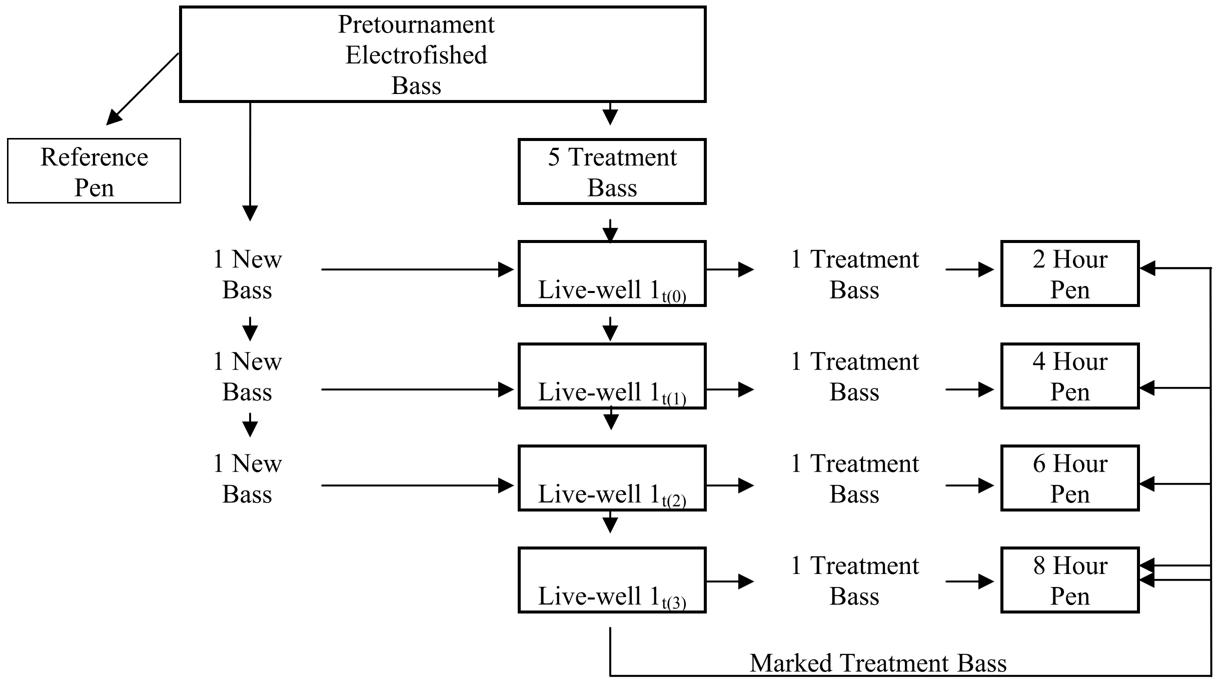

Figure 3. Diagram of how simulated tournaments were conducted. Culled bass were held in holding pens based on how long they were held in live-wells. As a bass was removed from a live-well to be placed in a holding pen, a new bass (marked with a culling clip) was placed in the live-well. Bass not held in live-wells served as reference bass.

6-hours, and 8-hours. The data from the Madison Chain simulated tournament MAS06 was compromised because muskrats chewed many holes in the holding pens, which consequently let most reference and treatment fish escape.

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, tournament officials at weigh-in judged fish dead or alive. 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 fish 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 were 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 ith day, $M_{D,i}$ is delayed mortality of fish captured on the ith 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.

Chi square analyses were run in Statistical Analysis Systems (SAS) to evaluate differences in mortality between treatment and reference fish. T-tests were also run in SAS to evaluate differences in lengths between dead and surviving largemouth and smallmouth bass.

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 were quantified at six professional bass tournaments taking place from August, 2005 to September 2006. Three tournaments (LC05, SB06, and LC06) had between 368 and 400 anglers participating while the other three tournaments (SH05, WC06, and MA06) had between 88 and 118 anglers participating. The three tournaments with larger numbers of participants caught larger numbers of bass (1757-3132) than the three smaller tournaments (226-317) (Table 2).

Culling rates varied among the tournaments we studied. Overall, 33% of the anglers who weighed in fish reported having culled at least one bass during the six professional bass tournaments we evaluated. Four tournaments had over 17% of the anglers culling bass which included the 2005 Mississippi River Tournament LC05 (17.5%), the 2006 Mississippi River Tournament LC06 (41.5%), the 2006 Wolf River Chain Tournament WC06 (23.8%), and the 2006 Sturgeon Bay Tournament SB06

(62.8%), while very little culling took place at the 2005 Shawano Lake Tournament SH05 (1.3%), and the 2006 Madison Chain Tournament MA06 (4.6%). The highest culling rate occurred during the first day of the 2006 Sturgeon Bay Tournament SB06 where 77.2% of the anglers that weighed in fish had culled at least one bass (Table 4). The lowest culling rate occurred at the 2005 Shawano Lake Tournament SH05 on the second day of the tournament where no anglers culled any bass. In general, anglers caught most of their fish in the first few hours of the day; most fish were caught from 0800- 0859 with catch rates steadily declining after that time (Figure 4). And while anglers caught more largemouth bass than smallmouth bass in this study, both species followed the same general trend as far as what time of day most of them where captured (Appendix B).

Tournament-Associated Mortality at Professional Bass Tournaments

Mortality rates varied greatly among the professional black bass tournaments studied in 2005 and 2006. Unadjusted total mortality rates ranged from 0% to 76.2% for largemouth bass and 0% to 42.3% for smallmouth bass across all professional tournaments. When adjusted for reference fish mortalities in holding pens, total mortality rates ranged from 0% to 15.6% for largemouth bass, and 0% to 33.9% for smallmouth bass. Smallmouth bass suffered greater initial mortality rates (0-3.3%) than largemouth bass (0-1.2%) (see Table 5). Adjusted delayed mortality rates ranged from 0% to 13.2% for largemouth bass and 0% to 31.5% for smallmouth bass (Figure 5). Chi-square analysis showed a significant difference ($p < 0.05$) in mortality between treatment and

Table 4. Summary of the percentages of anglers who culled at least one bass during the six professional bass tournaments evaluated during this study.

Tournament	Date	Number of anglers weighing in at least one bass	Number of anglers that culled at least one bass	% Culling
LC05	8/3/2005	311	53	17.0%
LC05	8/4/2005	283	45	15.9%
LC05	8/5/2005	16	6	37.5%
LC05	8/6/2005	18	6	33.3%
LC05	Total	628	110	17.5%
SH05	9/24/2005	43	1	2.3%
SH05	9/25/2005	36	0	0.0%
SH05	Total	79	1	1.3%
SB06	5/20/2006	189	146	77.2%
SB06	5/21/2006	134	57	42.5%
SB06	Total	323	203	62.8%
LC06	7/12/2006	380	154	40.5%
LC06	7/13/2006	353	141	39.9%
LC06	7/14/2006	40	23	57.5%
LC06	7/15/2006	20	11	55.0%
LC06	Total	793	329	41.5%
WC06	7/30/2006	101	24	23.8%
WC06	Total	101	24	23.8%
MA06	9/23/2006	48	3	6.3%
MA06	9/24/2006	39	1	2.6%
MA06	Total	87	4	4.6%
	Grand Totals	2011	671	33.4%

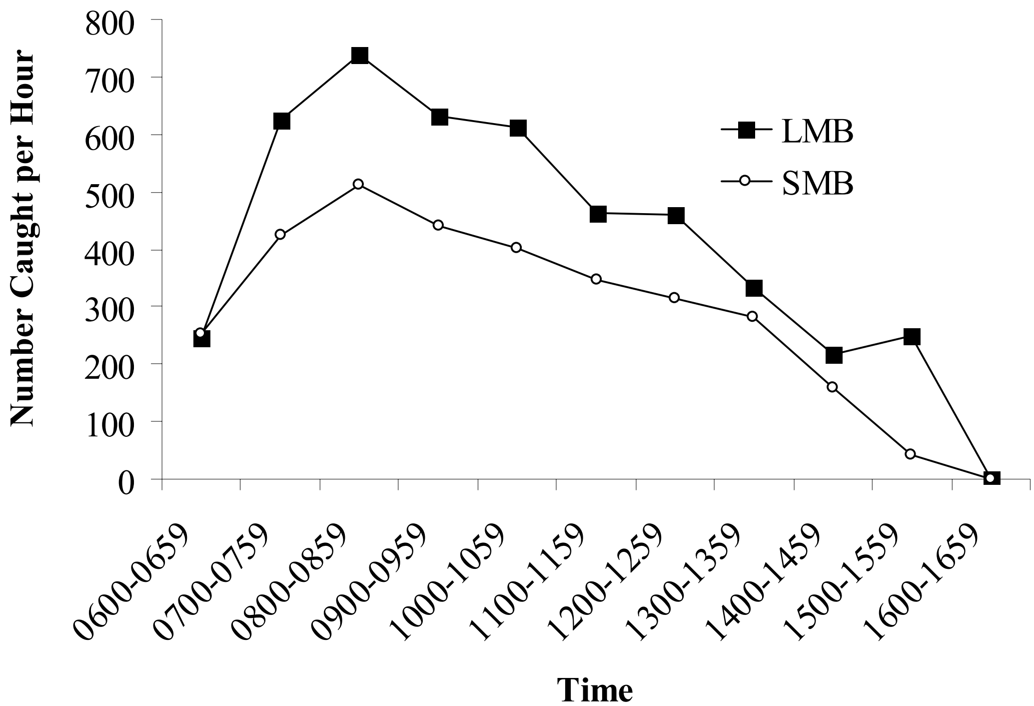

Figure 4. The total number of bass caught per hour during six professional bass tournaments studied in 2005 and 2006. Total number of largemouth bass = 4569. Total number of smallmouth bass = 3177.

Table 5. 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 Miss. River	SH05 Lake Shawano	SB06 Sturgeon Bay	LC06 Miss. River	WC06 Wolf R. Chain	MA06 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 ± 0.01	16.5 ± 0.30	14.6 ± 0.05	27.3 ± 0.05	27.8 ± 0.04	16.7 ± 0.03
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 ± 0.44	12.5 ± 0.30	11.9 ± 0.04	10.5 ± 0.08	7.3 ± 0.06	10.6 ± 0.03
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 ± 0.22	12.3 ± 0.29	12.3 ± 0.10	7.3 ± 0.03	7.0 ± 0.07	9.9 ± 0.03
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)
Total Anglers	368	88	400	400	112	118
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
LMB Total Mortality Rate (%)	0[2]	0.6	0	15.6	43.9[2]	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	-[3]	14.0	25.0	0
SMB Reference Mortality Rate (%)	26.9	-[3]	0	6.0	-[3]	-[3]
Adjusted LMB Delayed Mortality (%)	0[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
Chi X^2	4.2519	0.4566	0.253	13.6242	5.7481	-
P	0.0392	0.4992	0.6150	0.0002	0.0165	-
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

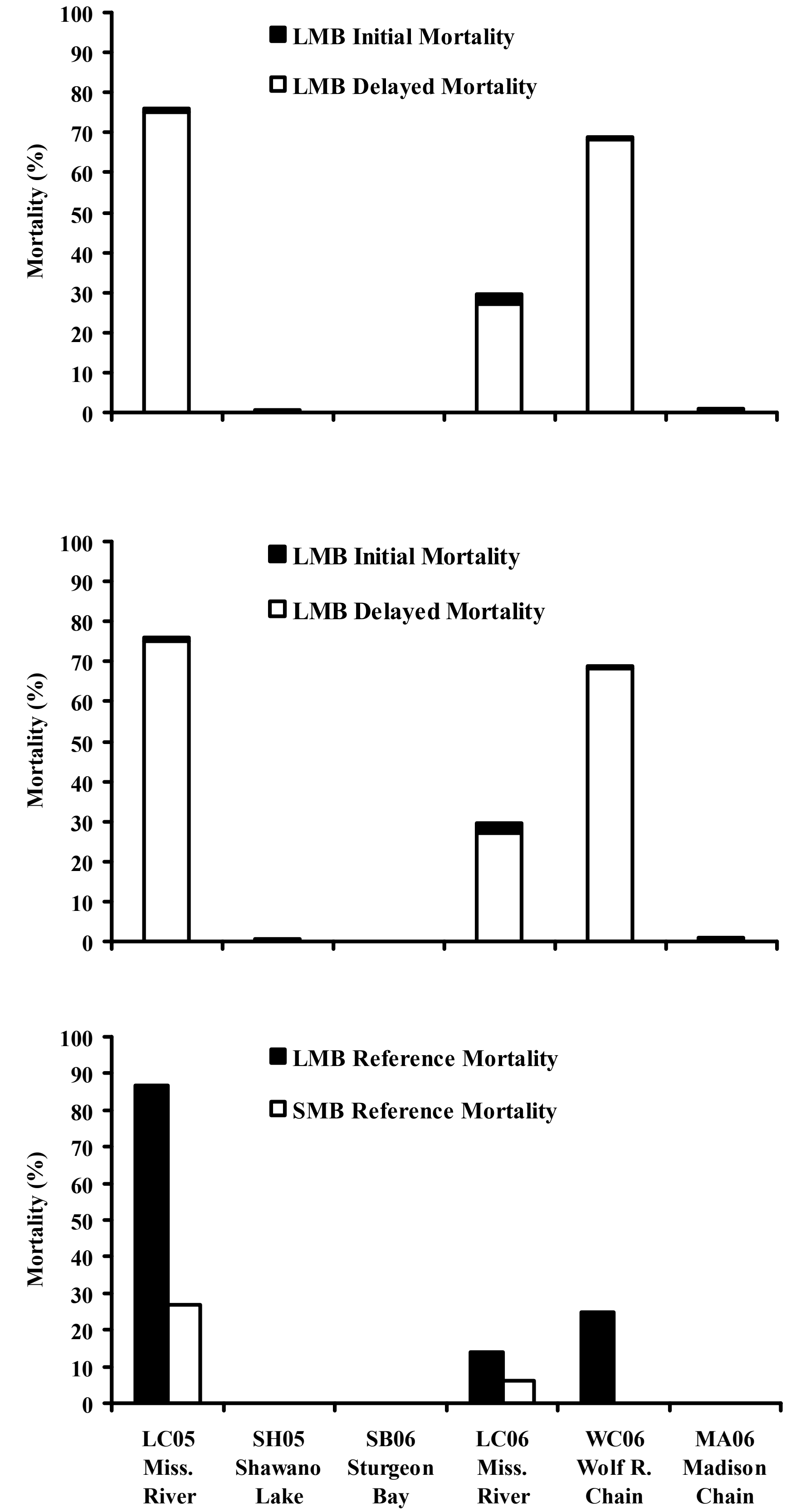

Figure 5. Total mortality of treatment and reference largemouth and smallmouth bass.

reference fish at the 2005 Mississippi River Tournament LC05 (χ^2 = 4.25, 1 d.f., p < 0.05), 2006 Mississippi River Tournament LC06 (χ^2 = 13.62, 1 d.f., p < 0.05) and the 2006 Wolf River Chain Tournament WC06 (χ^2 = 5.75, 1 d.f., p < 0.05), but no significant difference (p > 0.05) at SH05 (χ^2 = 0.46, 1 d.f., p > 0.05), SB06 (χ^2 = 0.25, 1 d.f., p > 0.05) or the 2006 Madison Chain Tournament MA06 were no fish died (see Table 5).

The presence of LMBV and warm water temperatures increased mortality rates. Mean surface water temperatures ranged from 15.2°C to 27.9°C at the tournaments and LMBV was present at four (LC05, LC06, WC06, and MA06) of the six tournaments (Table 5). Tournaments taking place in fisheries where LMBV was present had greater mortality rates for largemouth bass than tournaments where LMBV was absent, especially when the water temperature was above 25°C (Table 5). The three tournaments that had the highest mortality rates all took place in fisheries where the mean surface water temperature was > 25°C and LMBV was present. And despite the presence of LMBV, there was no mortality at the 2006 Madison Chain Tournament MA06 likely because the mean surface water temperature was lower at 16.7°C (Appendix A).

When mean surface water temperatures were above 25°C largemouth bass mortality rates were significantly higher (p > 0.05) than when temperatures were below 25°C as can be seen when using the results from this study and previous studies (see Table 6, and Figure 6). When LMBV is present and the surface water temperatures are above 25°C mortality rates increase rapidly (Figure 6). However, previous studies also show when LMBV is absent and the water temperatures are above 25°C the mortality rates for largemouth bass are highly variable (Figure 6). When surface water

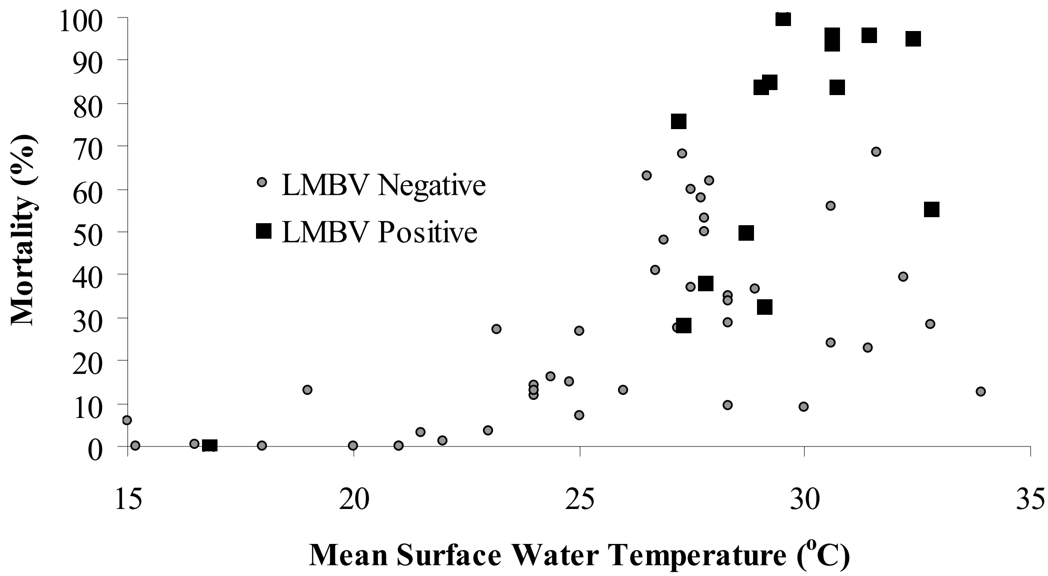

Figure 6. Mean total mortality rates for multiple largemouth bass tournaments (including this study) throughout the United States. Some data points represent multiple studies (Neal and Lopez-Clayton 2001, Hartley and Moring 1995, Kwak and Henry 1995, Schramm et al. 1985, Schramm et al. 1987, Edwards et al. 2004, Weathers and Newman 1997, and Schramm et al. 2004).

Table 6. Mean total mortality rates for multiple largemouth bass tournaments (including this study) throughout the United States (Neal and Lopez-Clayton 2001, Hartley and Moring 1995, Kwak and Henry 1995, Schramm et al. 1985, Schramm et al. 1987, Edwards et al. 2004, Weathers and Newman 1997, and Schramm et al. 2004).
*Asterisks indicate multiple studies.

Study	Tournament Location	Mean Surface Water Temperature (^{o}C)	Mean Total Mortality (%)
Kwak and Henry (1995)	MN	15.0	5.9
This Study	WI	15.2	0.0
This Study	WI	16.5	0.5
This Study	WI	16.8	0.0
Hartley and Moring (1995)	ME	18.0	0.0
Hartley and Moring (1995)	ME	19.0	13.0
Hartley and Moring (1995)	ME	20.0	0.0
Hartley and Moring (1995)	ME	21.0	0.0
Hartley and Moring (1995)	ME	21.0	0.0
Edwards et al. (2004)	*CT	21.5	3.2
Hartley and Moring (1995)	ME	22.0	1.0
Kwak and Henry (1995)	MN	23.0	3.6
Neal and Lopez-Clayton (2001)	PR	23.2	27.0
Schramm et al. (1985)	*FL	24.0	14.0
Hartley and Moring (1995)	ME	24.0	12.0
Neal and Lopez-Clayton (2001)	PR	24.0	13.0
Neal and Lopez-Clayton (2001)	PR	24.4	16.0
Neal and Lopez-Clayton (2001)	PR	24.8	15.0
Schramm et al. (1987)	*FL	25.0	26.7
Hartley and Moring (1995)	ME	25.0	7.0
Hartley and Moring (1996)	ME	26.0	13.0
Neal and Lopez-Clayton (2001)	PR	26.5	63.0
Neal and Lopez-Clayton (2001)	PR	26.7	41.0
Neal and Lopez-Clayton (2001)	PR	26.9	48.0
Weathers and Newman (1997)	AL	27.2	27.5
This Study	WI	27.2	76.0
Neal and Lopez-Clayton (2001)	PR	27.3	68.0
This Study	WI	27.3	28.4

Neal and Lopez-Clayton (2001)	PR	27.5	37.0
Neal and Lopez-Clayton (2001)	PR	27.5	60.0
Neal and Lopez-Clayton (2001)	PR	27.7	58.0
Neal and Lopez-Clayton (2001)	PR	27.8	53.0
Neal and Lopez-Clayton (2001)	PR	27.8	50.0
Schramm et al. (2004)	MS	27.8	38.3
Neal and Lopez-Clayton (2001)	PR	27.9	62.0
Weathers and Newman (1997)	AL	28.3	35.1
Weathers and Newman (1997)	AL	28.3	28.6
Weathers and Newman (1997)	AL	28.3	9.4
Weathers and Newman (1997)	AL	28.3	34.0
Schramm et al. (2004)	MS	28.7	50.0
Weathers and Newman (1997)	AL	28.9	36.5
Schramm et al. (2004)	MS	29.0	84.0
Schramm et al. (2004)	AL	29.1	32.5
Schramm et al. (2004)	MO	29.2	85.0
Schramm et al. (2004)	MS	29.5	100.0
Weathers and Newman (1997)	AL	30.0	9.1
Weathers and Newman (1997)	AL	30.6	56.0
Weathers and Newman (1997)	AL	30.6	24.1
Schramm et al. (2004)	AR	30.6	93.9
Schramm et al. (2004)	AL	30.6	95.9
Schramm et al. (2004)	AL	30.7	83.7
Weathers and Newman (1997)	AL	31.4	22.7
Schramm et al. (2004)	MS	31.4	96.1
Weathers and Newman (1997)	AL	31.6	68.4
Weathers and Newman (1997)	AL	32.2	39.5
Schramm et al. (2004)	MS	32.4	95.3
Weathers and Newman (1997)	AL	32.8	28.3
Schramm et al. (2004)	MS	32.8	55.7
Weathers and Newman (1997)	AL	33.9	12.7

temperatures are below 25°C mortality rates are generally low regardless of LMBV presence or absence (Figure 6).

Among all professional tournaments in this study low dissolved oxygen was only an issue at the 2006 Wolf River Chain Tournament WC06 where dissolved oxygen levels occasionally dropped to very low levels immediately adjacent to the holding pens (≈ 3.5 mg/l) which likely 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 5).

T-tests showed a significant difference in length of dead versus surviving smallmouth bass only at the 2005 Mississippi River Tournament LC05 ($p < 0.01$) (Table 7). There was no significant difference ($p > 0.05$) in the length of dead versus surviving smallmouth bass or largemouth bass at the rest of the tournaments.

Large numbers of bass were found along the shoreline in the vicinity of the tournament release areas at the 2006 Mississippi River Tournament LC06. Of the 3,132 bass weighed in during the 2006 Mississippi River Tournament LC06, WDNR biologist marked 2,840 (91%) of the bass before they were released. Over the next seven days we recovered 639 dead bass floating in the water or washed up on shore. Of the 639 dead bass 607 (95%) were largemouth bass with hole punches in their caudal fins. Twenty four bass that we collected had decomposed so much that we could not determine if there was a hole punch in there caudal fin or not. Five largemouth bass that were collected did not have a hole punch.

All anglers' live-wells had characteristics that were conducive to keeping fish alive. Nearly 82% of the anglers we interviewed had a live-well located in the stern of their boat (Figure 7). A water stream was the most popular type of aeration system used

Table 7. Differences in the lengths of dead vs. surviving largemouth bass and smallmouth bass at the six professional bass tournaments evaluated during this study.

Tournament	Species	Number of survivors	$\bar{X}$ Length (mm) 1	$\bar{X}$ ± se	Number of dead bass	$\bar{X}$ Length (mm) 0	$\bar{X}$ ± se	P
LC05	LMB	180	390	2.1	626	387	1.2	0.26
	SMB	143	406	3.2	102	392	4.1	0.01
SH05	LMB	249	382	2.0	1	470	0.0	0.01
	SMB	-	-	-	-	-	-	-
SB06	LMB	2	402	20.0	-	-	-	-
	SMB	497	419	1.6	1	435	0.0	0.66
LC06	LMB	174	390	2.3	65	388	3.9	0.60
	SMB	63	395	5.5	14	383	6.0	0.32
WC06	LMB	-	-	-	-	-	-	-
	SMB	-	-	-	-	-	-	-
MA06	LMB	283	375	2.8	-	-	-	-
	SMB	-	-	-	-	-	-	-

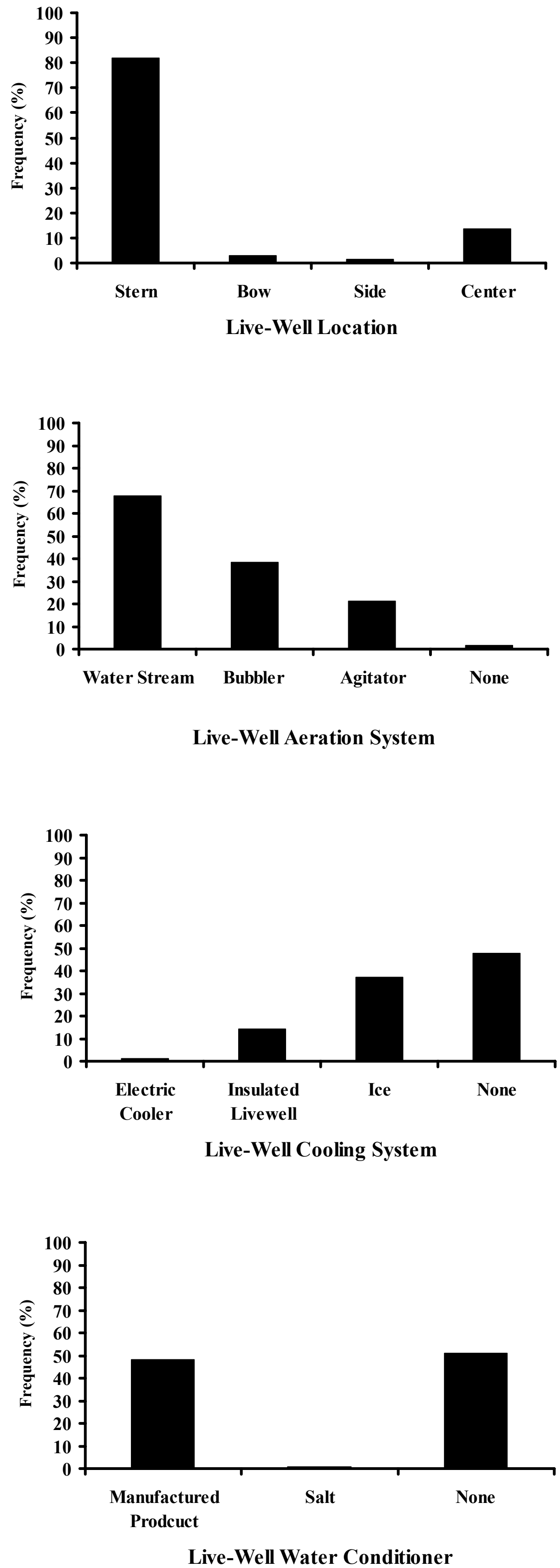

Figure 7. Live-well characteristics of interviewed professional bass anglers at the six tournaments evaluated in this study.

in live-wells (68%) while bubblers (38%) and agitators (21.2%) were also common types of aeration systems (Figure 7). Twenty nine percent of the angler's live-wells used more than one type of aeration system. Many anglers' (48%) live-wells did not have a cooling system but 37% of the interviewed anglers did use ice (Figure 7). Almost half (48%) the anglers we interviewed used a manufactured water conditioner (e.g. Catch and Release®, Rejuvenate®, and Please Release Me®) in their live-wells; only 1% of the interviewed anglers used salt and 51% reported using nothing (Figure 7).

Culling in Simulated Tournaments

The mortality rates of the culled bass seemed to follow the same trend as the tournament caught bass that had been through a weigh-in procedure. Three simulated tournaments were conducted to evaluate the mortality of culled bass resulting in varying mortality rates ranging from 0% to 43%. The Balsam Lake simulated tournament BA06 showed the highest adjusted mortality rate of culled bass at 16%, while the Minocqua Chain simulated tournament MI06 had a 0% mortality rate and cooler water temperatures (Table 8). The mean surface water temperature was 23.1°C at the Balsam Lake simulated tournament BA06 and 20.0°C at the Minocqua Chain simulated tournament MI06. LMBV was absent at the Balsam Lake simulated tournament BA06 and the Minocqua Chain simulated tournament MI06 (Table 8). Chi-square analysis showed no significant difference ($p > 0.05$) in mortality between culled treatment and reference fish at the Balsam Lake simulated tournament BA06 ($\chi^2 = 7.47$, 1 d.f., $p > 0.05$), (Table 8). Like the professional bass tournaments, mortality was higher for culled bass when the water temperatures were warmer.

Table 8. Summary statistics simulated tournaments bass tournaments in Wisconsin.

[1] Data compromised because most reference and treatment fish escaped from holding pens.

	Tournament		
	Balsam Lake BA06	Madison Chain MAS06	Minocqua Chain MI06
Date	6/17/2006	8/25/2006	9/8/2006
LMBV Presence/Absence	Absent	Present	Absent
Mean Surface Water Temp (°C)	23.1 ± 0.02	24.2 ± 0.02	20.0 ± 0.33
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 ± 0.02	9.6 ± 0.03	9.9 ± 0.03
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 ± 0.02	8.0 ± 0.03	8.3 ± 0.01
Mean Bottom D.O. (mg/l) Range	7.6 - 9.5	6.6 - 10.3	7.8 - 9.0
Mortality Rate (%)	47%	-[1]	0%
Adjusted LMB Mortality Rate	17%	-[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	-	-
P	0.058	-	-
Reference Fish Compromised?	No	Yes	No

The Balsam Lake simulated tournament BA06 was the only tournament we were able to evaluate mortality by hour at since the Madison Chain simulated tournament MAS06 was compromised and no fish died at the Minocqua Chain simulated tournament MI06. The six hour treatment showed the highest adjusted mortality rate of 30.0%, followed by the two hour treatment at 13.3%, and finally the four hour treatment at 6.7% (Figure 8, Table 8). 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 8).

Discussion

The objectives of this study were to quantify initial, 5-day delayed, and total mortality rates of tournament-caught largemouth and smallmouth bass in Wisconsin bass tournaments and to quantify the mortality rate of tournament-culled largemouth and smallmouth bass in simulated tournaments in Wisconsin. This was done as part of a three part study to help the state decide if culling should be allowed in Wisconsin bass tournaments. We found that when water temperatures were high for both largemouth and smallmouth bass, high mortality rates could be expected at professional bass tournaments. Edwards et al. (2004) found that during summer, the probability of initial mortality increased exponentially at temperatures above 25°C for largemouth bass and above 20°C for smallmouth bass. A study conducted by Schramm et al. (1987) on eleven tournaments in Florida found pre-release 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

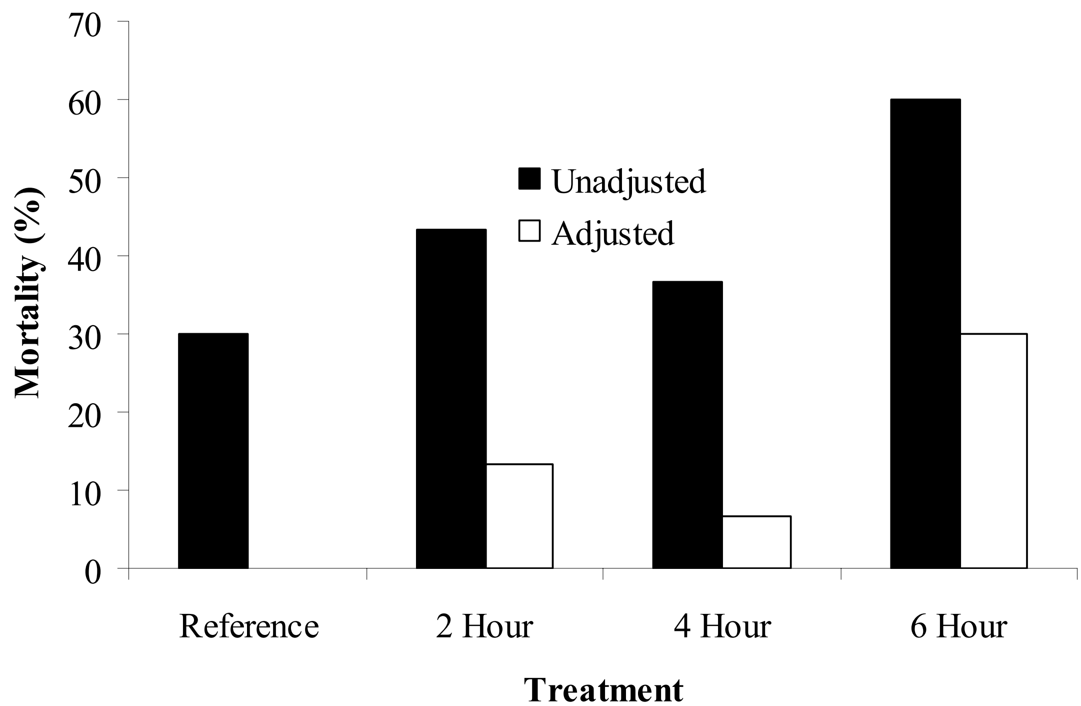

Figure 8. Mortality by length of time fish were held until culled at Balsam Lake simulated tournament. Note, no fish died at the Minocqua simulated tournament and the Madison simulated tournament could not be evaluated due to escape of fish from pens.

well (Edwards et al. 2004). Neal et al. (2001) concerned with these findings, evaluated 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).

LMBV is a recently discovered pathogen that has become widely distributed throughout the southeastern and mid-western United States and is considered responsible for large-scale fish kills of largemouth bass, particularly during summer months (Grant et al. 2005). LMBV is the only known virus that contributes to mortality in largemouth bass (Plumb et al. 1999). LMBV was first isolated from a largemouth bass that was collected from Lake Weir, Florida in 1991 (Grizzle and Brunner 2003). However, the first fish kill associated with LMBV occurred in 1995 in Santee-Cooper Reservoir that is an impoundment of the Santee and Cooper rivers in South Carolina (Plumb et al. 1999). LMBV infects several fish species including bluegill (*Lepomis macrochirus*), striped bass (*Morone saxatilis*), spotted bass (*Micropterus punctulatus*) smallmouth bass and largemouth bass, but has not caused any known natural (excluding laboratory experiments) mortalities in any species except largemouth bass (Grant et al. 2003).

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. 1985, 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. We evaluated three tournaments that had both high water temperatures (> 27.2°C) and LMBV and found high unadjusted delayed mortality rates (> 27%) for the three tournaments, which is similar to the research of Edwards et al. (2004) that indicated high mortality rates for largemouth bass occurred when water temperatures exceed 25°C, especially when LMBV is present, and smallmouth bass when temperatures exceed 20°C (Figure 5) (see Edwards et al. 2004). Schramm et al. (2004) also conducted evaluations during the summer on fisheries infected with LMBV while average surface water temperatures ranged from 27.8-32.8°C and found a mean total mortality rate of 76% for largemouth bass (Table 9, Figure 6). The combination of largemouth bass virus and warm water temperatures played a major role in the high mortality rates sustained by the largemouth bass in both studies.

Smallmouth bass mortality rates were generally unaffected by LMBV presence or absence, presumably because smallmouth bass are capable of carrying LMBV; no documented smallmouth bass fish kills have been associated with LMBV (Grant et al. 2003). However, as with largemouth bass, smallmouth bass mortality increased when water temperatures were high. In general the initial mortality rates of largemouth and smallmouth bass were lower than their delayed mortality rates, especially when largemouth bass virus was present because largemouth bass mortalities are delayed 1-5 days while the fish succumb to the virus.

Tournaments taking place under cool water conditions have low mortality rates regardless of largemouth bass virus presence or absence. For example, the tournament we studied in Madison (2006) took place in late September, while the mean surface water temperature was 16.7°C; the fishery has largemouth bass virus yet the delayed mortality rate was 0%. This is similar to the findings of other research by Hartley and Moring (1995), Edwards et al. (2004), and Kwak and Henry (1995). LMBV was absent and the mean surface water temperatures for all three of their studies were below 22°C. All three studies found mean total mortality rates below 5% for largemouth bass and below 9% for smallmouth bass, which supports our results (Table 1).

Technical problems that we had at two of the six tournaments may have affected the mortality data collected there. At the Mississippi River tournament in 2005, all reference fish were initially held in a modified hoop net after being electrofished and then held overnight prior to placement in the holding pens the following day. This added stress to the fish by confining them in a smaller enclosure than the holding pen prior to the start of the evaluation. These reference fish were crowded, did not have adequate ventilation, and showed excessively abraded fins and physical trauma. The fish were subjected to additional stress when they were removed from the hoop net and placed into the holding pen (two sets of handling time stress versus one handling time for all other tournaments). Consequently, 75% of the reference fish died, which was 9% higher than the combined largemouth and smallmouth bass delayed mortality rate of the treatment fish, and as a result the adjusted mortality rates are an underestimate.

During this tournament (LC05), large numbers of bass were also washing up along the shoreline where the release boats had released bass. These were likely tournament-caught fish, but that assumption could not be validated. When we returned to LaCrosse in 2006 we developed a plan to mark the released fish so if dead bass began washing up on shore again we would know if they had been through the tournament weigh-in. Immediately following the tournament, we began finding hundreds of dead bass washed up on shore in the same areas as they had been found in 2005 near the release sites. We found 607 marked dead bass, which is 21% of the 2840 we marked. In all, we found a total of 639 dead bass, but I assume that every bass we found had been through the tournament considering that we were only able to mark 91% of all the bass weighed in and some of the bass were badly decomposed. The 21% mortality rate of the fish we marked was higher than the 13.2% mortality rate we found in our holding pens. Clearly, 21% is a conservative estimate of the delayed mortality considering that we could not have found all the fish that died and washed up and that we have no way of knowing how many bass died and sank instead of floating to the surface.

We monitored the dissolved oxygen levels in the vicinity of the release site and found high dissolved oxygen levels that never dropped below 7 mg/l. The likely reason so many bass died was because the tournament was held in July when the daily high air temperatures were reaching over 37°C, the mean surface water temperature was over 27°C, and the fishery was infected with LMBV. Tournaments should not be allowed to take place under such extreme conditions.

We also had problems at the Winneconne tournament in 2006. The night after we collected reference fish, a severe thunderstorm occurred and the high winds and waves flipped the holding pen that held the reference fish. 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 new 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 were 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 fell below 5 mg/l in the holding pens during the five-day observation period. This likely contributed to the high mortality rate observed at this tournament as dissolved oxygen concentrations below 5 mg/l are considered stressful to largemouth bass (Gilliland et al. 2002).

Previous studies have found largemouth bass mortality to increase significantly with fish length (Weathers and Newman 1997, Meals and Miranda 1994). However, we did not find a significant difference in the length of bass that survived and bass that died ($p < 0.05$) at most of our tournaments. Only the smallmouth bass at the 2005 Mississippi River Tournament LC05 had a significant difference in size, but there was only one dead largemouth bass at the 2005 Shawano Lake Tournament SH05. The reason we did not find differences in the length of surviving versus dead largemouth bass was likely because the bass were infected with LMBV. It is possible that LMBV does not discriminate between largemouth bass that range in total length from 356 mm to 533 mm, which is approximately the range of bass we evaluated. Surprisingly, the only tournament that had a significant difference in length of surviving versus dead bass had a higher mean length for surviving smallmouth bass than dead smallmouth bass. We did not see differences in length of dead versus surviving bass likely because we evaluated a narrow range of sizes.

This study did not attempt to evaluate population-level effects of tournament-associated mortality, but it is important that population levels effects of tournament-associated mortality be considered for evaluation in future studies so fishery managers can better manage fishery resources. The Mississippi River in LaCrosse, Wisconsin hosts tournaments nearly every day throughout the summer, consequently large numbers of bass are likely being killed there. The death of hundreds of adult bass from a fishery during a single four day tournament may potentially affect the population size or size structure. If mortality rates like we found are prevalent during the summer months, it is possible that thousands of angled bass are killed throughout the summer and not consumed by humans. A previous study conducted on simulated impacts of tournament-associated mortality predicted that lakes with total tournament catch / total largemouth bass harvest ratios greater than three, tournament mortality would decrease population abundance if harvest estimates corresponded to 15% or more (Allen et al. 2004). One potential solution would be to eliminate tournaments during such high stress periods as the summer.

Another effect of tournament mortality is the potential effect it has on size structure, particularly if a large number of tournaments are held on the same waterbody. The same study conducted on simulated effects of tournament-associated mortality used a model to predict declines in the abundance of largemouth bass larger than 300 mm total length (Allen et al. 2004). The study predicted that when the mean annual tournament catch / mean annual harvest ratio exceeds three, and tournament mortality was between 20-30%, then a 5-12% decline in largemouth bass larger than 300mm in total length could be expected (Allen et al. 2004). During both tournaments held in LaCrosse on the Mississippi River many tournament anglers complained during interviews that the overwhelming majority of the fish they were catching were just shy of the minimum length limit. This may be the result of the many bass that are over the minimum length limit being taken through the weigh-in process of tournaments and not surviving, thus depleting stock densities of larger fish. However, this is merely a speculation.

Removing bass from nest during brood guarding period can lead to reduced nest success (Suski and Phillip 2004). The 2006 Sturgeon Bay Tournament SB06 tournament took place during the spawning season for largemouth and smallmouth bass. We found very little mortality occurring during this tournament; but many bass were removed from their nest during the tournament. It would be logical to assume that many nests were abandoned after guarding males were captured and placed into boat live-wells and then transported several miles to the weigh-in site. Many of these bass likely did not find their way back to their nest. For example, a previously mentioned study found only 14% of tournament-caught bass return to their site of capture (Wilde 2003). The delay in guarding males returning to nest, if they returned at all, increased the predation risk to the unguarded offspring (Kieffer et al. 1995). Many nests were likely raided by predators as soon as the guarding males were removed.

Furthermore, the study conducted by Suski and Phillip (2004) found male largemouth and smallmouth bass to be quite vulnerable to angling while guarding their nests with 70% of the largemouth and 54% of the smallmouth being hooked during experimental angling trials. The study also found vulnerability to angling correlated positively to the quantity of eggs in a male's nest, consequently the males with the largest broods were most likely to be captured, which indicated angling for nesting bass during the spawning season has the potential to negatively impact bass populations (Suski and Phillip 2004). So whereas very few bass died as a direct result of being handled in the tournament the population could possibly suffer declines because of reduced nest success. However, the Sturgeon Bay fishery is in Lake Michigan. Considering the large size of the fishery, any reduced nest success could be compensatory mortality as opposed to additive.

General Tournament Observations

This study evaluated tournament-associated mortality and effects of culling on tournament-associated mortality. Culling rates by anglers varied highly among tournaments and by day of the tournaments. The abundance of bass in the tournament fishery can likely explain most of the culling rates, however daily weather and time of year would also likely impact the culling rates. For example 77% of anglers that weighed in fish at the 2006 Sturgeon Bay Tournament SB06 culled at least one bass on the first day. However, the next day was very windy making fishing difficult and the fisherman had more trouble catching fish; consequently only 43% of the anglers who weighed in fish did any culling. The 2005 Shawano Lake Tournament SH05 and the 2006 Madison Chain Tournament MA06 tournaments both took place in early fall unlike the tournaments that had high culling rates which took place in spring and summer. Most anglers would likely argue that spring and summer are better times to fish for bass in Wisconsin than in the fall.

The importance of maintaining proper live-well conditions cannot be overstated, since bass can potentially spend hours in a live-well. Most fish caught during the tournaments I studied were caught before noon. This suggests that most bass caught in bass tournaments spend a longer than average length of time (i.e. relative to random catches) in a live-well before they are weighed in unless the anglers are culling frequently. We attempted to find out the characteristics of the anglers live-wells. We found all live-wells used by anglers in the tournaments we studied had characteristics that would help increase survival of bass. Most live-wells were located at the back of the boat, which is the smoothest riding part of the boat. Most anglers had fresh water being pumped on the fish and water streams and bubblers were common methods for aerating the live-wells. Most anglers used cooling systems in their live-wells when the water was "hot", but logically they did not when the water was already cool. About half the anglers used water conditioners. Anglers can use the recommendations of Hal Schramm and Gene Gilliland in Keeping Bass Alive to optimize the chances of keeping their bass alive (Gilliland and Schramm 2002).

Simulated Tournaments / Culling

At the two simulated tournaments, adjusted mortality rates of culled largemouth bass were 16.0% and 0%. Largemouth bass virus was absent at both tournaments and warm water temperatures were present at the tournament with higher mortality rate (23.1°C versus 20.0°C). Culling in the simulated tournaments did not appear to increase mortality rates relative to what was seen at the professional bass tournaments. No mortality occurred in one simulated tournament and no clear trend appeared in increasing mortality with increased time held in live-wells among culled fish in the tournament that had higher mortality. 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 that had cooler water temperatures.

We expected increased mortality with increased retention time in live-wells. A previous study found no significant relationship but did find a positive correlation between confinement time and initial mortality (Neal et al. 2001). However, in our study more fish in the 2 hour treatment died than in the 4 hour treatment. Our results may have been caused by small sample size or the time the fish was held in the live-well did not cause mortality, rather mortality may have been caused by the numerous other stressors the fish endured throughout the experiment.

Economic and Social Evaluations

Besides the biological evaluation we performed, the bass fishing tournament pilot program also evaluated economic and social aspects of culling in Wisconsin black bass tournaments. The WDNR contracted the University of Wisconsin Department of Regional and Urban Planning to evaluate the economic impacts that bass tournaments have on local communities. Specifically, their objectives were to estimate characteristics of tournament angling participants spending and to apply these expenditure characteristics to regional input-output models to estimate local economic impacts. Expenditure data was collected from surveys given to tournament anglers, tournament organizers, and spectators at seven Wisconsin black bass tournaments were culling was allowed. The Bassmaster Elite 50 tournament on Lake Wissota in June of 2005 was the only other tournament evaluated for economic impacts that was not part of the biological study. The economic evaluations concluded that all of the pilot program events provided positive local economic impacts on the host communities by having an estimated $65,368 to $459,143 economic impact on those communities; however the additional economic impact to the state as a whole due to allowing culling was small (Marcouiller et al. 2007).

The researchers felt that culling may not be essential for bass tournaments to provide substantive local economic benefits in Wisconsin (Marcouiller et al. 2007).

The WDNR research staff conducted the social evaluations. The attitudes of general anglers, tournaments anglers, lakeshore property owners, and boaters towards tournament fishing and culling were evaluated through mail surveys and interviews. The study found, in general, anglers do not support culling, but that opposition to culling was not overwhelming (51%) if live-well standards were required for tournament anglers (Petchenik 2006). The study also found bass tournament anglers strongly felt that culling should be allowed in bass tournaments (Petchenik 2006). Only 22% of anglers believed tournaments were harmful to fisheries and perceived biological impacts were the most important factor influencing attitudes towards culling (Petchenik 2006).

Conclusion

Given our limited data, culling in simulated tournaments did not appear to increase mortality rates relative to what was seen at the professional bass tournaments. However, our results support other studies that indicate tournament-associated mortality dramatically increases when water temperatures exceed 25°C (especially when largemouth bass virus is present) where largemouth bass are the primary target species and 20°C where smallmouth bass are the primary target species, and that strict regulation of bass tournaments under such conditions may be warranted (Neal and Lopez-Clayton 2001, Hartley and Moring 1995, Kwak and Henry 1995, Schramm et al. 1985, Schramm et al. 1987, Edwards et al. 2004, Weathers and Newman 1997, Meals and Miranda 1994, Schramm et al. 2004).

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Appendix A. Survey sheet for professional tournament anglers.

Individual Data Sheet for Angler

1	**Well Capacity (gallons)**						______
2	**Live-well Location**	Stern	Bow	Side	Center		**Circle one**
3	**Water Flow System**	New water		Recirculating			**Circle one**
4	**Aeration System**	Water stream		Bubbler	Agitator	None	**Circle all that apply**
5	**Cooling System**	Electric cooler	Insulated live-well		Ice	None	**Circle all that apply**
6	**Water Conditioners**	Manufactured product (product name) ______		Salt		None	**Circle all that apply**

7 **Number of Fish Over 14" Caught Per Hour**

Largemouth Bass — **Time Caught**

0600-0659	______	1300-1359	______
0700-0759	______	1400-1459	______
0800-0859	______	1500-1559	______
0900-0959	______	1600-1659	______
1000-1059	______	1700-1759	______
1100-1159	______	1800-1859	______
1200-1259	______	1900-1959	______

Smallmouth Bass — **Time Caught**

0600-0659	______	1300-1359	______
0700-0759	______	1400-1459	______
0800-0859	______	1500-1559	______
0900-0959	______	1600-1659	______
1000-1059	______	1700-1759	______
1100-1159	______	1800-1859	______
1200-1259	______	1900-1959	______

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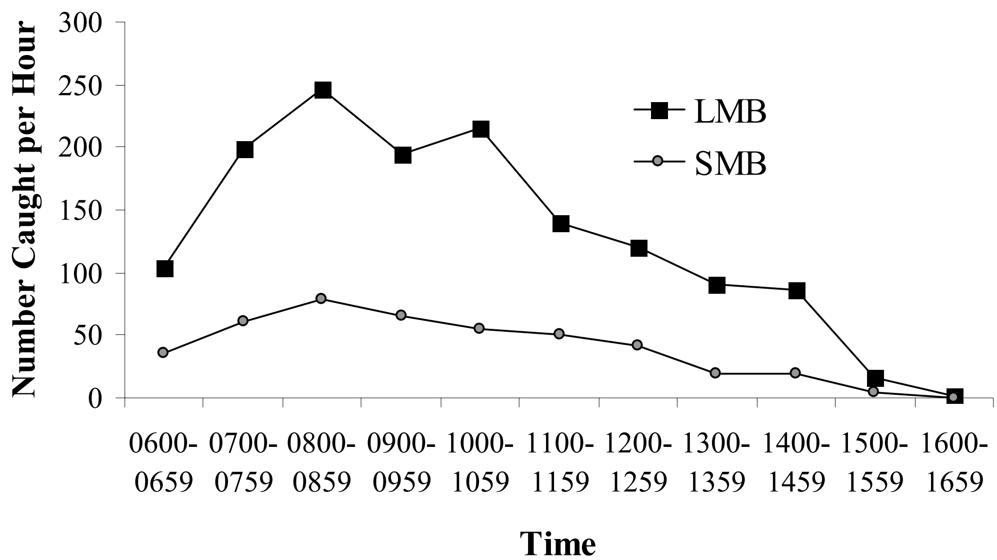
Appendix B. Summary data of professional tournaments evaluated.

Tournament	LC05	SH05	SB06	LC06	WC06	MA06
Date	8/3-6/05	9/24-25/05	5/20-21/06	7/12-15/06	7/30/2006	9/23-24/06
Boats	184	44	200	200	56	59
Anglers	368	88	400	400	112	118
Average Surface Water Temperature (˚C)	27.2	16.54	15.2	27.3	27.9	16.84
Creel Limit	5	5 per boat	6 per boat	5	5 Pro 3 Co	5 per boat
LMB Dead at Weigh-in	18	0	0	-	2	2
SMB Dead at Weigh-in	14	0	2	74*	1	0
LMB Held for 5 Days	711	172	2	180	173	183
SMB Held for 5 Days	242	28	398	32	23	4
LMB Delayed Mortalities	533	1	0	49	118	0
SMB Delayed Mortalities	96	0	1	12	12	0
Reference LMB Held for 5 Days	106	91	0	50	8	100
Reference SMB Held for 5 Days	26	0	101	50	0	0
Reference LMB Delayed Mortalities	92	0	0	7	2	0
Reference SMB Delayed Mortalities	7	0	0	3	0	0
LMB Weighed-in	1551	275	16	2498	271	220
SMB Weighed-in	540	42	1741	634	30	6
LMB Culled	286	1	6	924	43	6
SMB Culled	149	0	1113	247	5	0
LMB Tested for LMBV	18	30	0	30	30	30
SMB Tested for LMBV	2	0	0	0	0	0
LMB Testing Positive for LMBV	18	0	0	30	30	30
SMB Testing Positive for LMBV	2	0	0	0	0	0

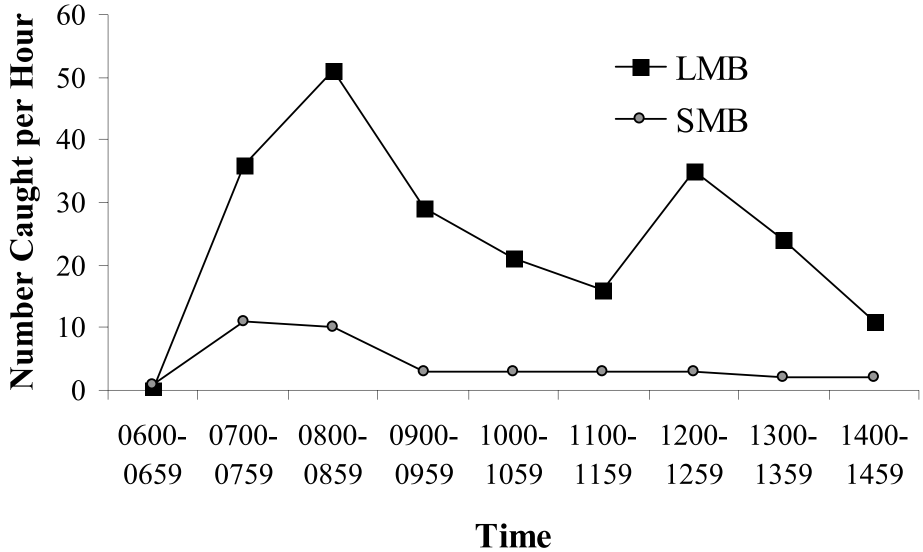
* Combined SMB and LMB initial mortalities

Appendix C. This appendix shows the number of bass caught per hour at each professional tournament we evaluated. Most tournaments began at dawn which would range between 0600 and 0700 depending upon the time of year. Larger tournaments had anglers leaving in multiple flights at half hour intervals so some anglers would begin fishing before others had even left the boat ramp. Some anglers would travel great distances before starting fishing as well. In general most bass were caught in the 0800 hour. This is likely the first full hour that anglers were able to fish which is why we see the most fish caught at this hour and declining throughout the day.

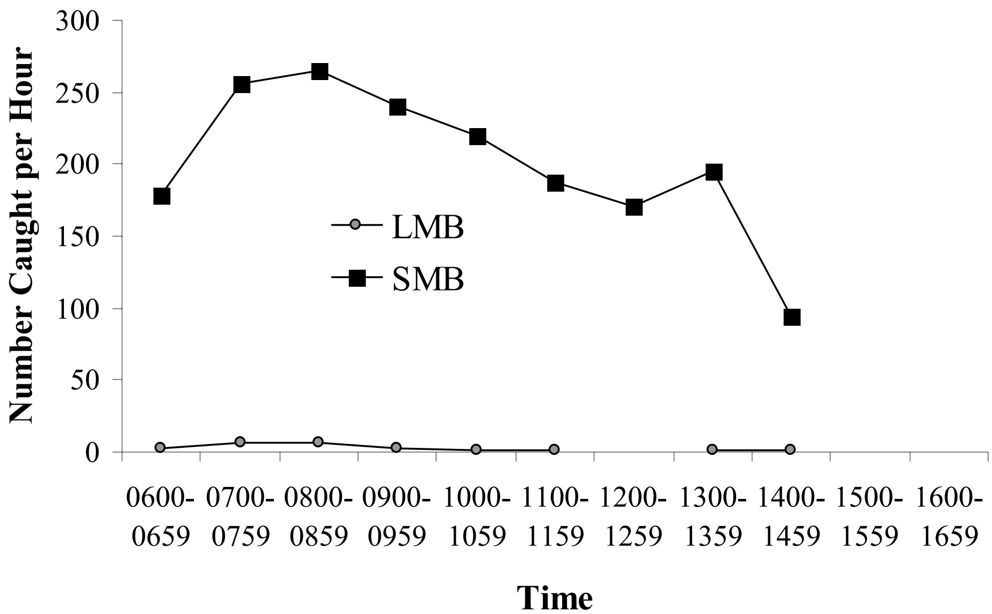
Number of Bass Caught Per Hour at LC05

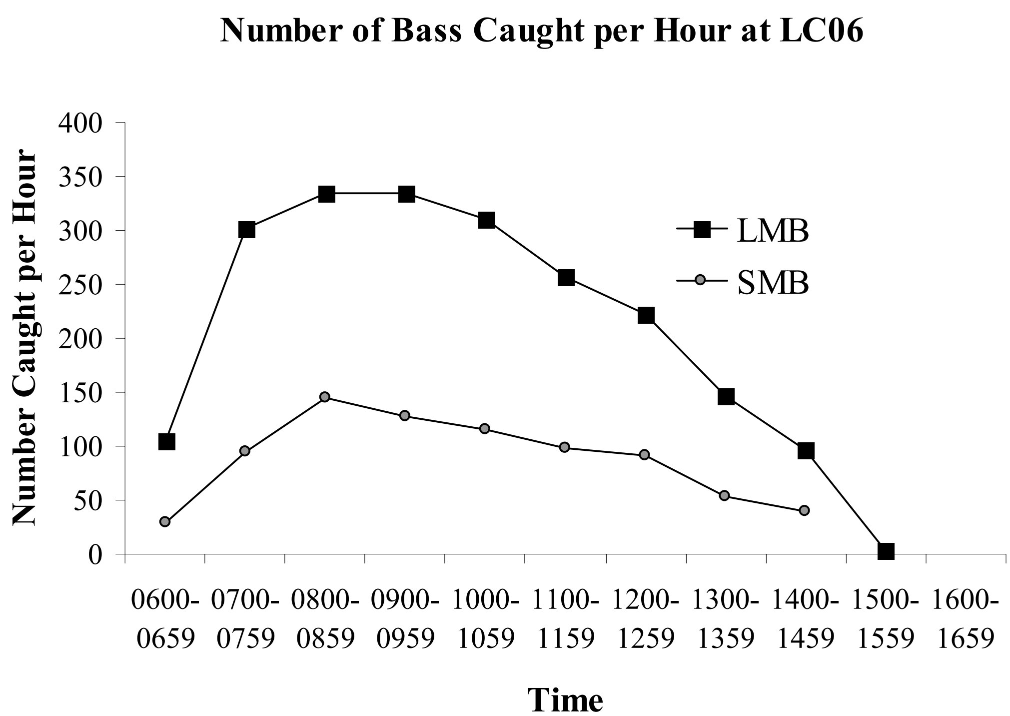


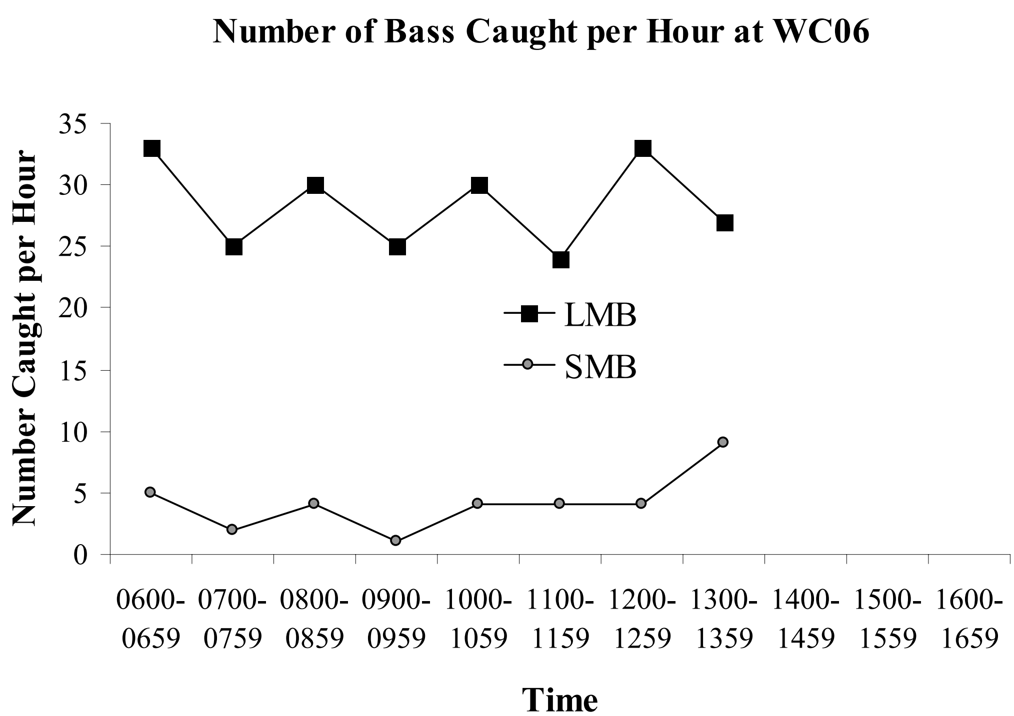
Number of Bass Caught Per Hour at SH05



Number of Bass Caught per Hour at SB05




Number of Bass Caught per Hour at LC06
Number Caught per Hour
400
350
300
250
200
150
100
50
0
LMB
SMB
0600-0659
0700-0759
0800-0859
0900-0959
1000-1059
1100-1159
1200-1259
1300-1359
1400-1459
1500-1559
1600-1659
Time


Number of Bass Caught per Hour at WC06
Number Caught per Hour
35
30
25
20
15
10
5
0
LMB
SMB
0600-0659
0700-0759
0800-0859
0900-0959
1000-1059
1100-1159
1200-1259
1300-1359
1400-1459
1500-1559
1600-1659
Time

Number of Bass Caught per Hour at MA06