SUMMARY OF WALLEYE MORTALITY STUDIES AT LIVE-RELEASE TOURNAMENTS IN ALBERTA 1991 - 1994

Prepared for

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1.0 INTRODUCTION

The Province of Alberta has experienced a marked increase in the number and popularity of organized fishing tournaments over the last decade. These tournaments have become increasingly better organized, with bigger sponsors, more valuable prizes, and greater number of participants. Although many consider tournament fishing to be a legitimate use of fish resources, concerns have been raised regarding potentially adverse effects on sportfish populations, especially walleye (*Stizostedion vitreum vitreum*), which is the target species of most of these competitive events. In response to these concerns, a "live-release" concept has been implemented in most Alberta tournaments since 1988. According to this concept, captured walleye are placed in an on-board livewell, transported to a central weigh-in station, weighed in a dry enclosure, and then released back into the lake under the assumption that most fish will recuperate from the stress and survive unharmed.

The validity of this assumption came under serious scrutiny following investigations conducted in the United States during 1988-1990 (Boland 1991, Goeman 1991). These studies demonstrated that despite the low immediate mortalities recorded at most tournaments, the delayed (i.e., after 5 d) mortality rates in tested fish were often quite high (37 to 94%). Concerned for the future of walleye stocks in the Province, the Alberta Fish and Wildlife Division (now known as the Department of Environmental Protection) and the major tournament organizers (Western Walleye Council and the High Prairie Chamber of Commerce) agreed to investigate and monitor walleye mortality at Alberta tournaments. The studies were financed as part of the Fisheries Management Enhancement Program, funded by annual contributions from Alberta angling licence sales.

R.L.& L. Environmental Services Ltd. was contracted to conduct the initial studies at four tournaments in 1991 (R.L. & L. 1992). The results indicated that delayed mortality was a cause for significant concern, especially at tournaments conducted under conditions of increased water temperatures and wave action (e.g., 68% mortality at the Golden Walleye Classic tournament on Lesser Slave Lake in August 1991). Based on this study, tournament organizers implemented several changes to the operating procedures for the 1992 tournaments, with the intent of improving survival rates of tournament caught walleye. The effectiveness of these changes in tournament regulations was evaluated in 1992; the results indicated considerable improvement toward minimizing walleye mortality (R.L. & L. 1993).

Walleye mortality and potential contributing factors were also investigated by the staff of the Fisheries Management Division of the Department of Environmental Protection in Peace River during 1992, 1993, and 1994. These investigations included mortality estimates at three annual tournaments on the Lesser Slave Lake (at Shaw Point, Joussard, and Slave Lake) and related studies on the effects of hooking injuries, capture depth, and cage-confinement of walleye caught by volunteer anglers at Sturgeon Lake; the field data from these studies were summarized in eight separate reports prepared by R.L. & L. (1996a to 1996h). In addition, specialized investigations of the effects of "fizzing" (swim bladder deflation) and depth of capture on walleye mortality were conducted jointly by the Fisheries Management Division and R.L.& L. Environmental Services in 1994 (R.L. & L. 1995).

The main intent of the present report is to summarize and discuss potential factors that may effect walleye mortality at live-release tournaments. The discussion is focused primarily on parameters that were commonly and consistently monitored during all studied tournaments in Alberta (e.g., tournament regulations, number of fish weighed-in, immediate, delayed, and total mortality, water temperature, wind conditions). By consolidating the standardized data collected at 12 individual tournaments, the overall effects of environmental factors and tournament procedures on walleye mortality are assessed from a broader perspective (i.e., increased "sample size" of studied tournaments). Additional factors that are known to influence mortality rates but were monitored only at specific tournaments or during experimental studies (e.g., capture depth, livewell holding time, fish size, tackle type used, "fizzing", test cage holding densities) are also discussed briefly in the present report. For a more detailed treatment of these factors, the reader is encouraged to review the respective reports that deal with these issues (e.g., R.L. & L. 1993, 1995, 1996c).

2.0 TOURNAMENT SETTINGS AND OPERATING PROCEDURES

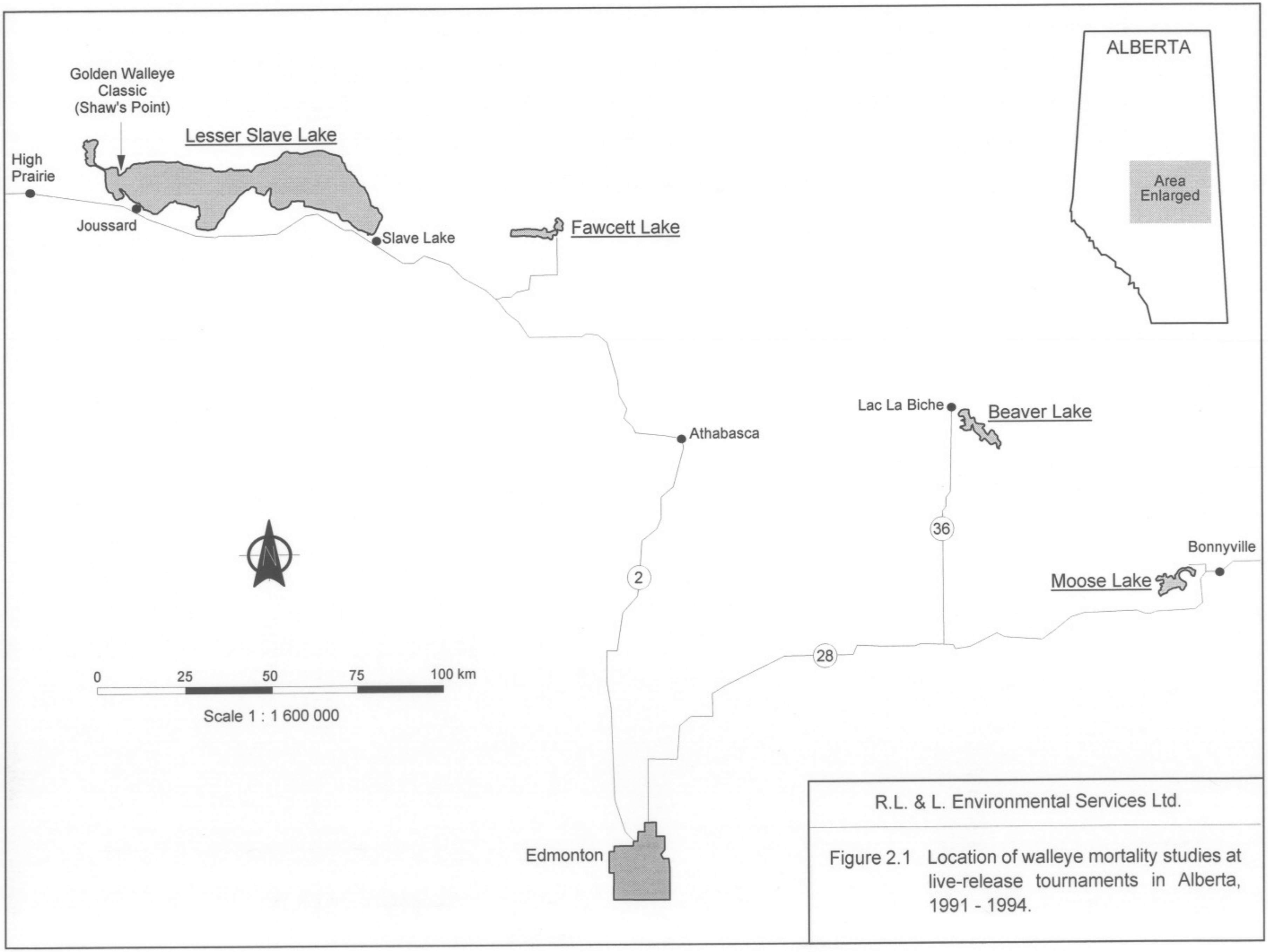
In total, walleye mortality studies were conducted at 12 live release-tournaments in central Alberta between 1991 and 1994 (Table 2.1). The tournaments ranged from small, locally organized events (e.g. Joussard) to the large Golden Walleye Classic competitions that attract up to 700 anglers from across Canada and the United States. Most of the studied tournaments took place on Lesser Slave Lake, a large (1160 km^2) eutrophic lake approximately 360 km northwest of Edmonton (Figure 2.1). Other studied tournaments were held on smaller lakes that included Beaver Lake (33 km^2), Moose Lake (41 km^2), and Fawcett Lake (34 km^2). The mean depths of the study lakes ranged from 6 to 11 m.

Table 2.1 Walleye mortality studies conducted at live-release tournaments in Alberta, 1991-1994.

Tournament	Organizer[a]	Lake	Date	Study Report
Golden Walleye Classic	HPDCC	Lesser Slave Lake	23-24 August 1991	RL&L 1992
Golden Walleye Classic	HPDCC	Lesser Slave Lake	21-22 August 1992	RL&L 1993
Golden Walleye Classic	HPDCC	Lesser Slave Lake	19-20 August 1993	RL&L 1996*d*
Golden Walleye Classic	HPDCC	Lesser Slave Lake	18-19 August 1994	RL&L 1996*g*
Slave Lake Tournament	SLGPS	Lesser Slave Lake	11-12 July 1992	RL&L 1996*b*
Slave Lake Tournament	SLGPS	Lesser Slave Lake	10-11 July 1993	RL&L 1996*c*
Slave Lake Tournament	SLGPS	Lesser Slave Lake	9-10 July 1994	RL&L 1996*h*
Beaver Lake Tournament	WWC	Beaver Lake	6-7 July 1991	RL&L 1992
Beaver Lake Tournament	WWC	Beaver Lake	27-28 June 1992	RL&L 1993
Moose Lake Tournament	WWC	Moose Lake	1-2 June 1991	RL&L 1992
Fawcett Lake Tournament	WWC	Fawcett Lake	5-16 June 1991	RL&L 1992
Joussard Tournament	JADA	Lesser Slave Lake	31 Jul - 1 Aug 1993	RL&L 1996*e*

[a]HPDCC - High Prairie and District Chamber of Commerce,
SLGPS - Slave Lake Golden Pike Society,
WWC - Western Walleye Council,
JADA - Joussard Area Development Association.

Although the studied tournaments were operated by different organizations, they shared similarities in format and regulations. For example, all tournaments advocated live-release of walleye and stipulated mandatory use of livewells (minimum 50 L capacity, fitted with a water exchange and/or internal recirculation system). Only live fish were eligible to be weighed-in; all dead fish were turned over to tournament officials and did not qualify for weigh-in.



R.L. & L. Environmental Services Ltd.

Figure 2.1 Location of walleye mortality studies at live-release tournaments in Alberta, 1991 - 1994.

All studied events featured a two-day tournament preceded by several days of pre-fishing, which allowed anglers to locate fish and experiment with gear and techniques. All tournaments allowed a maximum of two anglers per boat. Each two-person team was allowed to weigh-in five fish per day for a two-day total of 10 fish. The team that registered the highest combined weight over the two day tournament was declared the winner. In addition, there were special prizes for the teams that caught the largest individual walleye.

To be eligible for weigh-in, walleye had to meet a minimum size requirement that ranged between 381 mm (15") and 432 mm (17") in total length, depending on individual tournament regulations (Table 2.2). Application of this rule ensured that all fish retained for tournament purposes were in compliance with current provincial angling regulations (i.e., 381 mm minimum length). All eligible fish were transported by anglers to a central weigh-in dock, where the fish were placed in a perforated plastic tub to be weighed on a digital read-out, computer-linked scale. Immediately following weigh-in, walleye were placed in large, shore-based holding tanks, which were supplied with water continuously pumped in from the lake. Following a holding period of usually less than one hour, most of the walleye were transported by boat (equipped with a large capacity aerated livewell) to a suitable release location in the open-water portion of the lake. Subsamples of the weighed-in walleye were placed in holding cages to estimate the extent of delayed mortality (see Section 3).

Table 2.2 Summary of regulations at live-release tournaments monitored for walleye mortality in Alberta, 1991-1994.

Tournament	Year	Maximum Number of Angler Teams	Minimum Fish Size (Total Length)	Maximum Possession Limit	"Live" Criteria
Golden Walleye Classic	1991	300	381 mm (15")	5 fish	gill movement
Golden Walleye Classic	1992	320	406 mm (16")	3 fish	sounding test
Golden Walleye Classic	1993	320	406 mm (16")	3 fish	sounding test
Golden Walleye Classic	1994	350	406 mm (16")	5 fish	sounding test
Slave Lake Tournament	1992	100	432 mm (17")	3 fish	sounding test
Slave Lake Tournament	1993	120	432 mm (17")	3 fish	sounding test
Slave Lake Tournament	1994	150	432 mm (17")	3 fish	sounding test
Beaver Lake Tournament	1991	120	406 mm (16")	5 fish	gill movement
Beaver Lake Tournament	1992	120	406 mm (16")	3 fish	sounding test
Moose Lake Tournament	1991	120	406 mm (16")	5 fish	gill movement
Fawcett Lake Tournament	1991	120	406 mm (16")	5 fish	gill movement
Joussard Tournament	1993	75	406 mm (16")	3 fish	sounding test

In response to high mortality rates recorded at the tournaments studied in 1991, substantial changes in tournament regulations were introduced in 1992. One of these changes was the reduction in the maximum livewell possession limit from five fish in 1991 to three fish in 1992 and thereafter. Under this regulation, all teams were required to make at least two trips to the weigh-in station each day to fill their five fish per day quota. The intent of the new rule was to reduce the length of time individual walleye were held in livewells and to decrease fish density in livewells. The three fish per livewell limit has become the "standard rule" for all studied tournaments since 1992, with the notable exception of the Golden Walleye Classic (GWC) tournament in 1994, when the five fish per livewell limit was reintroduced.

Another major change in tournament regulations involved the introduction of stringent criteria for determining the "live" status of fish at the weigh-in. Prior to 1992, a fish that displayed even minimal gill or fin movement was considered live for tournament purposes. Under the revised 1992 regulations, most fish were required to maintain an upright position in the water column, and display other visible signs of good health. The evaluation of fish condition was generally accomplished by subjecting all fish to a "sounding test" prior to weigh-in. During this test, fish were held in a perforated plastic tub (i.e., same tub used for weigh-in), that was submerged in a large (700 L) test tank connected to a water exchange system and supplemented with diffused, pressurized oxygen. Only those fish that maintained upright position and displayed regular gill movement at the end of a one minute testing interval were allowed to be weighed-in. Fish that were observed "belly up" or exhibited signs of external damage (e.g., bruises, lacerations) were disqualified. When this occurred, the angler team registered a zero weight for each disqualified fish. Since 1992, the "sounding test" rule has been applied at all of the studied tournaments; however, it was later adapted to an "in the livewell" procedure to eliminate additional handling associated with the original sounding tank method. The major impact of the "sounding test" regulation appeared to be manifested through improved care and precautions taken by anglers prior to the weigh-in so that their fish would not be disqualified.

3.0 STUDY METHODS

The field studies to assess walleye mortality at four tournaments in 1991 were conducted by R.L.& L. Environmental Services. In 1992, R.L.& L. Environmental Services conducted follow-up studies at the Beaver Lake and Golden Walleye Classic tournaments, while the staff of the Fisheries Management Division evaluated walleye mortalities at the Slave Lake tournament. All subsequent field studies in 1993 and 1994 were conducted by the staff of the Fisheries Management Division.

The immediate mortalities recorded at all tournaments included fish that were disqualified from the weigh-in or were brought dead by the anglers and handed in to the tournament officials. The total number of dead fish were divided by the total number of fish that were either weighed-in or had died to determine the proportion of walleye that succumbed to immediate mortality.

The data on delayed mortality of walleye were determined experimentally at all studied tournaments. This involved collecting a random subsample of fish that successfully passed the weigh-in during each tournament day and enclosing them in submerged cages or pens. The condition of the enclosed fish was assessed after a three- or five-day holding period. The percentage of caged fish that died during the holding period was applied to the total number of fish that were weighed-in to determine the delayed mortality for each tournament day. Subsequently, total mortalities were calculated as a sum of immediate and delayed mortalities.

During the examination of the caged fish at the end of the holding period, it was often noted that some of the surviving fish were in "moribund" condition (i.e., due to severe equilibrium problems and physical damage, their probability of survival was deemed very low). Depending on the assumptions used in individual studies, these "moribund" fish were either included or excluded from the total number of dead fish used to estimate tournament mortality rates. To standardize these results in the present report, delayed mortality rates for all studied tournaments were re-calculated to include both scenarios (i.e., including and excluding "moribund" fish); these data are presented in Appendix A, Table A1. In order to simplify the presentation of the results, and because of the uncertainty regarding the criteria used for classifying the "moribund" condition during each study, only the latter scenario (i.e., excluding "moribund" fish from the dead fish counts) is discussed in this report. It should be noted, however, that the delayed and total mortality rates presented in this report are likely underestimated by treating the "moribund" fish as survivors.

The types of cages used for holding fish, the number of fish placed in each cage, and the duration of the holding period varied considerably between individual studies; these differences are summarized in Table 3.1. Despite the apparent differences in the experimental procedures, specific studies designed to determine the effect of cage type and stocking density on delayed mortality of walleye indicated no significant differences between the cage types and stocking densities that were generally used for tournament mortality assessments (R.L. & L. 1996b). Significant increases in delayed mortality were recorded only when cage densities exceeded 13 fish/m^2; the results from these densely stocked cages were excluded from the comparisons presented in this report. Because there were no significant differences between delayed mortalities recorded three and five days after confinement (R.L. & L. 1993), the results from both the three- and five-day holding periods were treated equally for the purposes of the present report.

Table 3.1 Changes in the experimental design for estimating delayed walleye mortality at live-release tournaments in Alberta, 1991-1994.

Tournament	Year	Number of Fish Tested	Number of Cages Used	Cage Type[a]	Mean Cage Density (fish/m^2)	Cage Holding Period (d)
Golden Walleye Classic	1991	226	11	Vexar	12	5
Golden Walleye Classic	1992	308	14	Vexar	11	5
Golden Walleye Classic	1993	105	2	Pen	6	3
Golden Walleye Classic	1994	108	2	Pen	6	3
Slave Lake Tournament	1992	119	6	Mesh	6	5
Slave Lake Tournament	1993	110	2	Pen	6	3
Slave Lake Tournament	1994	108	2	Pen	6	5
Beaver Lake Tournament	1991	250	10	Vexar	12	5
Beaver Lake Tournament	1992	326	14	Vexar	11	5
Moose Lake Tournament	1991	250	10	Vexar	12	5
Fawcett Lake Tournament	1991	250	10	Vexar	12	5
Joussard Tournament	1993	58	1	Pen	6	3

[a]Vexar - copper tubing frames (1.9 m long x 1.1 m wide x 0.8 m deep) surrounded by rigid Vexar™ material.
Pen - frameless rectangular enclosure (4.3 m long x 2.2 m wide x 4.3 m deep) constructed of 2.5 cm knotless nylon mesh and anchored into position.
Mesh - PVC frame (2.0 m long x 1.5 m wide x 1.0 m deep) surrounded by 2.5 cm nylon mesh.

Water temperature data were collected in the field at all tournaments. In cases where several measurements were taken in one day, the temperatures were averaged to characterize mean conditions for that day. Because of the difficulties in measuring wind conditions in the field, wind speed data were obtained from Environment Canada (Climatological Services Unit) for the station nearest to the tournament location. These stations included Slave Lake (for the Golden Walleye Classic, Slave Lake, and Joussard tournaments), Lac La Biche (Beaver Lake and Fawcett Lake tournaments), and Cold Lake (Moose Lake tournament). The wind speed data were averaged for the tournament hours (generally 7 am until 5 pm) to provide a consistent description of the wind condition during each tournament day.

4.0 WALLEYE MORTALITY AT TOURNAMENTS

Estimates of the immediate, delayed, and total mortalities recorded at the studied tournaments are summarized in Table 4.1. A more detailed comparison of the recorded mortalities (i.e., separated into individual tournament days and the number of fish involved) is provided in Appendix A, Table A1.

Table 4.1 Immediate, delayed, and total walleye mortality estimates for live-release tournaments in Alberta, 1991-1994.

Tournament	Year	Immediate Mortality (%)	Delayed Mortality (%)	Total Mortality (%)
Golden Walleye Classic	1991	7.5	65.5	67.5
Golden Walleye Classic	1992	0.8	3.7	4.5
Golden Walleye Classic	1993	1.5	39.0	39.5
Golden Walleye Classic	1994	2.0	38.9	40.0
Slave Lake Tournament	1992	3.2	7.6	9.3
Slave Lake Tournament	1993	1.4	5.5	6.7
Slave Lake Tournament	1994	0.9	11.1	11.9
Beaver Lake Tournament	1991	1.6	41.6	42.5
Beaver Lake Tournament	1992	1.8	21.4	22.8
Moose Lake Tournament	1991	1.0	13.6	14.7
Fawcett Lake Tournament	1991	1.1	23.2	24.3
Joussard Tournament	1993	3.7	3.4	5.5

In total, approximately 14 000 walleye were weighed-in during the 12 studied tournaments (Appendix A, Table A1). Immediate mortalities (n=314) accounted for 2.2% of the registered catch (ranged from 0.8% at the Golden Walleye Classic in 1992 to 7.5% at the same tournament in 1991). Of 2218 fish tested for delayed mortality (i.e., confined in cages), 560 fish (25%) died during the holding period. By extrapolating these results to the total registered catch for all studied tournaments, it was estimated that approximately 4000 walleye (28% of registered catch) died during the tournaments.

5.0 POTENTIAL FACTORS CONTRIBUTING TO WALLEYE MORTALITY

5.1 TOURNAMENT REGULATIONS

The total mortality rates recorded at tournaments which allowed five fish per livewell possession limit and did not implement a "sounding test" (i.e., tournaments held in 1991) were considerably higher than those recorded at subsequent tournaments that implemented more stringent regulations (Table 5.1). The comparison of the overall total mortality rates recorded at the three types of tournaments (Types A, B, and C categorized according to the strictness of the regulations) suggested that the reduction in livewell possession limit (from five to three) and the implementation of stringent criteria for classifying "live" fish (i.e., the sounding test) made positive contributions towards minimizing walleye mortality. By the same token, the reintroduction of "five fish per livewell" rule at the Golden Walleye Classic in 1994 (Type B) can be seen as a step backwards, as evidenced by the high total mortality rates recorded at this tournament (42%).

Table 5.1 Estimated total walleye mortality rates recorded at the three types of live-release tournaments in Alberta, 1991-1994.

Tournament Type[a]	Livewell Possession Limit	Sounding Test	Number of Fish Weighed-in or Disqualified	Number of Fish that Died	Total Mortality (%)
Type A	3 fish	Yes	8 200	1 404	17.1
Type B	5 fish	Yes	2 158	896	41.5
Type C	5 fish	No	3 840	1 667	43.4
Total			**14 198**	**3 967**	**27.9**

[a]Type A = all tournaments held in 1992-1993 and the 1994 Slave Lake tournament,
Type B = 1994 Golden Walleye Classic,
Type C = all tournaments held in 1991.

5.2 WEATHER CONDITIONS

The adverse effects of elevated water temperatures and strong wind conditions on walleye mortality during live-release tournaments have been observed and documented in past investigations (Boland 1991, Goeman 1991, R.L.& L. 1993). In an attempt to correlate these environmental variables with the estimated total walleye mortality rates, data from individual tournament days (Appendix A, Table A1) were separated into cool and warm water groups according to prevailing water temperatures (13.5-18°C and 18.5-22°C ranges) and plotted against mean wind speed during the tournament hours (Figure 5.1). Statistically significant correlations ($P<0.05$) between wind speed and mortality were obtained for both cool and warm water conditions, indicating that tournaments held under increased wind conditions tended to result in higher walleye mortalities. The slope of the

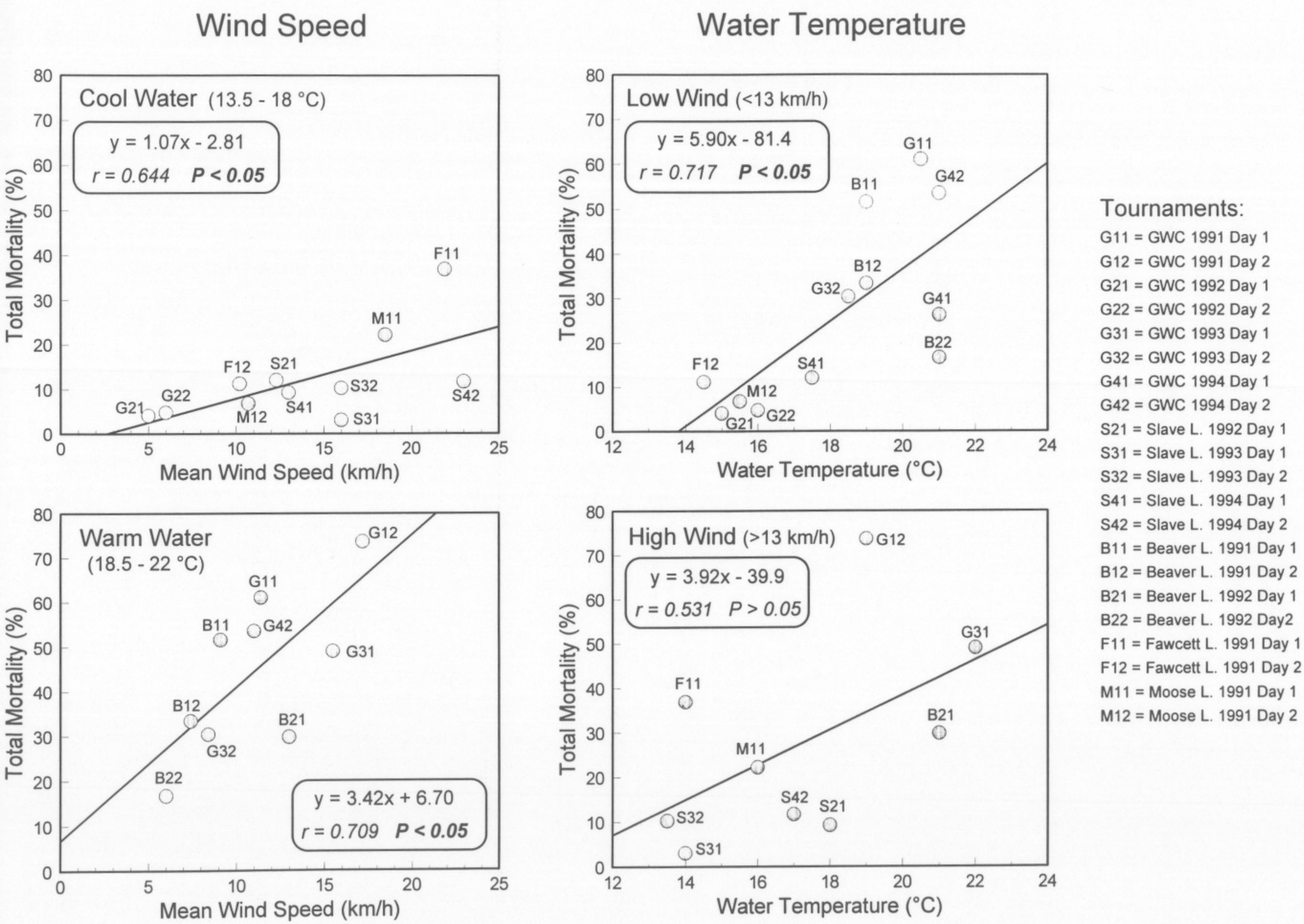


Figure 5.1 Relationships between weather conditions during tournament hours (mean wind speed and water temperature) and the total mortality rates of walleye at live-release tournaments in Alberta, 1991-1994.

regression line was considerably lower for the "cool water" tournaments than for the "warm water" events; this suggested that the adverse effects of high winds were more pronounced when combined with elevated water temperatures.

To assess the relationship between water temperature and total mortality, data were separated into groups of low and high wind conditions (using mean wind speeds of 13 km/h as separating criteria) and plotted in Figure 5.1. As intuitively expected, mortality rates were positively correlated with water temperature; however, the correlations were statistically significant ($P<0.05$) only under low wind conditions. The high slope of the regression line ($b=5.9$) suggested that even small increments in water temperature can result in a substantial increase in mortality rates (e.g., under low wind conditions, a 1°C increase in temperature corresponded to an approximately 6% increase in total mortality).

5.3 DEPTH OF CAPTURE

Walleye cannot easily dissipate the pressure of expanding swim bladder gases when they are brought to the surface from deep water because they are physoclistous (i.e., lack a connection between swim bladder and esophagus). For this reason, they are unable to return to deep water after being released and are subject to increased mortality from stress and predation. In extreme situations (i.e., capture depths greater than 15 m), mortality can occur due to swim bladder rupture or hyper-distension.

Experimental studies conducted at Lesser Slave Lake in August 1994 (R.L.& L. 1995) compared the survival of walleye captured at three depth categories (2.6-5.8 m, 6.1-7.5 m, and 7.6-10.1 m). Although mortality rates appeared to increase with depth (0%, 6%, and 10%, respectively), the differences were not statistically significant (χ^2 test; $P>0.05$). Considerably higher mortality rates (20%) were recorded for fish captured at 7.0-10.0 m depths during a similar study conducted at Lesser Slave Lake in August 1995 (D. Walty, Alberta Environmental Protection, pers. comm.). In contrast, all walleye captured from similar depths during an experimental ice fishing study at Lesser Slave Lake during April 1994 (R.L.& L. 1996f) survived a 5-day cage holding period. This suggested that cold water conditions enabled walleye to better cope with problems caused by distended swim bladders, and thus enhanced their survival.

5.4 HANDLING OF FISH

Alberta Environmental Protection conducted an experimental study on Sturgeon Lake during summer 1992 to assess the survival of angler-caught walleye that were released after minimal handling (R.L.& L. 1996a). The study was intended to mimic live-release tournaments with one notable exception: the captured fish were released immediately instead of being transported to tournament headquarters and subjected to weigh-in procedures. High survival rates recorded during this study (i.e., only 1 of 157 tested fish died during the cage holding period) indicated that when fish were released immediately after capture, their chances of survival were not effected by the angling procedure alone. By extrapolating the results of this study to conditions encountered at most live-release tournaments, it becomes apparent that high mortality rates often recorded at these tournaments are likely due to the additional stress associated with increased handling of captured fish and their prolonged holding in livewells prior to release.

Information collected through questionnaire forms distributed to tournament anglers in 1992 indicated that the mean time that fish were held in livewells prior to weigh-in was 2.3 hours at the Beaver Lake tournament and 2.2 hours at the Golden Walleye Classic (R.L.& L. 1993). Furthermore, a considerable percentage of fish (14.4% and 12.9%, respectively) were held in livewells for periods in excess of 4.0 hours. By tagging individual fish that were placed in cages at Beaver Lake, information on livewell holding time was related to subsequent death or survival of individual specimens. The results indicated that the mean livewell holding period was significantly longer (t-test; $P<0.001$) for fish that subsequently died (3.1 h) than for the survivors (1.7 h). This demonstrated that increased walleye mortality rates at live-release tournaments can be directly attributed to prolonged periods of holding fish in livewells.

5.5 SWIM BLADDER DEFLATION ("Fizzing")

Active deflation of swim bladders in walleye captured from deep water has become a common procedure among anglers who practice "catch-and-release". The intent of this procedure (often referred to as "fizzing") is to increase survival by providing an artificial release for expanded swim gases, thus allowing the fish to return to deep water (see Section 5.3). To assess the effects of this technique on walleye survival, "fizzed" and "control" fish captured at different depths in Lesser Slave Lake during August 1994 were placed in large holding pens for a period of five days (R.L. & L. 1995). The results indicated that fizzing did not affect the survival rates of fish captured at shallow depths; all fish captured from depths of less than 6.0 m survived the holding period, regardless of whether they were fizzed or not. In contrast, significant differences in survival rates between the fizzed and control treatment groups were recorded for fish that were captured between depths of 7.6 and 10.1 m. Whereas the survival rates of the control fish varied between 89.5% and 90.0%, the survival rates of the fizzed fish were significantly lower (between 42.9% and 66.0%). This indicated that, contrary to popular belief amongst anglers, fizzing of deep-caught walleye results in higher mortality rates than releasing them intact.

In another study, Alberta Environmental Protection examined a sample of walleye ($n=258$) captured during the Golden Walleye Classic tournament in 1993 for evidence of puncture marks on the body (i.e., indication of fizzing). The results indicated that at least 13.2% of tournament caught walleye were fizzed (R.L.& L. 1996d). Statistical analyses of the data demonstrated that the fizzed fish had significantly reduced probability of survival.

Although both of the above studies demonstrated that fizzing had a detrimental effect on the survival of deep-caught walleye, a third study conducted by Alberta Environmental Protection in August 1995 did not show significant difference between the survival of fizzed and control groups (D. Walty, pers. comm.). The study compared the survival of 50 fish captured at depths between 7 and 10 m; half of the sample were fizzed whereas the other half were released intact. The resulting mortality rates were identical for both treatment groups (20% each). Although these data suggested that fizzing did not effect survival, the small sample sizes in each treatment group precluded definite conclusions.

5.6 CAGE CONFINEMENT

All of the above mentioned studies determined walleye mortality rates by confining experimental groups of fish in cages or pen enclosures for a period of 3 to 5 days. To test the validity of extrapolating the delayed mortality results obtained through this method to the "real" mortality of fish released directly into the lake, several studies focussed on determining the effects of confinement alone on walleye survival (R.L.& L. 1992, 1993, 1996b). Studies conducted at walleye tournaments in 1991 and 1992 used a "control" group of fish (i.e., captured by cooperating anglers during the pre-fishing period) to provide "baseline" data on the effects of cage confinement and to compare these results with the "tournament" groups of fish (i.e., fish subjected to extended livewell holding periods and weigh-in procedures). On average, the delayed mortality rates of the "control" groups were five times lower than the delayed mortality rates of the corresponding "tournament" groups (R.L.& L. 1992, 1993). These results were supported by the 1992 study on Sturgeon Lake, where only 1 of 157 "control" walleye (0.6%) died after cage confinement (R.L.& L. 1996a).

In an attempt to assess the relationship between cage stocking density and delayed mortality of tournament-caught walleye, Alberta Environmental Protection conducted an experiment during the Slave Lake tournament in July 1992 (R.L.& L. 1996b). By holding walleye for a 5-day period at three stocking densities (5, 8, and 13 fish/m^2), it was determined that mortality rates in the two lower density treatment groups (2.0% and 5.3%, respectively) were significantly lower than the mortality rate recorded in the high density cages (14.3%). These results suggest that cage confinement at low stocking densities has a minimal effect on walleye mortality and therefore can be used as a valid method to estimate delayed mortality at tournaments. On the other hand, if the tested fish are confined at high stocking densities (i.e., 13 fish/m^2 or higher), the resulting estimates of tournament induced mortality rates will likely be exaggerated due to the effects of cage overcrowding.

6.0 ESTIMATING THE RISKS OF WALLEYE MORTALITY

The results presented in the preceding sections indicated that walleye mortality rates at live-release tournaments in Alberta were influenced by several factors. Many of these factors were cursorily investigated at individual events; however, factors such as water temperature, wind speed, and tournament regulations were consistently recorded at all studied tournaments. The results presented in sections 5.1 and 5.2 indicated that these three factors appeared to influence the recorded mortality rates, nevertheless, it remained uncertain how they interacted together to produce the overall effect.

In an attempt to develop a "risk index" that could be used for predicting walleye mortality at future tournaments, these three independent variables (i.e., tournament regulations, water temperature, and wind speed) were assigned a coded rating on a scale of 1 to 5 (i.e., 1 = low risk, 5 = high risk; Table 6.1). Subsequently, the three ratings were multiplied to obtain a "risk index" that could be correlated with the recorded total mortality for each tournament day during 1991-1994 (Figure 6.1). The resulting linear regression ($r = 0.92$) was highly significant ($P < 0.01$), suggesting that this rating system may have useful implications for fisheries management of live-release tournaments.

Table 6.1 Rating system for estimating the "risk index" for walleye mortality at live-release tournaments in Alberta.

Risk Code	Tournament Regulations	Water Temperature (°C)	Mean Wind Speed (km/h)
1	Type A (3 fish possession limit; sounding test)	≤ 17	≤ 7
2	Type B (5 fish possession limit; sounding test)	18	8 - 10
3	Type C (5 fish possession limit; no sounding test)	19	11 - 12
4	-	20	13 - 14
5	-	≥ 21	≥ 15

The derivation of the "risk index" for each tournament day is provided in Appendix A, Table A2. Tournament days characterized by low risk indices (10 or less) resulted in total mortality rates between 3 and 30% (mean of 10%; Table 6.2). Tournaments with moderate risk indices (11-20 range) featured mortality rates that ranged from 22 to 52% (mean of 33%). Risk indices higher than 20 were associated with very high mortality rates that ranged from 49 to 74% (mean of 59%).

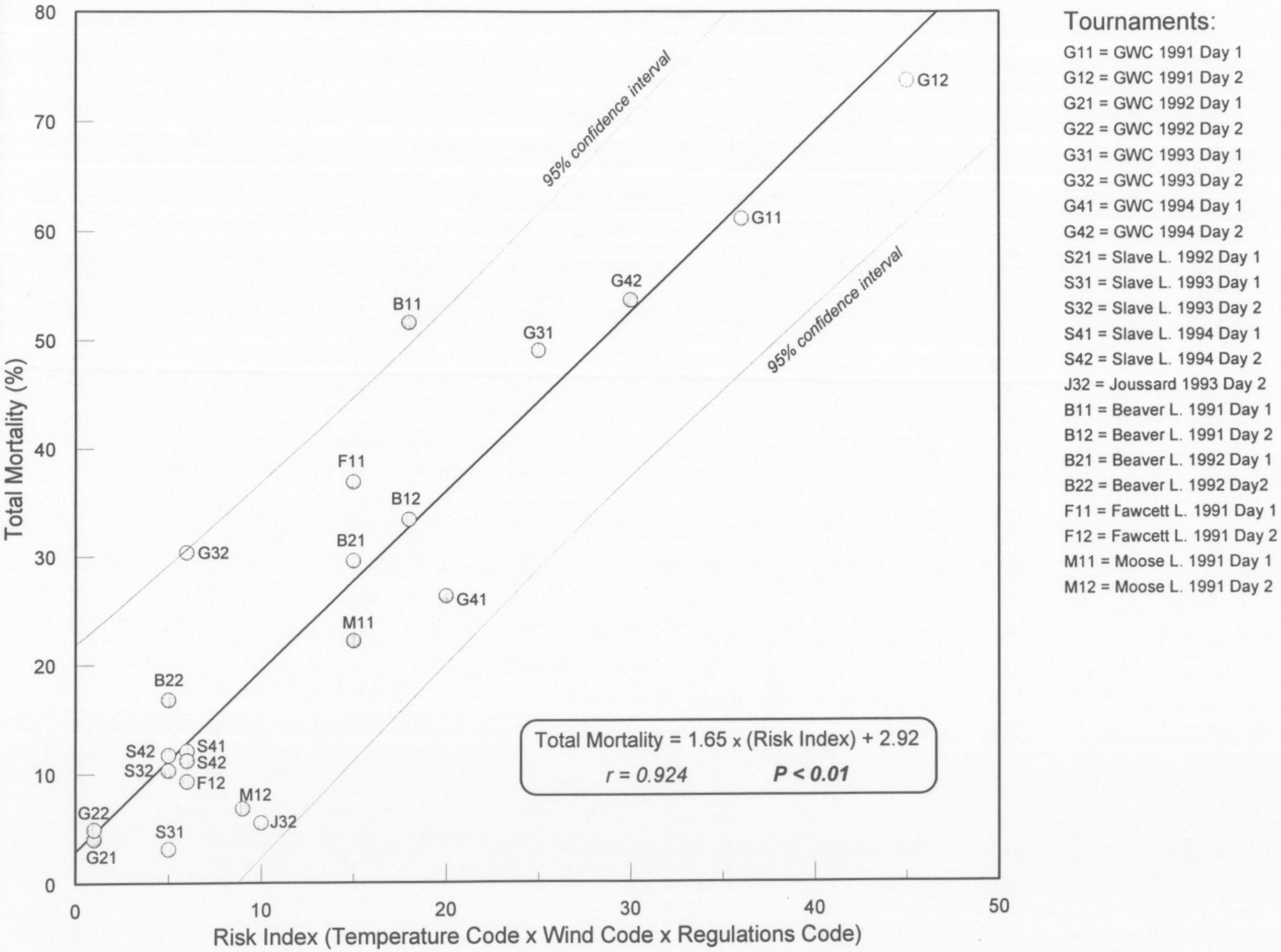


Figure 6.1 Relationship between the "risk index" (product of coded water temperature, wind speed, and tournament regulation ratings) and the total walleye mortality rates recorded at live-release tournaments in Alberta, 1991-1994.

Table 6.2 Relationship between the calculated "risk index" and the recorded walleye mortality rates at live-release tournaments in Alberta, 1991-1994.

Risk Index	Number of Tournament Days	Total Mortality (%)		
		Mean	Std Dev	Range
Low (1 - 10)	12	10.5	7.5	3.1 - 30.4
Moderate (11 - 20)	6	33.3	10.3	22.2 - 51.6
High (> 20)	4	59.3	10.8	49.0 - 73.7

The application of the risk index for predicting walleye mortality at live-release tournaments may have a potential use in assessing the environmental conditions at the onset of each tournament. Depending on the calculated risk, the tournament organizers can modify some of the tournament procedures in order to minimize the expected mortality rates. These modifications may involve more frequent weigh-ins, reduction of livewell possession limits, application of boat speed limits (to reduce the pounding impact of the waves), restriction of the allowable fishing area (to reduce travel distance), or re-scheduling of the tournaments. Even if it proves impractical to implement these measures on very short notice (because of the difficulties in long-term weather forecasting), the use of the risk index can eliminate the "element of surprise" and prepare tournament organizers to proactively deal with elevated mortality rates that may be unavoidable under extreme environmental conditions.

7.0 RECOMMENDATIONS

Based on our present knowledge of factors that contribute to walleye mortality at live-release tournaments, it is apparent that management strategies designed to maximize the survival of fish captured at these popular events will need to address a number of issues. Although the cumulative effects of all contributing factors have been quantified at several tournaments in the past (by determining total mortality rates), it is much more difficult to quantify the importance of each of these factors separately or to determine the biological pathways that result in excessive (i.e., lethal) levels of stress in fish. Nevertheless, the studies summarized in this report provided an important baseline for identification of guidelines that may enable tournament organizers and fisheries managers to minimize the impact of tournament events on walleye populations in Alberta. Some of these guidelines are briefly outlined below.

1. Avoid scheduling tournaments during warm water periods. Water temperatures in excess of 18°C often resulted in excessive mortalities during past tournaments. The recommended periods for holding tournaments in north-central Alberta are late spring (June) and early fall (September).

2. Minimize the amount of fish handling (by anglers and tournament officials during weigh-in) and the length of time fish are held in livewells. This could be accomplished in several ways:
   - bringing each fish to the weigh-in station as soon as it is caught (i.e., maximum possession limit of one fish),
   - imposing larger minimum size limits for fish (as fewer fish will qualify for weigh-in, more will be released immediately),
   - allowing fishermen to release their own fish after weigh-in (eliminates waiting period until enough fish are accumulated to be released by tournament officials),
   - placing weigh-in sites at locations where fish can be released directly into good quality water, and
   - reducing allowable fishing area (to minimize transport distance and time).

3. Enforce strict "sounding" criteria for qualifying fish eligible for weigh-in (to ensure careful treatment of fish by anglers).

4. Disallow the practise of "fizzing" and disqualify all fish that show evidence of puncture marks.

5. Develop a strategy for high wind conditions. Although it is impossible to predict the weather while setting up tournament schedules, organizers should be prepared to deal with the possibility of strong winds occurring during the event. Studies have demonstrated that strong and sustained winds (i.e., mean speeds in excess of 15 km/h) were often associated with high mortality rates, mainly due to the wave pounding effect on fish

transported in livewells. The high wind strategies should be established in advance of each event and the threshold criteria for their implementation should be well defined (e.g., wind speed, wave height, or the "risk index" outlined in section 6.0).

6. Conduct studies at each tournament to monitor delayed mortality of walleye. These studies should utilize a cage confinement method at low stocking densities (< 10 fish/m^2). Previous studies demonstrated that cage confinement at low stocking densities had minimal effect on walleye mortality and therefore can be used as a valid method to estimate delayed mortality at tournaments. The mortality studies could be incorporated into each tournament format and would allow for an "instant feedback" evaluation on the success or failure of tournament strategies in maximizing walleye survival.

7. Organize an educational campaign regarding proper fish handling techniques and the effects of tournaments on fish mortality. The increase in angler awareness of pertinent issues associated with imposing undue stress on fish will likely result in improved fish handling practices and thus will contribute to increased fish survival.

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APPENDIX A

Walleye Mortality Data

Table A1. Comparison of walleye mortality results from twelve live-release tournaments in Alberta, 1991-1994.

Tournament	Date	Year	Water Temp (°C)	Wind Speed (km/h)	Fish Weighed In	No. of Fish Tested	No. of Fish Dead	No. of Fish Moribund	Immediate Mortality		Delayed Mortality				Total Mortality			
											Dead Only		Incl. Moribunds		Dead Only		Incl. Moribunds	
									n	%	*n*	%	*n*	%	*n*	%	*n*	%
Golden Walleye Classic	23 Aug	1991	20.5	11.4	718	101	59	0	*49*	6.4	*419*	58.4	*419*	58.4	*468*	**61.1**	*468*	61.1
	24 Aug	1991	19.0	17.2	734	125	89	2	*69*	8.6	*523*	71.2	*534*	72.8	*592*	**73.7**	*603*	75.1
	GWC-91		19.8	14.3	1452	226	148	2	*118*	7.5	*942*	65.5	*954*	66.4	*1060*	**67.5**	*1072*	68.3
	21 Aug	1992	15.0	5.0	654	182	14	7	*7*	1.0	*21*	3.0	*41*	6.0	*28*	**4.0**	*48*	7.0
	22 Aug	1992	16.0	6.0	729	126	9	6	*4*	0.5	*32*	4.3	*50*	6.7	*36*	**4.9**	*54*	7.2
	GWC-92		15.5	5.5	1383	308	23	13	*11*	0.8	*53*	3.7	*91*	4.2	*64*	**4.5**	*102*	7.1
	19 Aug	1993	22.0	15.5	1034	54	26	2	*17*	1.6	*498*	48.1	*536*	51.9	*515*	**49.0**	*553*	52.6
	20 Aug	1993	18.5	8.4	1083	51	15	2	*16*	1.5	*319*	29.4	*361*	33.3	*335*	**30.4**	*377*	34.3
	GWC-93		20.3	11.9	2117	105	41	4	*33*	1.5	*816*	39.0	*897*	42.9	*849*	**39.5**	*930*	43.3
	18 Aug	1994	21.0	n/a	1050	53	13	1	*25*	2.3	*258*	24.5	*277*	26.4	*283*	**26.3**	*302*	28.1
	19 Aug	1994	21.0	11.0	1064	55	29	3	*19*	1.8	*561*	52.7	*619*	58.2	*580*	**53.6**	*638*	58.9
	GWC-94		21.0	5.5	2114	108	42	4	*44*	2.0	*819*	38.9	*896*	42.6	*863*	**40.0**	*940*	43.6
Slave Lake	11 Jul	1992	18.0	13.0	359	119	9	12	*7*	1.9	*27*	7.6	*63*	17.6	*34*	**9.3**	*70*	19.2
	12 Jul	1992	18.0	23.0	330	0	-	-	*16*	4.6	not assessed							
	SL-92		18.0	13.0	689	119	9	12	*23*	3.2	*54*	7.6	*127*	17.6	*68*	**9.3**	*141*	19.2
	10 Jul	1993	14.0	16.0	587	55	1	1	*8*	1.3	*11*	1.8	*21*	3.6	*19*	**3.1**	*29*	4.9
	11 Jul	1993	13.5	16.0	579	55	5	1	*8*	1.4	*53*	9.1	*63*	10.9	*61*	**10.3**	*71*	12.1
	SL-93		13.8	16.0	1166	110	6	2	*16*	1.4	*63*	5.5	*85*	7.3	*79*	**6.7**	*101*	8.5
	9 Jul	1994	17.5	12.3	830	55	6	2	*11*	1.3	*91*	10.9	*121*	14.5	*102*	**12.1**	*132*	15.7
	10 Jul	1994	17.0	23.0	771	53	6	3	*3*	0.4	*87*	11.3	*131*	17.0	*90*	**11.7**	*134*	17.3
	SL-94		17.3	17.7	1601	108	12	5	*14*	0.9	*178*	11.1	*252*	15.7	*192*	**11.9**	*266*	16.4
Joussard	31 Jul	1993	n/a	41.0	121	0	-	-	*8*	6.2	not assessed							
	1 Aug	1993	18.0	30.0	188	58	2	0	*4*	2.1	*6*	3.4	*6*	3.4	*10*	**5.5**	*10*	5.5
	J-93		18.0	30.0	309	58	2	0	*12*	3.7	*13*	3.4	*13*	3.4	*21*	**5.5**	*21*	5.5
Beaver Lake	6 Jul	1991	19.0	9.1	356	125	63	2	*9*	2.5	*179*	50.4	*185*	52.0	*188*	**51.6**	*194*	53.2
	7 Jul	1991	19.0	7.4	361	125	41	2	*3*	0.8	*118*	32.8	*124*	34.4	*121*	**33.4**	*127*	34.9
	BL-91		19.0	8.3	717	250	104	4	*12*	1.6	*298*	41.6	*309*	43.2	*310*	**42.5**	*321*	44.1
	27 Jun	1992	21.0	13.0	383	181	56	15	*9*	2.3	*105*	28.0	*137*	36.6	*114*	**29.6**	*146*	38.1
	28 Jun	1992	21.0	6.0	428	145	25	10	*6*	1.4	*66*	15.6	*97*	22.8	*72*	**16.8**	*103*	23.9
	BL-92		21.0	9.5	811	326	81	25	*15*	1.8	*171*	21.4	*234*	7.7	*186*	**22.8**	*249*	30.6
Moose Lake	1 Jun	1991	16.0	18.5	412	125	27	25	*3*	0.7	*89*	21.6	*171*	41.6	*92*	**22.2**	*174*	42.0
	2 Jun	1991	15.5	10.7	390	125	7	4	*5*	1.3	*22*	5.6	*34*	8.8	*27*	**6.8**	*39*	10.0
	ML-91		15.8	14.6	802	250	34	29	*8*	1.0	*111*	13.6	*206*	25.2	*119*	**14.7**	*214*	26.4
Fawcett Lake	15 Jun	1991	14.0	21.9	370	125	45	16	*5*	1.3	*133*	36.0	*181*	48.8	*138*	**36.9**	*186*	49.5
	16 Jun	1991	14.5	10.2	353	125	13	16	*3*	0.8	*37*	10.4	*82*	23.2	*40*	**11.2**	*85*	23.8
	FL-91		14.3	16.1	723	250	58	32	*8*	1.1	*170*	23.2	*262*	36.0	*178*	**24.3**	*270*	37.0
All Tournaments Combined					**13884**	**2218**	**560**	**132**	***314***	**2.2**	***3671***	**25.2**	***4291***	**31.2**	***3967***	**28.3**	***4586***	**32.7**

Table A2. Risk indices and total walleye mortality recorded on individual tournament days at live-release tournaments, 1991-1994.

Tournament	Date	Year	Water Temp (°C)	Wind Speed (km/h)	Coded Ratings [1] Temperature	Wind Speed	Regulations	Risk Index	Total Mortality [2] (%)
Golden Walleye Classic	23 Aug	1991	20.5	11.4	4	3	3	**36**	61.1
	24 Aug	1991	19.0	17.2	3	5	3	**45**	73.7
	21 Aug	1992	15.0	5.0	1	1	1	**1**	4.0
	22 Aug	1992	16.0	6.0	1	1	1	**1**	4.9
	19 Aug	1993	22.0	15.5	5	5	1	**25**	49.0
	20 Aug	1993	18.5	8.4	3	2	1	**6**	30.4
	18 Aug	1994	21.0	light	5	2	2	**20**	26.3
	19 Aug	1994	21.0	11.0	5	3	2	**30**	53.6
Slave Lake	11 Jul	1992	18.0	13.0	2	3	1	**6**	9.3
	10 Jul	1993	14.0	16.0	1	5	1	**5**	3.1
	11 Jul	1993	13.5	16.0	1	5	1	**5**	10.3
	9 Jul	1994	17.5	12.3	2	3	1	**6**	12.1
	10 Jul	1994	17.0	23.0	1	5	1	**5**	11.7
Joussard	1 Aug	1993	18.0	30.0	2	5	1	**10**	5.5
Beaver Lake	6 Jul	1991	19.0	9.1	3	2	3	**18**	51.6
	7 Jul	1991	19.0	7.4	3	2	3	**18**	33.4
	27 Jun	1992	21.0	13.0	5	3	1	**15**	29.6
	28 Jun	1992	21.0	6.0	5	1	1	**5**	16.8
Moose Lake	1 Jun	1991	16.0	18.5	1	5	3	**15**	22.2
	2 Jun	1991	15.5	10.7	1	3	3	**9**	6.8
Fawcett Lake	15 Jun	1991	14.0	21.9	1	5	3	**15**	36.9
	16 Jun	1991	14.5	10.2	1	2	3	**6**	11.2

[1] see Table 6.1 for the expanation of the rating system

[2] moribund fish excluded from calculations