THE SHIMANO WATER WEIGH-IN SYSTEM
A "FISH-FRIENDLY" GUIDE




SHIMANO®

DR. B.L. TUFTS, QUEEN'S UNIVERSITY • KINGSTON, ONTARIO

PHIL MORLOCK, DIRECTOR, ENVIRONMENTAL AFFAIRS • SHIMANO

INTRODUCTION BY RAY SCOTT, FOUNDER B.A.S.S.

"Good ideas
often come from
humble beginnings…
and necessity."

I introduced Catch-and-Release fishing to bass tournaments at the Bassmaster Florida Invitational in 1972, after a fishing trip to Colorado where I watched with fascination as fly fishermen carefully released trout they had caught. I was no fly fishing expert, but I saw how much pleasure it gave them to release these little fish. And I thought bass tournament guys just might enjoy it even more. Bass boats did not have livewells then and it was tough to handle the fish properly, but I'm proud that our anglers did their very best with coolers, stringers and nets.

Biologists told me that fishing tournaments couldn't harm the bass resource, but I felt that as the popularity of competitive fishing grew we were facing a serious public relations problem. We donated fish to charity, but the sight of dead bass at every event was not a good image for fishing. I felt we had a responsibility to do the right thing. Bass tournament anglers got solidly behind the idea of releasing their fish. Even though there were problems along the way, we managed to keep the interest high enough that anglers kept looking for better ways to keep their fish alive. Particularly after we began penalizing contestants for dead fish.

There have been many changes in livewells, bass boats and catch-and-release fishing tournaments since those early days. One thing has not changed – and that's how people who fish, and who love fishing, will spend a lot of time, effort and money to keep trying to find ways to take better care of the resources. Which brings us to this book and the reasons for it.

Shimano makes excellent fishing rods and reels, but there is a lot more to this company. Ever since Tom Brooke and Don Lloyd at Shimano Canada invented the first Live-Release Boats in the early 1980's, Shimano has looked for ways to improve fish handling methods to keep tournament caught fish alive and healthy. These boats have released millions of fish across the U.S. and Canada, and have been redesigned and copied several times. Rather than be satisfied with these highly successful efforts, Shimano continues to sponsor leading edge scientific research that improves catch-and-release fishing.

Shimano's conservation efforts have led to the discovery of some remarkable new fish handling methods that can benefit every catch-and-release tournament. They are simple, easy to implement and don't cost a lot. This book tells you how to use them. As the "Grand Daddy" of catch-and-release fishing tournaments, I've payed close attention to what Shimano has done with this research. And I'm very proud to have been asked to offer suggestions along the way.

The ***Shimano Water Weigh-In System*** has the potential to truly benefit fish populations every time it is used for handling and releasing tournament-caught fish. It works. And I urge tournament organizers everywhere to adopt it. Catch-and-release fishing is the future of our sport and it reflects the best of our conservation heritage. Shimano is a company that truly understands this.

Good fishing!

Ray Scott

RAY SCOTT, FOUNDER B.A.S.S.

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Looking Forward

Catch and release fishing has become one of the most important conservation initiatives in the history of the sport. For more than 30 years anglers and tournament organizers have been releasing fish alive and unharmed across North America. Joe Izumi organized the first catch and release tournament in Canada on Lake Erie in the late 1960's. Ray Scott initiated the practice at Bass Angler Sportsmen Society (B.A.S.S.) tournaments in the U.S. in the early 70's as Forrest Wood was introducing the first factory installed livewells in Ranger boats.

Tournament anglers winning major events continue to promote catch and release fishing on television and in other media, and the practice has gained common acceptance with anglers and fishery managers across the continent. Recreational anglers have benefited from what has been learned at competitive events. Selective harvest works every time people keep some fish for the pan and choose to release the larger fish alive to conserve the future of our lakes and streams.

At Shimano we believe the conservation heritage of tournament fishing requires us to build on the foundations of the past. In 2001 we entered into a scientific research partnership with Queen's University and the Natural Sciences and Engineering Research Council of Canada. Dr. Bruce Tufts is a fish physiologist and internationally recognized expert on catch and release fishing. His research over the past decade has been published in leading scientific journals as well as popular outdoor magazines in Canada and the U.S.

Dr. Tufts and his capable team of dedicated researchers at Queen's have worked closely with us to use the very best science to determine how we may improve fish handling and live-release methods at catch and release tournaments. This research has led to some startling and very positive discoveries for the fish. Competitive events of any size will be able to apply the information in this book with the confidence that these methods are based on extensive research and field testing. A lot of fine folks and companies have helped us over the years in this effort – take the time to read who they are. Each of them has made a lasting contribution on behalf of the future of fishing.

Most tournament anglers won't really notice much of a change – but the fish surely will.

Phil Morlock, Shimano

Background

Shimano initially partnered with the research team at Queen's University because of their determination to minimize the impact of live-release tournaments on fish. Researchers from the University examined the physiological condition of bass and walleye after many different live-release events, carefully monitoring the environmental conditions to which fish are exposed during every aspect of a tournament. In addition to the research conducted at real tournaments, numerous experiments under highly controlled conditions helped to determine the impact of specific tournament procedures on the physiology of different fish species. This research has provided us with a better understanding of the ways in which live-release tournaments affect the physiological condition of fish.

Important scientific findings show that the weigh-in process is the most critical time for fish caught in a live-release tournament. The traditional weigh-in procedure contributes to a large metabolic disturbance in fish, which can lead to increased stress levels and mortality.

Based on these findings, we have developed the new ***"Shimano Water Weigh-In System"*** that improves the physiological condition and survival of fish in live-release tournaments.

PHIL MORLOCK, DIRECTOR OF ENVIRONMENTAL AFFAIRS, SHIMANO

Understanding What the Fish Tell Us

As mentioned, our research shows that the traditional weigh-in process causes a large metabolic disturbance in fish. Before discussing how to reduce this problem, however we first need to understand ***why*** it happens. The main cause of this metabolic disturbance is a shortage of oxygen. Similar to humans, fish can tolerate reduced oxygen levels for very short periods of time. But if the period of oxygen deprivation lasts longer than a few seconds, it begins to have very significant physiological consequences.

Most tournament organizers make a significant effort to maintain water oxygen levels during the weigh-in. Unfortunately, few appreciate how challenging this task can be without proper equipment. Because many tournaments are weighing in large numbers of big fish, water oxygen levels change very rapidly at certain steps of the weigh-in, especially in hot weather.

Water oxygen levels are not the only factor that contributes to a shortage of oxygen within the fish. Whenever a fish is removed from water, the regions of the fish's gill used to take up oxygen (the lamellae) will collapse and the exchange of respiratory gases (oxygen and carbon dioxide) will be restricted. During the traditional weigh-in process, which involves weighing the fish in air, they will experience a significant bout of oxygen deprivation.

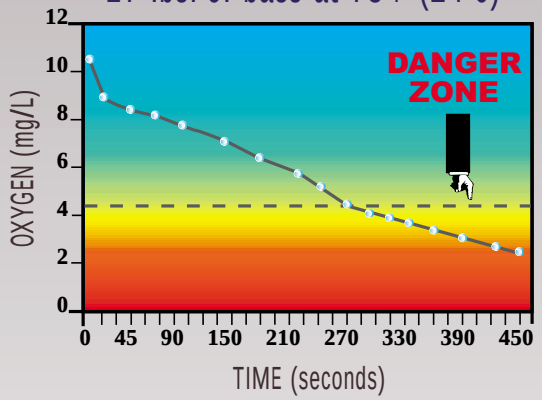
Now that we've identified ***"oxygen"*** as the most important issue for fish during the weigh-in process, we need to look at how difficulties arise. Remember, there is not just one aspect of the weigh-in causing oxygen shortages for the fish. A common problem during traditional weigh-ins is that deadly ***combinations*** of low oxygen conditions can be created. The following scenario is a classic example of how fish are exposed to ***sequences*** of conditions that deprive them of sufficient oxygen in a traditional weigh-in process.

Traditionally, fish are held in transfer bags for several minutes on the way to the scale.

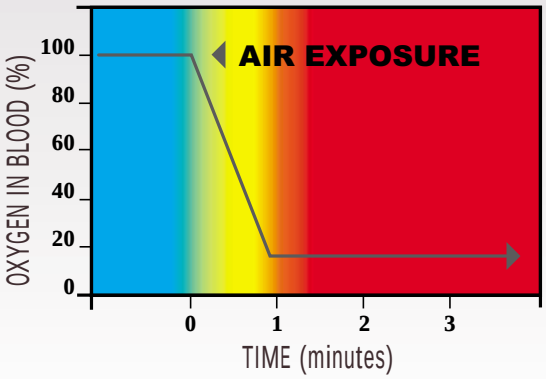
At the scale, the fish are exposed to air for a period of time.

First, the fish are held in transfer bags for several minutes on the way up to the scale. At the scale, the fish are then exposed to air for a short period of time. After being weighed, the fish are transported (still in air) back to a live release boat. At the shoreline, fish are then placed into live release boats with very high fish densities and usually only modest aeration.

Changes in dissolved oxygen concentration in a water filled plastic bag with 17 lbs. of bass at 75˚F (24˚C)



Oxygen content in the arterial blood of fish removed from water



(adapted from Ferguson and Tufts. 1992 Can J Fish Aq Sci)

Each of these steps has been found to be a potential oxygen problem for the fish. Because large masses of fish are placed in transfer bags with very little water, oxygen levels fall extremely rapidly in the bags. The problem is further complicated because some anglers bag their fish while still waiting in their boats, well ahead of their weigh-in time. Weighing fish in air then exposes them to another bout of oxygen deprivation. If fish are not placed into water immediately after being weighed, this acute bout of oxygen deprivation is further extended. As the weigh-in continues, fish may be exposed to low oxygen conditions in the live-release vessel, or holding tanks, because the metabolic requirements of a large mass of fish can exceed the boat's (or tank's) capacity for aeration. This is a common situation observed during the traditional weigh-in process, but there are many different variations on this theme.

The important point is that there's not a single incident of oxygen deprivation in this scenario that fish could not handle for a short period of time. When these bouts of oxygen deprivation are combined, however the situation rapidly becomes very dangerous for the fish. In many cases, they are still alive when released, but in relatively poor physiological condition.

The following sections will describe new strategies that have been developed to eliminate these cumulative problems.

Solving the Transfer Bag Problem

Bags used to transfer fish from the livewell to the weigh-in site are an integral part of almost every tournament weigh-in. The problem with bags is that they are a closed environment often containing a relatively large mass of fish and a small volume of water. The oxygen in these bags changes very quickly. The best way to solve this problem is to minimize the amount of time that fish remain in the bags.

The type of weigh-in bag is also critical. Bags that are ventilated, slotted or of some other configuration that will not hold water should not be used. For the ***Shimano Water Weigh-In System*** to work at its best, the fish should *always* remain in water.

During events where Shimano has worked with the Canadian Fishing Tour to conduct weigh-ins, transfer bags are now only used to transport fish a very short distance from the livewell to the weigh-in site. Anglers are advised not to place the fish from the boat livewells into the transfer bags until it's their turn at the weigh-in site. At the weigh-in site, anglers encounter a well-aerated water trough, shaded by a canopy, to minimize temperature fluctuations. Once the anglers reach this trough, their fish are immediately transferred into a covered basket with a series of holes in the bottom, so that well-aerated water will quickly enter the basket. Using this strategy, the amount of time that fish are held in transfer bags is greatly reduced and the fish remain in a well-aerated environment on their trip to the scale.

Other strategies can be used to solve some of these problems. For example, we experimented with hoses of compressed air that anglers can place into their transfer bags as they wait in line. Some manufacturers also offer portable aeration devices that individual anglers can use for the same purpose. If these, or other methods, are used properly, oxygen can be maintained in the transfer bags. In our opinion, however, the aerated trough approach is ideal as it's under the complete control of the tournament organizers. Upon reaching the weigh-in site, anglers can now relax and be certain that their fish will be well looked after.

The Shimano Water Weigh-In System

The biggest change that's been incorporated into fish handling procedures at tournaments during the past year is to ***weigh the fish in water.*** This eliminates one of the most serious bouts of oxygen deprivation for the fish and further reduces the deadly sequence of low oxygen conditions that arise using traditional weigh-in methods.

This system therefore provides measurable physiological benefits for the fish. The muscle energy reserves in fish weighed in water are much greater than those of fish weighed in air. The concept of weighing objects in water has been around for a very long time in scientific circles. Anglers can therefore rest assured that the weights of fish obtained in water are as accurate than those obtained in air. For those skeptics, we have confirmed this issue with our own independent laboratory experiments. In fact, weights of fish obtained in water may even be more accurate, because the fish are no longer flopping on the scale.

Tournament organizers will be pleased to know that there is little need for specialized equipment, making it easier (and less costly) for them to switch to water weigh-ins for their tournament circuit.

The first piece of equipment necessary for the ***Shimano Water Weigh-In System*** is a modified weigh-in (fish) basket. These baskets can be easily obtained by drilling a series of holes around the base of any standard plastic weigh-in basket (as in the associated picture). The purpose of these holes is to allow aerated water to quickly move in or out of the basket as it moves through the weigh-in.

There are a few things to keep in mind in the construction of these water weigh-in baskets. First, eliminate any rough edges from the drilled holes, to minimize any physical damage to the fish. It's also critical that all the baskets weigh the same after they are drilled. Starting with standard plastic baskets, this is accomplished by drilling exactly the same number (and size) of holes in each basket. The weight of all the baskets can be easily checked and modified (if necessary) by drilling smaller holes, once the initial drilling process is completed. The goal is to obtain baskets of identical weight (within the degree of accuracy required for the weigh-in). Baskets with flip-top lids are desirable as they minimize the chance that a fish will jump out as baskets are held within the trough or while sitting on the scale.

The next item required for a water weigh-in is a container that will serve as a water basin on top of the scale. It must have dimensions that allow a fish basket to be easily placed within it. It should fit close around the fish basket, so that the water required to fill the basin past the level of the fish is minimized. The vertical dimension (height) of the basin should allow for quick and easy handling of the baskets, as they will be added and removed at a rapid pace during the weigh-in. A picture of the basin that Shimano used on the Canadian Fishing Tour is provided.

During the weigh-in, the basin is filled with about 6-8 inches of water (permanently marked as a standard level on the basin). When the fish basket is added, the height of this water level is increased due to the extra volume in the basin, easily covering the fish. The height of the water is not an essential factor to obtain accurate weights with Shimano's system, but is simply provided as a rough guide to ensure that the fish are covered. In theory, almost any basin and/or volume of water can be used, as long as the tournament organizers have a scale with appropriate features that take this into account as fish weights are obtained.

As in any weigh-in, the most critical element in the water weigh-in is the scale itself. To conduct a ***Shimano Water Weigh-In,*** the scale should have a capacity of at least 100 pounds. Interestingly, when we first worked with Shimano on their water weigh-in method, the scales normally used already had this capacity, so there was no need to purchase new scales. For many tournament circuits, this is probably also the case. If new scales with a higher capacity are needed, scales with the same accuracy, but with slightly higher capacity, are relatively easy to obtain.

Other scale necessities include a base that will support the water basin and a zeroing (tare) function. These features are already provided on most tournament scales, but are also easily obtained on many models if new scales are necessary. The reason that scales with a capacity of at least 100 pounds are necessary to conduct a ***Shimano Water Weigh-In*** is that the scale must be able to accurately weigh a limit of fish (usually five), as well as about 60 to 80 pounds of water (depending upon the dimensions of the containers used), the water basin, and fish basket. The zeroing function is necessary because an initial weight of the fish basket, water basin and water must first be taken into account on the scale, (when it is zeroed) before the weights of the fish can be obtained.

Once all the necessary equipment is in place, the process of weighing the fish in water is quite simple. First, the water basin is filled with an appropriate volume of water (usually to a pre-determined fixed mark that coincides with about 60-80 pounds of water). Depending on the strength of the plastic in the basin it is sometimes necessary to insert a thin plywood support between the water basin and the scale so that the basin is better supported when the water is added.
Next, an empty fish basket is placed across the top of the water basin (see picture).

Everything is now on the scale that will be weighed for each angler, except the fish.
By pressing the zeroing (tare) function at this point, the scale will now automatically deduct the weight of all of these objects.
This process is no different from that normally used to remove the weight of the baskets during the traditional weigh-in process.
The scale is now ready to weigh a basket of fish, but will only provide the weight of the fish, because the weight of everything else on the scale has already been taken into account.

To be certain that the most accurate weights are obtained, there are some

important points to keep in mind.
It's best to zero the scale between each new fish basket to account for any small changes in the volume of water in the scale basin. It's also imperative that all of the water is drained from each fish basket as it is moved from the trough to the scale.

Predictably, one of the early concerns about the ***Shimano Water Weigh-In System*** was that additional steps would increase the overall time required. This is not the case, much time is saved because the fish quickly settle down when weighed in water. Thus, the ***Shimano Water Weigh-In System*** is as efficient as any traditional weigh-in process, or more so.

Time required for the scale to reach a constant weight during our experiments to evaluate the new weigh-in procedure.

	TIME (seconds)
Old Weigh-In Procedure (air)	30.9
New Weigh-In Procedure (water)	4.2

It is important to remember that oxygen in the water of the weighing basin will be depleted over time. Thus it's best to have an air hose available to aerate the scale basin when fish are not being weighed. It is also a good idea to exchange the water in the basin several times throughout the weigh-in as it accumulates fish mucus, wastes, and ammonia. Exchanging the water in the scale basin also minimizes the possibility that fish will be exposed to extremely warm temperatures when being weighed.

SEE APPENDIX I

Back to the Water Body

Most of the excitement ends after fish are weighed, but the job is certainly not over when it comes to fish care. Some of the worst fish handling situations we've identified occur after the fish weigh-in. Although the fish have been kept in water up to this point, their metabolic rates are elevated as they have been being jostled about in a foreign environment. Obviously, this is not the time to place them in a waterless environment and leisurely transport them back to the water body (lake) or live-release boat. Similar to the other steps in the weigh-in process, the fish should be placed into a well-aerated aquatic environment. Depending upon the configuration of the weigh-in, this might be the lake itself, a live-release boat, or a portable transportation tank to take the fish to the shoreline or release vessel.

Because each weigh-in site has a unique set of logistical challenges, there are several creative solutions that can be used to safely transport fish back to their environment. There are a couple of impressive solutions to this problem (1) A floating weigh-in stage with a live-release boat parked directly behind it. Here, the fish can be placed directly into the live-release boat after they are weighed. (2) For weigh-in sites further inland, another workable solution is to shuttle fish to the shoreline in well-aerated tanks on the racks of ***All Terrain Vehicles.*** Unlike other aspects of the weigh-in, there is probably a long list of other adequate solutions to the issue of transporting fish back to the water body. The main point to keep in mind here (and throughout the weigh-in process) is that the time that the fish are out of the water should be kept to an absolute minimum.

Live-Release Boats

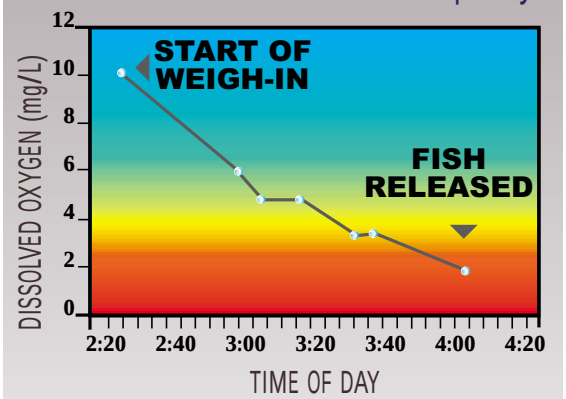
Many larger events now use live-release boats to redistribute fish around the water body at the conclusion of each tournament day. We'll therefore address the pros and cons of this strategy. These issues also apply to any large holding or transportation tank.

It is critical that tournament organizers realize they are planning to hold a large number of the water body's best fish, in a relatively small environment, for a significant period of time. While the practice of redistributing fish is a good one, it is also a tremendous responsibility when it comes to fish care and to the longevity of our sport. Organizers utilizing live-release boats, or other fish transportation strategies, should understand the potential pitfalls associated with their approach, so that problems can be avoided.

Releasing large numbers of fish directly at the weigh-in site can be less than ideal for the fish and for the public image of tournament fishing. Weigh-ins are often held at a marina, where poor water quality can be an issue. Fish often remain in the release location for a few days and they can be easily caught by anglers during this period, making numbers of the larger fish more susceptible to angling pressure than would normally be the case. The Shimano Live-Release Boats were originally developed in order to redistribute tournament caught fish at various locations on their home water. Studies have confirmed that redistributing tournament fish to multiple locations is a good practice, but with it comes the responsibility to care for the fish properly.

The empty tanks of most live-release boats look pretty large at first glance. At the end of a tournament day, when a significant number of tournament boats have caught a lot of large fish, however the tanks can become very crowded with fish. Even in boats that appear to have good aeration, there is a point where the working capacity of the boat's tanks are exceeded and oxygen levels decline. A real example of this type of situation is provided in the associated graph. These are values observed in a live-release boat with a large weight of fish on a relatively warm day before we began to implement corrections to this problem. This is a very dangerous situation for fish. Once the boat's working capacity is exceeded and oxygen levels begin to fall, it is only a matter of time before the entire group of fish in the boat are severely stressed by oxygen deficiency.

Changes in water oxygen in a live-release boat that's over-capacity



(Although this boat appeared to have good aeration, the oxygen consumption of the large number of fish clearly exceeded the amount of oxygen being added to the water)

In addition to understanding that every live-release boat has a limited working capacity, tournament organizers should remember that this limit will vary on any given day depending on

A Few Easy Measurements Can Save a Lot of Fish

factors such as fish species, size of the fish and water temperature. The relationship between these factors and metabolic rate (oxygen consumption) is well established in scientific literature. This issue could therefore get very complicated, but the solution is actually quite straightforward. To ensure the well being of the valuable cargo in live-release boats, tournament organizers just need to make a few simple measurements. We'll discuss this issue in more detail in the next section.

Oxygen

The importance of sufficient oxygenation for tournament fish cannot be overemphasized. Our research shows this to be the most common problem that tournament organizers encountered in their events. This problem is also exacerbated by higher temperatures and large numbers of big fish. In certain situations, poor oxygenation can lead to large numbers of stressed or, dying fish. Fortunately, tournament organizers don't need to work through complex physiological relationships involving oxygen solubilities, water temperatures and metabolic rates of different species. In fact, this critical issue is quite easy to solve.

If there is only one piece of equipment that every tournament organizer should have, and learn how to use, it would be an ***oxygen meter.*** A wide variety of these devices are available from many manufacturers. A good oxygen meter usually costs less than the sonar and GPS systems on most tournament boats. Instructions for use are easy to follow and anyone who can operate a sonar or GPS should be able to accurately measure oxygen in only a few minutes. Once the ability to measure oxygen is achieved, individuals responsible for the well being of the fish at these events can gather their own information about the oxygen levels in all of their tanks, live-release boats, etc. Operating without oxygen information is much like working in the dark. Regardless of how well someone thinks their aeration is working in all of these tanks, nothing compares to having actual oxygen measurements to accurately assess the situation. In events where live-release boats are being used, it makes good sense to have one oxygen meter entirely devoted to monitoring the oxygen levels in the tanks on these vessels as they fill up with fish. It's really quite surprising how quickly the oxygen levels in these boats can change, even in the presence of lots of aeration, when large weights of fish are added. When it comes to fish handling at tournaments, there are many situations when a few routine oxygen measurements can really save a lot of fish.

Temperature

Apart from oxygen, the next most important measurement that tournament organizers should monitor is ***temperature.*** Savvy anglers and event organizers know that water temperature has a big impact on the physiology of fish. Some fish species go to great lengths to find comfortable water temperatures that are only a few degrees different. This is because the body temperature of poikilothermic ("cold blooded") animals, such as fish, is not regulated internally. All of their physiological and biochemical processes are influenced by their environmental temperature. Therefore, each species of fish has clearly defined temperature preferences where they function optimally. Moreover, extreme changes in temperature will have profound negative implications on their internal processes. Similar to oxygen, it's important that tournament organizers routinely measure the temperatures in their holding tanks, live-release boats, etc.

Extremely high water temperatures, or exposure to rapidly increasing (or decreasing) water temperatures, can have many negative consequences. Because fish do not actively regulate their internal temperature, increases in water temperature will increase their body temperature resulting in an increase in their metabolic rate, or oxygen requirements. In most fish species, increases in body temperature will also reduce the oxygen affinity of their hemoglobin. This means that increased temperatures usually result in a decreased amount of oxygen carried by the blood of fish. The solubility of oxygen in water is also affected by temperature. Therefore, the total amount of oxygen present in warm water is less than that in cool water. As fish approach their upper lethal temperature (highest temperature they can tolerate), many of their routine physiological processes are also compromised, making them more susceptible to other stress.

Although the negative consequences of high temperatures are relatively easy to see, it's important to remember that rapid decreases in environmental temperature can also be a problem for fish. Similar to temperature increases, rapid decreases in temperature can disrupt normal physiological and biochemical fish processes. We recently demonstrated this phenomenon in experiments that exposed fish to extremely cool water during the weigh-in. Largemouth bass appeared to settle down and looked perfectly normal when exposed to a 27˚F (15˚C) decrease in water temperature during the weigh-in. When these bass were subsequently returned to normal temperatures following the weigh-in, however, their stress levels were significantly elevated compared to bass which had not been chilled.

The message here is that water temperature is another important variable that tournament organizers should monitor at their weigh-in sites. Furthermore, substantial deviations in water temperature either above, or below, that of the water body where fish were caught should be avoided.

pH

If water oxygen levels and temperature can be kept within appropriate limits in all of the aquatic environments that fish are exposed to during the weigh-in, it's likely that the fish should remain in very good physiological condition. In situations where large numbers of fish are being held in a common tank, however another variable that may be important for tournament organizers to monitor is water pH. As with oxygen meters, there are a number of commercial pH meters available that are targeted mainly to the aquaculture industry. These are relatively easy to operate and their cost is in the ballpark with an oxygen meter. A less expensive alternative is to measure water pH with commercially available kits designed for home aquarium users. These are very simple to use. Also, kits capable of 50-100 measurements can usually be purchased for about $10 from pet stores that deal in aquarium supplies.

Like humans, fish respiration involves the consumption of oxygen and the excretion of carbon dioxide. When their metabolic rates are increased, as during a weigh-in, fish consume more oxygen and produce more carbon dioxide. Much of this carbon dioxide combines with water molecules in a chemical reaction that produces protons (and bicarbonate ions). The protons resulting from this reaction thereby lower the water pH (since pH is actually a measure of the free proton concentration in a solution).

Water pH may also be influenced by the fact that fish recovering from bursts of exertion, release additional protons into the water. What's important to remember is that large numbers of fish held in closed environments can have a significant impact on water pH.

Why is water pH important? Most anglers realize that increased water acidity (low pH) is harmful to fish because of the attention paid to the acid-rain issue in recent years. In tournaments, there are several ways that low pH can influence the physiological condition of fish. An increase in the acidity of the environmental water may reduce, or even reverse, the ability of the fish's gills to excrete protons. This can contribute to lower blood pH in fish recovering from the weigh-in process. A reduction in water pH in holding tanks may also indicate that there are increased levels of CO_2 (carbon dioxide) there as well. Exposing fish to elevated CO_2 levels can further reduce their blood pH. When blood pH in fish is reduced (for whatever reason), there is often a reduction in the ability of their blood to transport oxygen. Measuring CO_2 levels in water is somewhat difficult, but measuring water pH, (which is much easier) is a good way to determine if this might be happening. So, what does all this mean?

The bottom line is that low water pH, or increased water CO_2 levels, can inhibit a fish's ability to obtain the oxygen needed to fully recover from the weigh-in. For this reason, it's a good idea for tournament organizers to monitor water pH in any tanks with extremely high densities of fish.

What are the Important Thresholds for Water Quality?

Now that we've highlighted the importance of monitoring environmental factors such as oxygen, temperature and pH, we are ready to discuss the critical thresholds for these variables. But first, we must mention some biological considerations influencing these thresholds.

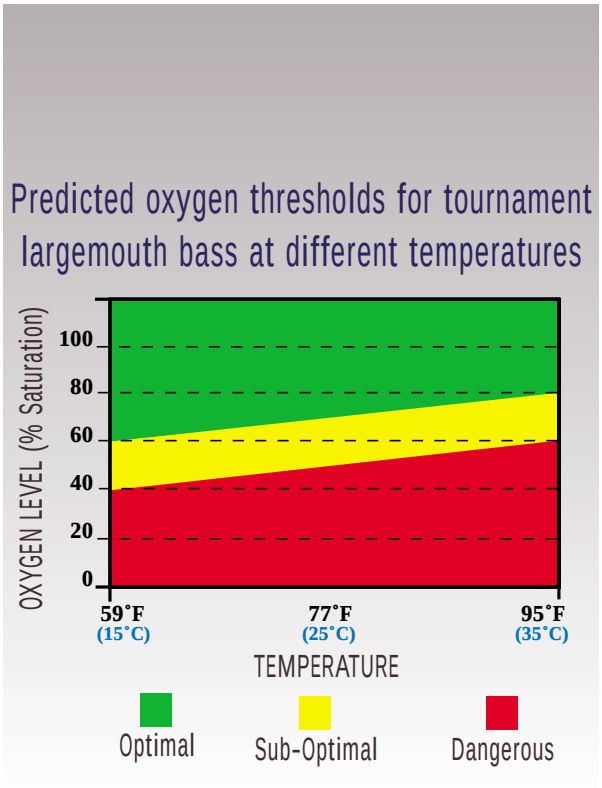
Initially, tournament organizers need to understand that the ***exact*** threshold for any potential stressor (oxygen, temperature, pH, etc.) in a fish's environment is extremely difficult to determine, because they are influenced by many independent factors. For example, oxygen thresholds will be influenced by several factors, including water temperature, pH, fish size and metabolic rate. These critical thresholds, are also different for every fish species. Thus, it is virtually impossible to produce a complex table of the critical thresholds of all the different environmental variables.

Where does this leave us? In view of these issues, we believe that the best strategy is to provide conservative thresholds for each of the environmental variables. These thresholds incorporate safety factors allowing them to be applied under any set of circumstances to maintain tournament fish in good physiological condition. The water quality conditions we suggest should also be relatively easy to maintain at tournament weigh-in sites, as long as the organizers make an effort to achieve this goal.

As a general rule of thumb, tournament organizers should strive to maintain water quality variables at their weigh-in site as close as possible to those in the natural water body where the fish were caught. When large numbers of fish are passing through the weigh-in site, however, this can become difficult. Thus we also provide the following conservative guidelines for the critical thresholds of the environmental variables discussed. Our initial focus is on largemouth bass, but we will also discuss what is known about these thresholds in other important tournament species, such as smallmouth bass and walleye.

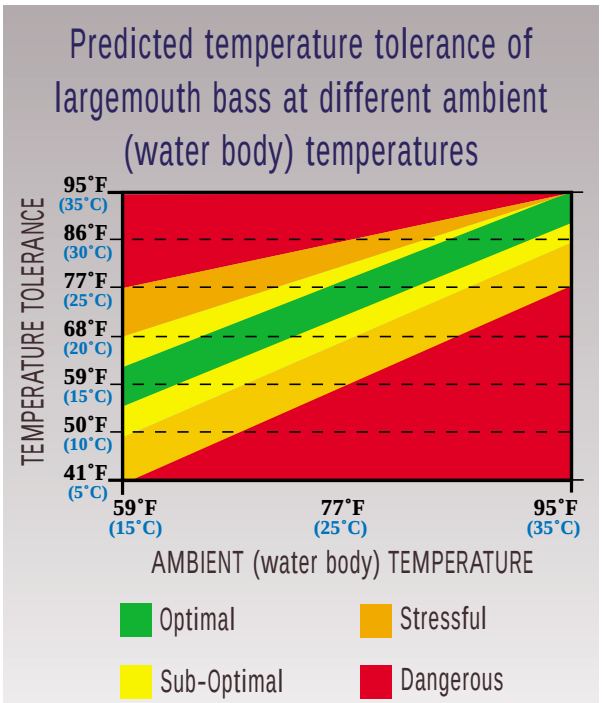
Because temperature affects many of the factors that determine the oxygen requirements of fish, we have provided a theoretical graph to illustrate how the oxygen thresholds of largemouth bass will be influenced by the ambient (water body, lake, river) temperature. Organizers using information from this graph as a guide can see that the critical oxygen thresholds of largemouth bass will be lower at cooler temperatures.

Tournament organizers wishing to simplify things should always strive to maintain oxygen saturation above the most conservative threshold on the graph, which is about 75%, at average temperatures.



The ambient (water body, lake, river) temperature has an important influence on the fish's temperature tolerance. To better understand this relationship, we have provided another theoretical graph to illustrate how the temperature tolerance of largemouth bass will likely be influenced by ambient (water body) temperature. Several important points should be noted in this graph. Largemouth bass (and any other species of fish) are always most comfortable when held as close as possible to their original water temperature. At cool or moderate temperatures there is room for error in this relationship, without adding serious stress to the fish. As the ambient water temperature increases, there is less room for error in terms of temperature increases at the weigh-in site.

When water temperatures in the natural water body of the proposed tournament approach within 10˚F (~5˚C) of the upper lethal limit of the target species, organizers should consider re-scheduling their event. This is because most, if not all, published values for upper lethal temperatures have been obtained for ***resting fish.*** Laboratory studies, as well as numerous observations, indicate that the upper lethal temperature of fish exposed to additional disturbances (hooking, handling, etc), are actually several degrees lower than their "resting" upper lethal temperature. We have also included a table showing how the upper lethal temperature of several important tournament species is shifted when this "activity factor" is taken into consideration.



Organizers who hold events near these upper temperature thresholds should make every effort to provide water temperatures at the weigh-in site that are similar to, or slightly below, those in the water body where the fish were caught.

Upper lethal temperatures for popular tournament species

SPECIES	UPPER LETHAL TEMPERATURES (REST)	"PREDICTED" UPPER LETHAL TEMPERATURE (ACTIVE)
Largemouth Bass	97 - 108˚F (36 - 42˚C)	87 - 98˚F (31 - 37˚C)
Smallmouth Bass	95 - 98.6˚F (35 - 37˚C)	85 - 89˚F (31 - 32˚C)
Walleye*	93˚F (34˚C)	~83˚F (~29˚C)

Note that upper lethal temperatures are usually for resting fish. The upper lethal temperature of fish experiencing additional disturbances (eg angling, confinement, handling) will be several degrees lower than the values for resting fish. We have also included "predicted" upper lethal temperatures for active fish. References used to create this table can be found in Appendix IV.

*Very little information is available for adult Walleye.

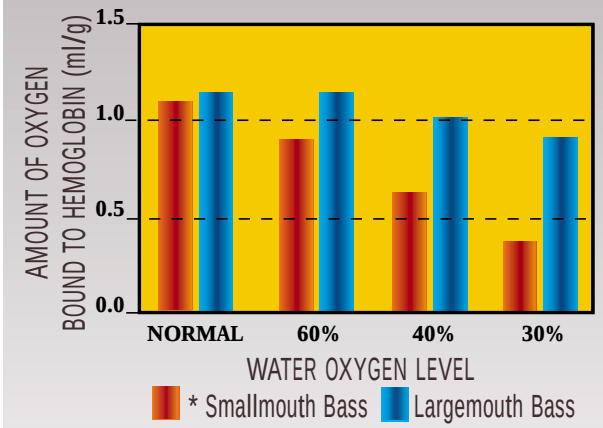
Water pH levels at the weigh-in site should normally be maintained between pH 6 to pH 8, except for circumstances where the water body itself is naturally basic or acidic. In these cases, the water pH should be maintained as close as possible to that of the natural water body (within 1 pH unit).

Largemouth bass are the most tolerant popular tournament species. This is because other tournament species, such as smallmouth bass and walleye, are more sensitive to changes in some of these important environmental variables. For example, the associated graph shows the results of some recent lab experiments where we found that the oxygen sensitivity of smallmouth bass is significantly greater than that of largemouth bass.

Smallmouth bass will therefore be less tolerant of changes in water oxygen levels. Preliminary experiments indicate that walleye are also much more sensitive to changes in oxygen than largemouth bass. In view of these findings, the tournament organizers for these species should make an extra effort to maintain their water oxygen levels above our conservative threshold of 75%.

Be aware that species such as smallmouth bass and walleye have lower upper lethal temperatures than largemouth bass. Although the upper lethal temperature for walleye has been shown to be greater than 86˚F (30˚C), evidence suggests that this species is much ***less tolerant*** of tournament stresses in the upper end of their temperature range. Organizers of walleye events should therefore make extra efforts to

Differences in the amount of Blood Oxygen in Smallmouth Bass and Largemouth Bass at different environmental oxygen levels.



NOTE: These values should NOT be used as precise oxygen thresholds for tournament bass because these values were obtained from quietly resting fish. Tournament bass will have different oxygen thresholds because of higher metabolic rates.

* Smallmouth Bass are much more sensitive to low oxygen.

avoid scheduling events when dates correspond to high water temperatures for this species. There is still much to be learned about the temperature sensitivity of some of these popular tournament species. The best strategy, however, is to maintain water temperatures at the weigh-in site as close as possible to (or slightly below) the temperature where the fish came from.

Solutions to Some Common Problems

Oxygen

Insufficient oxygen is by far the most common, and most serious, problem encountered during tournaments. In many cases, the cause is simple, such as complete lack of aeration in a holding tank, trough, etc. In these situations, addition of an aeration device quickly solves the problem. In other cases, the cause is less obvious. Some holding tanks may appear to be very well aerated, but the measured oxygen levels are still too low to maintain bass or walleye in good physiological condition. The problem is that the amount of oxygen being consumed by the fish in the tank is greater than the amount of oxygen being produced by the aeration devices. Because this is impossible to determine by simple observation, this is where the ability to monitor oxygen becomes so important. With an oxygen meter, organizers can quickly detect this type of problem and can then either (1) improve the aeration to see if this brings water oxygen levels into a more appropriate range, or (2) reduce the number of fish in the tank. Reducing the number of fish in the tank reduces the amount of oxygen being consumed and is often a simple way to solve the problem if better aeration is unavailable.

It's also important to mention that all aeration devices are not created equal. The amount of oxygen getting into the water (where the fish can access it) depends on the flow of air through the aeration device, as well as the size of the air bubbles that are produced, usually by an ***air stone.*** If the air bubbles are too large (as when an air hose is placed directly in the water), very ***little*** oxygen will enter the water. In contrast, much ***more*** oxygen will enter the water when a fine mist of air bubbles is produced from a high quality air stone. So when it comes to fish care at tournament weigh-ins, it is well worth the investment to purchase high quality aeration devices. Fortunately, there is a wide range of equipment available today because of the tremendous growth of the aquaculture industry (and associated products) in North America.

In view of the emphasis that we've placed on oxygen, it's also essential to discuss the issue of ***pure oxygen.*** This issue came up time and again during our tournament research, as a potential solution to oxygenation problems. In this regard, there are a number of very important issues to consider.

The most important issue is safety - pure oxygen is highly flammable. Anyone responsible for using pure oxygen in any environment, including tournament weigh-ins, should have proper training and be well aware of the risks and safety procedures. This could often require professional certification. Another important issue is that extremely high levels of oxygen (100% O_2) have been shown to have ***negative*** physiological consequences for fish by reducing their ventilatory drive and causing an acid-base disturbance (build-up of respiratory CO_2). Pure oxygen should therefore ***not*** be used to saturate the water with 100% oxygen. Since fish live in an aquatic environment, their hemoglobin already has a higher affinity for oxygen than humans. Thus, there is really no obvious benefit to exposing them to higher levels of oxygen.

In view of the safety concerns, to both humans and fish, and numerous alternative solutions, we do not recommend the use of pure oxygen at weigh-ins.

Temperature

There are several strategies that can eliminate problems with water temperatures during tournament weigh-ins. To minimize the possibility that water will become excessively warm in holding tanks, troughs etc., they should not be filled too early in the day. Water should be exchanged each day during multi-day events, especially in warm environments. Tents or canopies will protect holding tanks and troughs from the sun and reduce their rate of warming.

If ice is required to maintain water temperatures at the weigh-in site, be sure to monitor water temperature and don't allow it to fall more than 10˚F (~5˚C) below that of the water body where the fish were caught. Although it is believed that ice created from tap water will probably not contain enough chlorine to harm fish after thawing, ice packs or well contained, ***unopened*** bags of ice are best as they will not alter the composition of the water they are intended to cool.

pH

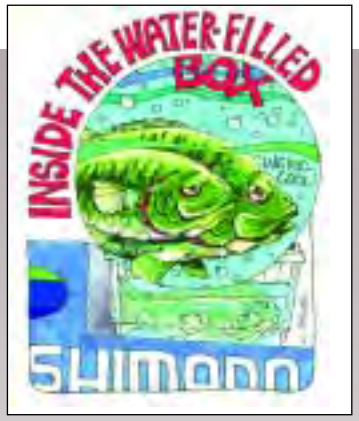
As mentioned, water pH becomes a significant issue when high densities of fish are held in closed water systems, as in any holding tanks. Because high-fish densities will increase the CO_2 and proton load of the water in these tanks, any deviations in water pH will be toward the acidic portion of the pH scale (lower pH).

If the water becomes severely acidic (pH less than 6), there are several easy ways to deal with this problem. The easiest solutions are to exchange some of the water in the fish tanks and/or reduce the number of fish in the tanks. Partial exchange of water in live-release boats is now a common strategy used by Shimano personnel to reduce water quality problems as these boat's tanks are filled with fish. If this is not a practical solution at the weigh-in site, another solution to this problem would be to add bicarbonate to the water. An environmentally friendly form of bicarbonate is readily available as sodium bicarbonate… common baking soda! If you do this, it's essential to constantly monitor pH, so that the water pH does not overshoot and become excessively basic (pH greater than 8), which can also become a serious problem for fish.

What if You are a Small Tournament Organizer?

If your annual tournament involves just a few boats and live-release at dockside, there are still ways in which you can take advantage of our research results. Whatever the size of your organization, you will still want to ensure that any fish caught remain in good physiological shape throughout your tournament.

First, plan to weigh your fish in water. Borrow a weigh scale with the capacity noted previously and prepare appropriate water weigh-in baskets and a water basin for the scale. Organize a water holding trough and some means of exchanging the water periodically. Ensure that you have at least one volunteer with proper training, whose job is to monitor the aquatic environment. Partner with another organization to purchase a good oxygen meter, and some system of aerating the water in your trough.



Plan your logistics carefully so that the fish remain in an **aquatic environment** throughout your tournament.

Disease Issues

Because large numbers of fish typically pass through tournament weigh-ins, some discussion of disease prevention is warranted. Fish biologists agree that there is also an important relationship between stress and disease. Because severely stressed fish are more susceptible to disease, it's important to minimize tournament-related stresses.

If the guidelines in this document are followed, most fish released after tournament weigh-ins should be in relatively good condition. These fish will be less susceptible to disease outbreaks related to stress.

To further minimize the possibility of disease transmission and outbreaks among fish involved in tournaments, BASS* also advocates additional precautions, such as the "salt-dip" at weigh-in sites. In brief, the "salt-dip" technique involves a quick (10-15 second) immersion of fish in a 3% salt solution (3.5 pounds of salt in 15 US gallons of water). The basic principle is that any external disease organisms will be killed by the shock of the salt dip, while there will be minimal impact on the internal physiology of the fish. Presently we're not aware of any scientific literature conclusively demonstrating the value of this technique at tournament weigh-ins. However, similar strategies have been used by fish hatchery managers for many years to prevent disease transmission among broodstock. In areas where disease transmission among tournament fish is an important concern, the "salt-dip" technique, or other strategies to reduce disease transmission, may be something that tournament organizers should consider.

* BASS is a trademark of BASS, Inc.

Personnel in Charge of Fish Care

Clearly, there are a number of issues that warrant attention from tournament organizers in order to keep fish in good condition during and after the weigh-in. Although none of the tasks described in this document are overly difficult to carry out, it makes good sense that the job of at least one person at the weigh-in site should be to ensure the proper care of the fish.

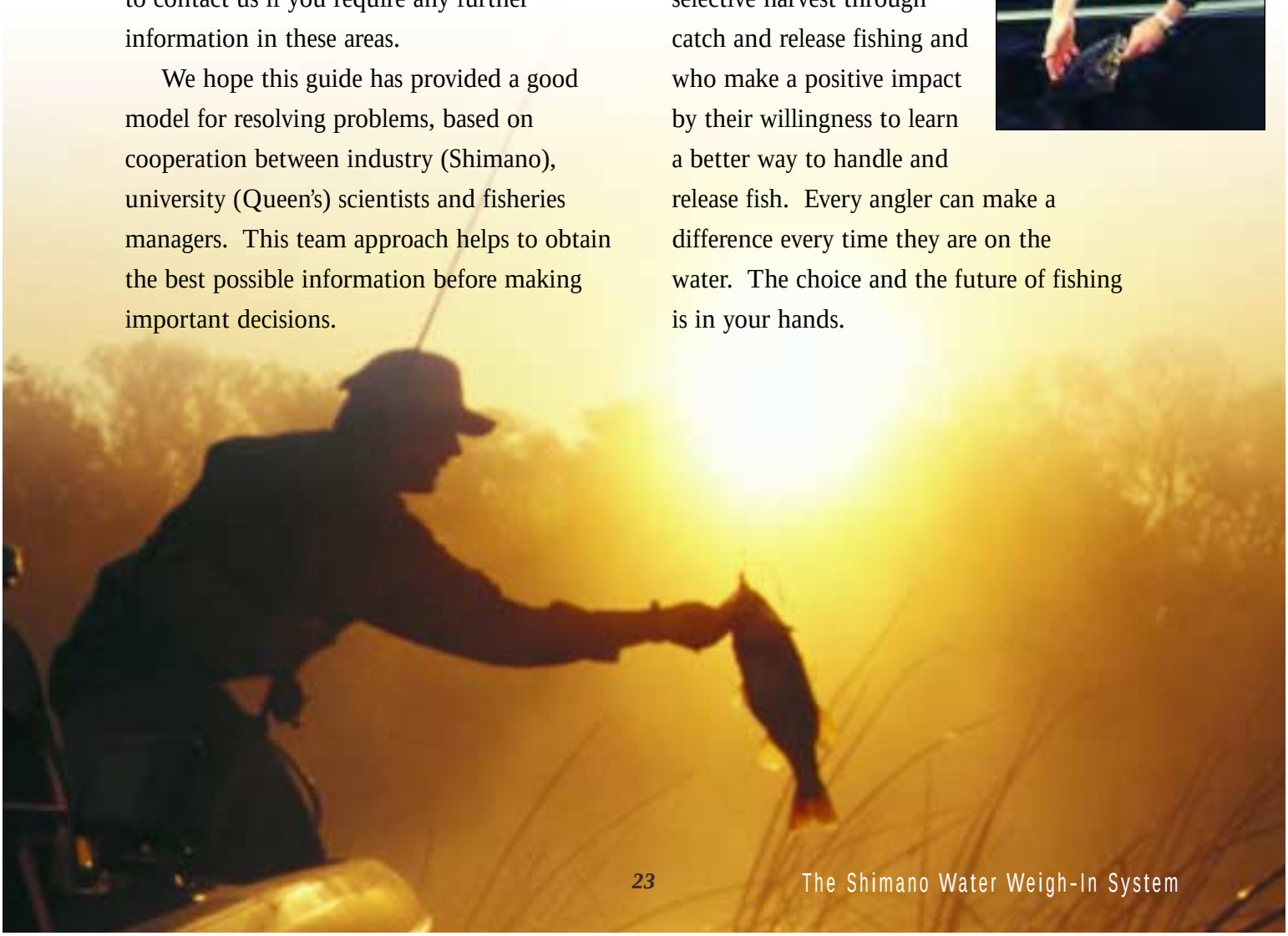
This person should learn to measure the important water quality variables, ensure that tanks have proper aeration and water exchanges, assess the condition of fish etc. In situations where we observed problems related to fish care at tournaments, they could have been avoided if one person was solely dedicated to these tasks.

Where We've Been…Where We Are, and the Future…

Years ago, we recognized that there were significant gaps in our scientific knowledge about tournaments. This began a cooperative research project to gather much needed information about tournaments based on sound scientific experiments. In addition to publishing this research in fisheries journals, the primary goal was to make the information available to tournament organizers and anglers, so that it could be used to reduce fish mortality and improve the physiological condition of tournament-caught fish. We hope that you find this document useful for these purposes. Please don't hesitate to contact us if you require any further information in these areas.

We hope this guide has provided a good model for resolving problems, based on cooperation between industry (Shimano), university (Queen's) scientists and fisheries managers. This team approach helps to obtain the best possible information before making important decisions. We suggest that other groups combine for a similar cooperative approach to resolving future issues concerning effective fish handling.

Our research partnership has also helped to confirm that there is still much work to be done. The more we learn, the more there is to learn. We are building on the efforts of others who have pioneered new ideas, and who continue to look for ways to improve. Our partnership is really with all of the anglers who practice selective harvest through catch and release fishing and who make a positive impact by their willingness to learn a better way to handle and release fish. Every angler can make a difference every time they are on the water. The choice and the future of fishing is in your hands.



Appendix I

Summary of Steps Involved in Weighing Fish in Water

1. Place thin hard surface to support bottom of water basin on top of scale.

2. Place water basin on top of hard surface on the scale

3. Fill water basin with 60-80 pounds of water and mark this level with a permanent marker on the basin for future reference.

4. Place empty "calibration" fish basket across the top of the basin, so that it sits perpendicular to the basin, rather than resting inside the basin (see photos).

5. Zero (tare) the scale, so that the weight of the fish basket, water, basin, etc. will be removed from future weights (scale should read zero).

6. Remove the empty "calibration" fish basket.

7. You are now ready to insert an angler's fish basket into the water basin.

8. Record the weight of the angler's fish.

9. To obtain accurate weights of fish for each angler, repeat steps 4 through 8.

10. Remember to aerate the water in the basin during pauses in the weigh-in and also exchange this water periodically.

NOTE: If scale indicates "over-capacity" (or a similar message) when fish are being weighed, the amount of water in the basin may have to be reduced, or a scale with a larger capacity may have to be used.

Appendix II

Weigh-In Checklist

1. Do not add water to troughs and holding tanks until shortly before the weigh-in, to avoid over heating and oxygen loss.

2. Minimize the time that the fish will be held in transfer bags by eliminating early bagging from boat livewells and/or provide aeration for the transfer bags.

3. Do not expose tanks and troughs to direct sunlight for long periods of time.

4. Monitor water temperatures in all troughs and holding tanks and keep their temperatures as close as possible to that of the water body where the fish were caught.

5. Monitor oxygen levels in all troughs and tanks and do not let oxygen fall below 75% saturation.

6. Frequently aerate the water basin on scale.

7. Replace water from basin on scale several times during the weigh-in.

8. Minimize all air exposure for fish during the weigh-in.

9. Keep fish in well-aerated water on their way back to the water body.

10. If live-release boats or other large tanks are being used to hold and/or re-distribute fish after the weigh-in, frequently monitor oxygen, temperature and pH in these systems and be sure to maintain at least 75% saturation for oxygen, temperatures close to those of the water body, and pH 6-8 (unless water body is naturally acidic or basic).

11. Use new water in all fish holding tanks, troughs for each tournament day.

Appendix III

Understanding Oxygen Measurements

Throughout this document, we have emphasized that environmental oxygen is probably the most important variable that tournament organizers should learn how to measure. We realize, however, that many people are not familiar with the terminology associated with oxygen measurements. Thus, the purpose of this appendix is to provide a brief explanation of that terminology.

Most oxygen meters on the market express oxygen levels in a number of different units (parts per million, milligrams per liter, % saturation etc). For our purposes, it is easiest to discuss oxygen levels in terms of percentage (%) saturation. Air, or water that is completely saturated with air at the same temperature, will have an oxygen saturation level of 100%. For example, a bucket of water that is bubbled with air until it reaches maximum oxygen level with no oxygen consumers (fish) present is considered 100% saturated. If the oxygen meter in use does not provide oxygen values in terms of percent saturation, then the maximum value it provides under these fully saturated conditions (eg 10 mg per liter) is equivalent to the 100% saturation value.

The important threshold that we suggest organizers should try to maintain in all of their fish holding systems is 75% of this fully saturated value. In cases where the oxygen meter does not provide percent saturation values, then it is simply 75% of the original maximum value in air saturated water (7.5 mg per liter if the original maximum value was 10 mg per liter).

It's important to point out that normal air contains about 20% oxygen.

Appendix IV

Relevant Scientific References

For those interested in learning more about issues relevant to this document, we suggest the following references:

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