Effectiveness of Smith-Root's Fish Handling Gloves to Immobilize Lake Trout and Rainbow Trout

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Abstract:
The safe immobilization of fish is a top priority for hatchery personnel that directly handle fish. Most commonly, fish are chemically immobilized to aid safe handling. Recently, however, gloves have been developed to immobilize fish with electricity but the effectiveness of handling fish with these gloves is unknown. Our objective was to determine the effect of different amperage settings for Smith-Root Fish Handling Gloves™ on the immobilization response and recovery of Rainbow Trout (*Oncorhynchus mykiss*) and Lake Trout (*Salvelinus namaycush*) in a hatchery setting. Twenty fish from each species were handled with the Gloves at five amperage levels. Each fish was measured for length and weighed, at it would be in typical biological sampling within the hatchery. In addition, a qualitative assessment of the physical reaction of each fish to the electrical impulse of the Gloves was recorded (4 mA, 6.3 mA, 10 mA, 16 mA, 25 mA). The physical reaction of the fish among the different amperage levels differed between the two species. An amperage level of 16 mA produced the desired effect (category 3) most often for Rainbow Trout (80% of the time), whereas 25 mA produced the desired result most often for Lake Trout (65% of the time). We have shown with this preliminary study that the Smith-Root Fish Handling Gloves™ are effective for immobilizing these two species, but that effectiveness differed by amperage level. Thus, users will need to determine the most appropriate level for the Gloves for each species to be handled. Future work should use larger sample sizes to more precisely define the distribution of physical reactions and test whether effectiveness and recovery differ by size of the fish.

Introduction:
Chemical immobilization of fish is common in the hatchery setting for purposes such as sampling and even simple transportation of fish to different tanks or locations. Most commonly chemical anesthetics are used to immobilize fish. These chemical anesthetics are often difficult to obtain due to legal regulations and are also moderately expensive (Sigler *et al.* 1990). Currently, the only chemical anesthetic that is approved of by the FDA- Food and Drug Administration, for use in food fishes with stipulations is MS-222 or Tricaine methanesulfonate (Carter *et al.* 2010), however MS-222 has recently been banned in Canada (Coyle *et al.* 2004).

In addition to the difficulty presented by the availability and cost factors, there have been recent studies which have found that MS-222 can negatively affect many species of fish for various reasons and can even result in death. The use of MS-222 in food fishes or fish that will be released to the wild presents a cost issue for facility managers, as fish that are exposed to MS-222 require a 21 day withdrawal period before it can be consumed or released (Carter *et al.* 2010); This withdrawal period results longer stay in the hatchery before the fish can be released results in increased food and water costs to the facility. Further, MS-222 is a retinotoxin and mucus membrane irritant in humans if it becomes airborne, which is easily done as MS-222 is most commonly sold in powder form (Carter *et al.* 2010).

Due to these issues surrounding MS-222, a safe cost-effective alternative would be of great use in fish hatcheries. One potential alternative is the Fish Handling Glove™ (FHG) produced by Smith-Root (http://www.smith-root.com/electrofishers/fhg/). The FHG is designed to electrically immobilize fish using current supplied from a power pack to one positively charged and the other negatively charged glove. The fish closes circuit, which in turn immobilizes the fish. If this new product proves effective, the negative effects of MS-222 could be avoided.

To specifically study how effective the gloves are we will initially identify if the gloves are effective for immobilizing two common hatchery fish species, Rainbow Trout, and Lake Trout. If the gloves prove to be effective, we will attempt to identify the most effective amperage level that produces the desired effect most often for each species. Then we will look to identify if there is a difference in the most effective amperage between species.

Methods & Materials:

This study was conducted at University of Wisconsin- Stevens Point Northern Aquaculture Demonstration Facility using fish donated by the Iron River National Fish Hatchery, a facility operated by the USFWS. Fish were raised in 12 foot recirculating aquaculture system tanks and were separated by species; feed was withheld from the fish for 10 days prior to handling, as is common practice in most aquaculture facilities before fish are harvested or transported.

In total, a sample of 100 fish of each species, Rainbow Trout and Lake Trout were handled with the FHG. Twenty fish of each species were sampled at one of the five amperage levels available on the FHG (4, 6.3, 10, 16, and 25 mA). Fish were moved from the 12 foot tanks using a net to a 20 gallon container. Each fish was then removed from the container while using the FHG and to simulate typical handling, the weight (kg) and length (mm) of each fish was recorded while the fish was immobilized. Fresh oxygen rich water was replaced in the 20 gallon container between each group of five fish to alleviate stress and general lethargy of the fish caused by low oxygen levels. Additionally, the gloves were wiped off using a dry towel after the handling of several fish to reduce fish slime build up on the gloves. After data was collected from each fish, it was placed into a 4 foot flow through tank, where they were then observed for delayed mortality or injury for up to four days following handling. The physical response of each fish to handling with the FHG was immediately categorized as shown in Table 1. The 3 category of response was considered the desired response to the FHG.

Table 1. Response categories for physical effect of FHG on each species.

Response 1	Response 2	Response 3	Response 4	Response 5
No effect of Fish.	Fish was only partially immobilized.	Fish was completely immobilized, and recovered immediately upon release.	Fish was completely immobilized, but did not recover immediately upon release.	Fish died due to handling.

Chi-square tests were used to test if the distribution of responses differed by amperage level for each species separately. Post-hoc pairwise comparisons were conducted with chisqPostHoc() from the NCStats package (Ogle 2016) A two way logistic regression was used to determine if the proportion of desired responses (category 3) varied by species, amperage level, or the interaction between species and amperages. All tests were performed in R v0.4.5 () and used a significance level of 0.05 (α=0.05).

Results:

At least one amperage level on the FHG were found to be effective for immobilizing both Rainbow Trout and Lake Trout. The most effective amperage level differed between species (logistic regression interaction p=0.0003; Table 2).

Table 2. ANOVA table from logistic regression for comparison of most effective amperage level between species.

	Df	Deviance	Resid. Df	Resid. Dev	Pr(>Chi)	
NULL			199	266.58		
species	1	11.302	198	255.28	0.0007741	***
amps	1	17.005	197	238.28	3.729e-05	***
species:amps	1	13.139	196	225.14	0.0002892	***

The distribution of responses differed by amperage level for Rainbow Trout (x2=; p=; Figure 1). Specifically the percentage of desired responses by Rainbow Trout differed among amperage levels (x2=; p=), with the percentage of desired reactions at 16 mA significantly greater than the percentage at 4 mA (p=). In general, fewer Rainbow Trout were sufficiently immobilized at amperage levels less than 16 mA and more Rainbow Trout showed delayed recovery at amperage levels greater than 16 mA.

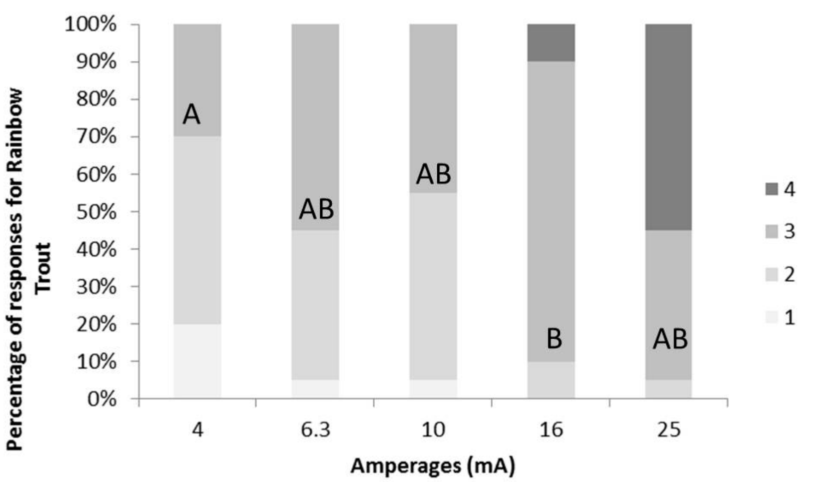

Figure 1. Frequency of 20 fish that exhibited the desired reaction for each amperage for Rainbow Trout. Amperages with the same letter did not differ within the species.

Similar finding were also identified for Lake Trout; the distribution of responses differed by amperage level for Lake Trout (X^2=55.3852; p= <0.0005; Figure 2). Specifically the percentage of desired responses by Lake Trout differed among amperage levels (X^2=32.7752; p= <0.0005), with the percentage of desired reactions at 25 mA significantly greater than the percentage at 4 mA (p=0.0015). In general, fewer Rainbow Trout were sufficiently immobilized at amperage levels less than 16 mA and more Rainbow Trout showed delayed recovery at amperage levels greater than 16 mA.

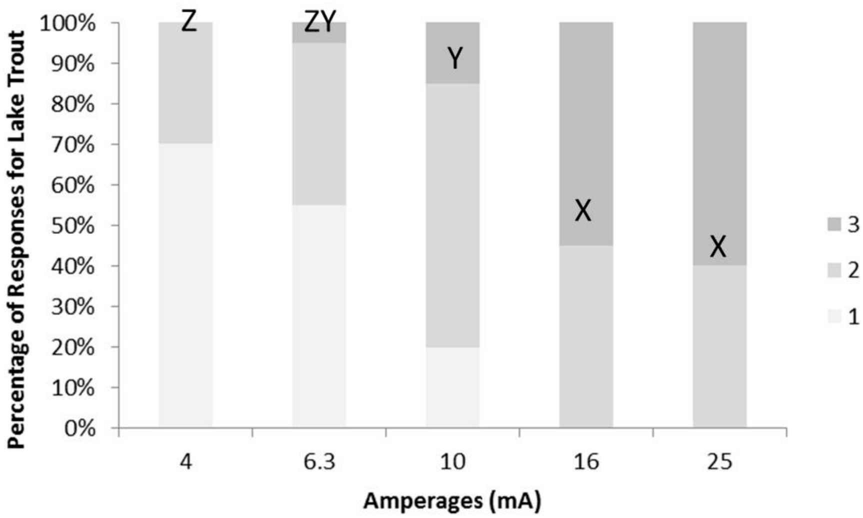

Figure 2. Frequency of 20 fish that exhibited the desired reaction for each amperage for Lake Trout. Amperages with the same letter did not differ within the species.

After differences were identified within species we analyzed if there was a difference in effective amperage levels between species. It was identified that there was a difference in the effective amperage level between species ($p < 0.0005$) (Table 2).

Discussion:

Smith Root's Fish Handling Gloves are effective at immobilizing both species tested in this preliminary study. The most effective amperage level was identified for Rainbow Trout and Lake Trout; additionally a difference in the most effective amperage level between species was identified. These results are in support of the FHG as an effective alternative to chemical immobilization for sampling and transporting fish. However these gloves will not and are not intended to serve as an anesthetic for surgical procedures on fish, as they only provide temporarily immobilization. In general, Lake Trout required a higher amperage level to elicit the desired response in comparison to Rainbow Trout, although there is a possibility that this was a result of difference in size of the two species, Lake Trout being larger. The maximum amperage (25 mA) was required to produce the desired response but only produced the desired response 60% of the time. This suggests that higher amperage may prove more effective on larger fish; as such future work may look to identify the relationship, if one exists, between effectiveness and size of the fish being handled. In theory all amperage levels on the FHG are effective for some amount of immobilization of Rainbow Trout, as all amperage levels produced the desired response a percentage of the time. These gloves have the possibility to significantly change how sampling and fish transportation within the hatchery setting is done, a new alternative that can provide cost saving benefits and a safer environment for both fish and handler.

The design of the FHG is very intuitive and user friendly allows for use by younger or inexperienced staff without the concern of injuring fish. However it was a slightly cumbersome during handling and movement due to the wires connecting the gloves to the power pack; additionally, if allowable, the gloves may benefit from a textured surface to provide more gripping ability.

Other studies that have focused on the effect of MS-222 stated the importance of accurately making a proper anesthetic solution (Carter *et al.* 2010), which requires handlers to have experience with anesthetics as well as the proper concentration required for the species in question. In addition to the risk of improper concentrations, MS-222 efficacy is also influenced by water quality parameters, and biological factors, including pH, hardness, salinity, age, sex, size, weight, lipid content, species, and density of fishes (Popovic *et al.*2012). MS-222 is known to negatively affect physiological conditions in fish and result in mortality if used improperly. The loss of muscle control caused by MS-222 can result in reduced gill perfusion, leading to hypoxia, and eventually death (Hill *et al.* 2002). MS-222 has also been found to reduce the heart rate of Rainbow Trout (Hill *et al*. 2002).

Although relatively few if any studies exist that explore the physiological effects of electroshocking fish in the hatchery setting, it is suggested that another study be performed to examine these biological parameters during electro immobilization. This data could then be used to compare whether electroshocking or chemical immobilization is least stress inducing for fish based on biological parameters. This preliminary study identified that this new product Smith-Root's Fish Handling Glove ™ is effective for immobilizing Rainbow Trout and Lake Trout, however it is suggested that future studies be conducted on larger sample sizes that monitor physiological data, and also account for size and species of fish.

Conclusion:

Smith-Root's Fish Handling Gloves™ were effective at immobilizing both Rainbow Trout and Lake Trout in this preliminary study. A difference in effectiveness between amperages existed for both species; with higher amperages required to elicit the desired response in Lake Trout when compared to Rainbow Trout. These findings support the Fish Handling Gloves™ as a possible effective alternative to chemical anesthetics for the purpose of immobilizing fish species in the hatchery setting. I suggest that future research focus on identifying differences in effectiveness across fish of different sizes; as I believe size of fish may have a significant impact on effectiveness, supported by this study's findings which found that the Lake Trout sample, which were larger in size, required higher amperage levels to produce the desired effect. Further, if possible, it may be worthwhile to the manufacture to include higher amperage levels for the gloves, especially if it is found that size of fish influences the effectiveness of the gloves.

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