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The efficacy of assisted ventilation techniques for facilitating the recovery of fish that are exhausted from simulated angling stress

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ABSTRACT

Employing science-based best angling practices is important for sustainable catch-and-release fisheries. In situations where fish lose equilibrium (unable to maintain upright posture to swim in a coordinated manner), anglers often provide assisted ventilation by hand, which typically involves maneuvering fish to move water over the gills until equilibrium is regained. However, it is unclear whether these tactics are effective at facilitating physiological and behavioural recovery and improving survival. Here we tested the efficacy of assisted ventilation techniques in two freshwater species popular for angling, largemouth bass and brook trout. Fish were captured by angling with rod and reel, and subsequently air exposed until equilibrium was lost. Treatments included maneuvering fish in a back-and-forth manner or in a constant forward motion, which were compared to controls that did not experience assisted ventilation. In largemouth bass, physiological stress values (i.e., blood glucose, lactate, pH, hematocrit) and rates of equilibrium regain were not significantly different between treatments, while all fish survived a 24-h holding period. In brook trout, fish maneuvered in a back-and-forth manner regained equilibrium fastest, but differences between treatments were not statistically significant. Further, once equilibrium was regained, brook trout often spent extended periods resting on the bottom, and likely had limited capabilities to avoid predators. We found little evidence of any physiological or behavioural benefits of two common assisted ventilation techniques that would result in improved fish survival or fitness with largemouth bass or brook trout in recreational angling scenarios. However, releasing fish in poor condition may lead to greater predation risk, so retaining fish with minimal handling until swimming capabilities return is likely the most advisable course of action.

1. Introduction

Catch-and-release angling is a popular conservation strategy predicated on the assumption that released fish will survive and experience limited fitness consequences (Wydoski, 1977; Arlinghaus et al., 2007). Fish are released to comply with mandated regulations (i.e., harvest regulations) or as a voluntary action reflecting conservation ethic of anglers (Cowx, 2002; Brownscombe et al., 2014a). However, due to angling-related physiological stress and injury, fish fitness and survival can be impacted (Cooke and Schramm, 2007). The outcome of angling events varies greatly due to angler behaviour and environmental conditions. Therefore developing and applying best angling practices (i.e. those that maintain the welfare status of fish) is essential for sustainable recreational fisheries (Cooke and Suski, 2005; Brownscombe et al., 2016).

Despite the best intentions of anglers, there are still cases where fish experience significant stress as a result of the additive effects of the fight and handling, mediated by environmental conditions (Cooke and Suski, 2005; Arlinghaus et al., 2007). When stressors are extreme (which is a relative species-specific construct) it can lead

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to fish exhaustion and behavioural impairment. While behavioural impairment is challenging to measure post-release, reflex tests are a good predictor of behavioural impairment and mortality in angled fish (Brownscombe et al., 2013, 2014b). The most obvious reflex indicator of exhaustion is when fish are unable to maintain upright posture (equilibrium) or swim away from the angler in a coordinated manner. In these instances fish have a much lower probability of survival due to the physiological stress or post-release predation by opportunistic predators (Danylchuk et al., 2007; Raby et al., 2012). When fish are unable to swim away, anglers often hold fish by hand and maneuver them in various patterns through the water in an attempt to assist the fish in regaining equilibrium (Pelletier et al., 2007). In lentic systems (i.e. lakes, reservoirs), these assisted recovery techniques typically involve moving the fish back-and-forth in the water, or in a constant forward motion in a figure-8 or circular pattern. In riverine systems, it is common to hold fish facing into the flow to provide assisted ventilation. However, Robinson et al. (2013, 2015) found no evidence that this technique improves survival or migration success in sockeye salmon (*Oncorhynchus nerka*). To our knowledge, no studies have ever tested the efficacy of assisted ventilation techniques at reducing stress or improving fish survival in lentic systems. Fish gill lamellae are designed to uptake oxygen from anteriorly-sourced water flow using a counter-current gas exchange system (Gilmour, 1997), so it is generally believed that constant forward movement is more efficient for oxygen uptake, while back-and-forth movement may be detrimental (Pelletier et al., 2007).

The objective of this study was to test the efficacy of commonly employed assisted ventilation techniques at facilitating physiological and behavioural recovery and improving survival of recreationally angled fish. We tested two different techniques with two freshwater fish species that support popular recreational fisheries, largemouth bass (*Micropterus salmoides*; Quinn and Paukert, 2009) and brook trout (*Salvelinus fontinalis*; Power, 1980), in an effort to determine the best course of action when fish show signs of exhaustion and behavioural impairment from recreational angling. For largemouth bass we examined secondary physiological stress responses, reflex impairment, and mortality. Due to logistical constraints at the field site, for brook trout we examined only reflex impairment.

2. Methods

2.1. Largemouth bass recovery

This experiment was conducted at Queen's University Biological Station (QUBS) Lake Opinicon (44° 35′ 6.4″, −76° 17′ 47.7″) in Ontario, Canada between 01-05-2015 and 04-05-2015 at water temperatures from 15 to 22 °C. Largemouth bass were angled from a single shallow embayment using 2-m-long, medium-strength fishing rods and reels equipped with 6.8 kg break-strength braided fishing line. Terminal tackle included a 1/0 octopus hook, baited with a 15 cm wacky-rigged plastic worm. Upon capture, largemouth bass were air exposed in a rubberized net until equilibrium was lost. Based on initial tests and previous literature (Thompson et al., 2008), a minimum of 10 min of air exposure was required to cause largemouth bass to lose equilibrium at these water and air temperatures. In order to avoid placing fish in water to test equilibrium periodically, an initial reflex test was applied prior to testing equilibrium. The initial reflex test involved grabbing the fish by the lower jaw; the fish flexing its body indicated a positive response. Starting at 10 min of air exposure, initial reflex tests were conducted every 2 min until fish were unresponsive. Equilibrium was then tested by flipping the fish upside down in water; a positive response was indicated by the fish righting itself within 3 s. If the response was positive, air exposure continued under the same initial reflex test procedure until equilibrium was lost.

Upon equilibrium loss, additional reflex tests were conducted using RAMP methods (Davis, 2010). Five predictors were measured: tail grab, body flex, equilibrium, head complex impairment, and vestibular-ocular response (VOR). These predictors were selected because they are strong indicators of fish behavioural impairment and mortality, and also feasible for anglers to adopt (Davis 2010; Raby et al., 2012; Brownscombe et al., 2013; Brownscombe et al., 2016). Tail grab was tested by grabbing the fish's tail in water; an attempt to escape indicated a positive response. Body flex was tested by holding the fish in air by the center of the body; flexing in attempt to escape indicated a positive response. A positive head complex response was indicated by regular opercular movement in water. Vestibular-ocular response (VOR) was tested by rolling the fish side-to-side; a positive response was indicated by the eyes moving to track level. Each indicator was scored as 0 = unimpaired and 1 = impaired and overall RAMP scores were calculated as the proportion of indicators impaired.

After RAMP assessment, fish were treated with one of three assisted ventilation techniques: control (n = 25), forward motion (n = 24), or back-and-forth (n = 24) for up to 3 min in 90 l holding containers. Fish in the control treatment were left untouched aside from equilibrium checks. Fish in the forward motion treatment were held by the center of the body while maneuvering the fish in a circular pattern in constant forward motion to generate anteriorly sourced water flow. While anglers typically manoeuvre fish in an 'S shape' or 'figure-8', the circular motion was more feasible in the holding containers and generated similar anteriorly sourced water flow. Fish in the back-and-forth treatment were held in the same manner as the forward motion treatment but manoeuvred forward and backward through the water. Equilibrium was checked every 20 s, and the recovery period concluded once equilibrium was regained, up to a maximum of 3 min.

After the recovery period fish were held for 1 h prior to blood sampling to assess physiological stress, as secondary stress levels typically peak around 1 h post-stressor in the blood of largemouth bass (Suski et al., 2007). For blood sampling, fish were transported to a sloped trough filled with lake water where ~1 mL of blood was extracted via the caudal venipuncture of each fish using an 18-gauge syringe and 3 mL Vacutainer® (75 USP lithium heparin). Blood was immediately stored on ice and later analyzed using point-of-care devices effective with fish (Cooke et al., 2008; Stoot et al., 2014) for glucose (in millimoles per litre; Accu-Chek Compact Plus), lactate (in millimoles per litre; Nova Biomedical, MA, USA), and pH (HI-99161; Hanna Instruments, RI, USA). Hematocrit (erythrocyte volume fraction) was measured by spinning whole blood at 5000 rpm for 5 min in capillary tubes (CritSpin, MA, USA). Lastly, fish were given a fin clip unique to each treatment and transported back to QUBS where they were placed in a 1.22 m × 1.22 m × 1.22 m floating net pen to monitor mortality for 24 h. All fish were released after experimentation.

2.2. Brook trout recovery

This experiment was conducted on Collins Lake in Kenauk Nature Reserve, Quebec, Canada (45° 44′ 38.0″, −74° 48′ 24.7″) on 06-10-2015 and 07-10-2015 at water temperatures ranging from 13 to 14 °C. Brook trout were stocked from hatcheries near Mont-Tremblant in 06-2015 and 09-2015. Fish were captured using in-line spinner lures (size 2 or 3) with barbed treble hooks and held overnight in a net pen (1.2 × 1.2 × 1.2 m, maximum density 20 fish) as a part of another study examining angling-related mortality. The following day, brook trout that were not deeply hooked and had no visible signs of injury or behavioural impairment were included in this study.