Impacts of dissolved oxygen on the behavior and physiology of bonefish: implications for live-release angling tournaments

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Summary of study findings

During live-release angling tournaments, bonefish can be held in livewells for extended periods of time. During this holding period, potential exists for bonefish to experience low oxygen concentrations (hypoxia). To combat the negative effects of hypoxia, anglers sometimes employ oxygen infusion systems whereby oxygen gas is bubbled into a livewell; it is possible, however, that unattended infusion systems can over-oxygenate the water resulting in conditions of higher dissolved oxygen concentrations than expected (hyperoxia). Because angled bonefish are in the process of recovering from exercise, and also because livewell holding can last for several hours, it is imperative that oxygen concentrations be at optimal levels to maximize survival after release. A major limitation to the use of oxygen systems is that the dissolved oxygen requirements of bonefish have never been scientifically defined, making it difficult to provide recommendations on optimal oxygen concentrations.

The objective of this study was to quantify the physiological and behavioral impacts of dissolved oxygen variation on bonefish, with the goal of providing oxygen guidelines for tournament organizers and anglers. Experiments were performed that included behavioral assessments and blood sampling under different dissolved oxygen concentrations. Behavioral experiments consisted of placing bonefish in one of three dissolved oxygen concentrations (low, normal sea water, high) and monitoring gill ventilation rates (breathing rates). For blood sampling, bonefish were exercised and then recovered in water with low, normal or high oxygen concentrations, replicating an angling event coupled with different livewell holding conditions.

Upon being placed in water with *low* dissolved oxygen (hypoxic water) bonefish exhibited an increase in ventilation rates. Increased ventilation serves to pass more water over the gills to increase oxygen exchange, and is a typical response in fishes indicating disturbance

or discomfort. Placing fish in water with *high* dissolved oxygen concentration caused a dramatic decrease in ventilation rates. This reduction in breathing occurred because one of the cues that motivate fish to breathe is a lack of oxygen in the environment. While this may not seem to be a negative consequence, gill ventilation not only brings in oxygen, but also removes wastes such as carbon dioxide. A lack of breathing can impair carbon dioxide excretion and cause waste accumulation that can impair recovery. Together, the behavioral study showed that exposure to dissolved oxygen concentrations either above or below that of normal seawater can have negative consequences for bonefish.

Results from the blood experiments showed that recovery from exercise was slowed by low oxygen conditions relative to normally oxygenated seawater. Similar results were observed for fish recovered in water with high oxygen compared to normal seawater, with hyperoxygenated water causing physiological disturbances that persisted for several hours. Together, results from the blood experiments compliment results from the behavioral study and demonstrate physiological impairment for bonefish recovered in water with oxygen concentrations either above or below that of regular seawater.

Recommendations for oxygen concentrations during holding are as follows:

1. Dissolved oxygen concentrations should remain **between 4 mg/L and 8 mg/L (ppm)**. Normal seawater has dissolved oxygen of around 6 mg/L. To maximize recovery of angled bonefish, anglers can increase flow rates of seawater to a livewell or reduce fish density.
2. Oxygen infusion systems should be used *with caution* to prevent over-oxygenation of water.
3. Only properly functioning dissolved oxygen meters should be used as a means of ensuring that target oxygen concentrations are met, and to avoid over-oxygenation.