Do bonefish (*Albula vulpes*) use mangroves for protection from predators following catch-and-release angling?

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ABSTRACT

Bonefish (*Albula* spp.) inhabit shallow tropical and subtropical mangrove environments world wide and are economically important due to their popularity among recreational anglers. Despite their importance as sportfish, very little is known about the biology and ecology of bonefish. In particular, little information is available on how voluntary catch-and-release angling practices affect the behavior and survival of individual fish and the fishery as a whole. .The purpose of this study was to examine how different angling, handling, and release techniques affect the short-term post-release survival of bonefish inhabiting mangrove creeks in Eleuthera, The Bahamas. A total of 87 bonefish were angled, released, and visually tracked using small surface floats. A total of 15 (17%) bonefish were preyed upon by either juvenile lemon sharks (*Negaprion brevirostris*) or great barracuda (*Sphyraena barracuda*) within the one hour observation period following release. Bonefish released near protective mangrove cover did not experience a decrease in short-term predation risk. In addition, 17 (20%) of bonefish following release were observed swimming into open water (> 2.5 m deep) rather than staying in close proximity of mangrove cover. These results indicate that mangroves themselves may not act as a refuge from predation for bonefish. Handling practices employed by anglers may play a more important role in the short-term survival of bonefish following release than the location anglers choose to release their catch.

KEYWORDS: Bonefish, *Albula*, catch-and-release angling, Eleuthera, The Bahamas.

¿ Utiliza el macabí(Albula vulpes)los manglares para protegerse de la depredación despues de ser capturado y liberado por pescadores deportivos?

Bonefish (*Albula* los spp.) habitan ambientes tropicales y subtropicales bajos del mangle por todo el mundo y son económicamente importante debido a su renombre entre pescadores deportivos. A pesar de su importancia como pez deportivo, muy poco se sabe sobre la biología y la ecología del macabi. Particularmente, poca información está disponible de cómo la captura y liberación voluntaria por parte de los pescadores deportivos afectan el comportamiento y la supervivencia de los peces liberados a nivel individual o de toda la pesqueria. El propósito de este estudio era examinar cómo el diversos metodos de pesca, liberación, manejo del los peces y las técnicas del lanzamiento afectan el a corto plazo la supervivencia del macabi que habita los cayos de manglar en Eleuthera, Las Bahamas.. Un total de 87 macabis fueron capturados, liberados y seguidos visualmente usando un pequeña boya. Un total de 15 macabis (17%) fueron comidos por tiburones limón juveniles (*Negaprion brevirostris*) o gran barracuda (*Sphyraena barracuda*) dentro de la primera hora de observación. El Bonefish liberado cerca del mangle no experimentó una disminución del riesgo a corto plazo de la depredación. Además, 17 (20%) del macabi liberado nadaron libremente en el agua (> 2.5 m de profundo) más bien que permaneciendo en la proximidad cercana de la cubierta del mangle. Estos resultados indican que los mangles por si mismo no actúan como refugio contra la depredación para el macabi. La manipulación de las prácticas empleadas por los pescadores puede desempeñar un papel más importante en la supervivencia a corto plazo del macabi después de la liberacion bonefish que la localidad escogida por los pescadores para la liberación.

PALABRAS CLAVES: Macabi *Albula vulpus*, captura y liberación, Eleuthera, Las Bahamas

INTRODUCTION

Bonefish (*Albula* spp) inhabit shallow subtropical and tropical nearshore flats environments worldwide (Alexander, 1961), and their wariness and speed make them one the most sought after group of marine fishes among recreational anglers (Kaufmann, 2000). Because of their popularity, bonefish have become the focus of a tourism-based recreational angling industry that generates substantial revenue for coastal communities in many regions. For example, the recreational bonefishing industry in Florida is estimated to be worth several billion dollars annually, making the economic value of an individual adult bonefish in this region potentially quite high (Humston 2001). In addition, the relative value of bonefish in small nations, such as The Bahamas, can be much greater, such that the revenues generated through bonefishing-related tourism can form the entire economic foundation of local coastal communities (Danylchuk et al. 2007b).

The sustainability of a recreational bonefishing industry is contingent upon the maintenance of abundant and healthy stocks and habitats. In the case of bonefish, most recreational anglers voluntarily practice catch-and-release in an effort to ensure that local populations do not become depleted (Policansky 2002). Catch-and-release angling can be an effective way to help maintain bonefish stocks but only if post-release mortality is minimized (Cooke and Suski 2005). When a fish is hooked by an angler, many factors affect the outcome of the event for the fish (Cooke et al. 2002). At best, the fish will survive the event and no long-term effects will ensue. At worst, the fish will not survive. Although anglers strive for the former outcome, an intermediate outcome in which the fish suffers transient physiological and behavioral deficits is more likely (Cooke and Philipp 2004, Cooke and Suski 2005, Bartholomew and Bohnsack 2005, Suski et al. In Press). Such deficits can, in turn, increase the susceptibility of caught-and-released fish to predation (Cooke and Philipp 2004, Danylchuk et al. 2007a, Danylchuk et al. 2007c), potentially causing population-level effects and ultimately reducing the sustainability of a recreational bonefishing industry.

Despite the importance of bonefish to the recreational angling industry, only a few studies have focused on how catch-and-release angling influences the survival of bonefish. Crabtree et al. (1998) assessed hooking mortality in bonefish that were repeatedly angled, and although they reported a post-release mortality rate of only 4%, their study site lacked predators, thereby providing only limited generalization to "normal" fishing situations. More recently, Cooke and Philipp (2004) and Danylchuk et al. (2007a and 2007c) focused on the post-release mortality of bonefish in the natural environment. These studies collectively demonstrated that short-term (< 24 h) mortality of bonefish following catch-and-release angling ranged from 0-40% and was dependent upon the relative abundance of predators present at the site of release. In addition, Danylchuk et al. (2007a) found that if bonefish were able to avoid predation for the first few minutes to hours following release, then delayed mortality (> 48 h) was minimal. Danylchuk et al. (2007c) also found that fish that loose equilibrium at the time of release are six time more likely to suffer post-release mortality in the first hour after release. Collectively, these results suggest that attributes of the angling event including the environment in which the angling is occurring can influence the susceptibility of bonefish to predation post-release.

Mangroves are common to the shorelines and cays of nearshore flats and they are frequently postulated to offer refuge from predation because of the structural complexity of their root systems (Kieckbusch et al., 2004). For instance, the prop roots of red mangroves (*Rhizophora mangle*) are commonly inhabited by a diverse community of marine and estuarine fauna, and it is often stated that they offer protection for newly settled, juvenile, and even adult fishes and invertebrates (Faunce and Serafy 2006). Bonefish frequent shallow, nearshore areas of flats that include mangroves, thus these areas, or those immediately adjacent to them, are often sough out by recreational anglers because of the abundance of bonefish and their ease of accessibility. As such, We hypothesized that bonefish might use mangroves as refuge from predators that co-inhabit flats, such as lemon sharks (*Negaprion brevirostris)* and great barracuda *(Sphyraena barracuda)*, following catch-and-release angling.

The purpose of our study was to determine whether the proximity to mangrove cover at the time of release is an attribute of the angling event that could influence the susceptibility of bonefish to predation. Give that mangroves offer structural complexity to tropical and subtropical tidal creeks, we predicted that bonefish released adjacent to mangrove prop roots would suffer less predation following catch-and-release than those released more distant from cover. We also predicted that if bonefish use mangroves for protection from predators, then bonefish should move towards mangroves regardless of the proximity to mangrove cover post-release.

METHODS

This study was conducted in shallow flats off Cape Eleuthera and Rock Sound, Eleuthera, The Bahamas (18 364035 E, 2747609 N; Fig. 1) and included some of the same study sites as Danylchuk et al. (2007a and 2007c). The shoreline in this area is composed of tidal creeks, sandy bays, mangroves, and sharp calcium carbonate outcroppings. The area contains many tidal creeks characterized by a mosaic of sandy beach and turtle grass beds (*Thalassia testudium*) surrounded by tracts of red mangroves.

Preliminary genetic analysis of the bonefish used in this study indicated that all specimens were *A. vulpes*; this is important since multiple, outwardly similar species of bonefish potentially occur in The Bahamas (Colburn et al., 2001). Other species of fish common to our study area were lemon sharks, great barracuda, and yellowfin mojarra (*Gerres cinereus)* (Danylchuk et al., unpublished data.).

Bonefish in our study were angled from a skiff or by wading using conventional fly fishing gear (7-9 wt rod and reel, barbed bonefish flies). Once bonefish were landed, a visual float was attached just below the posterior origin of their dorsal fin. Visual floats consisted of a fishing hook tied to 3-4 m of 4 lb test monofilament fishing line and attached to a 3 cm brightly colored, oval fishing bobber at the opposite end (Cooke and Philipp, 2004). At the time of release it was noted whether the location of release was near to (<10m) or far from (≥ 10m) mangrove cover and whether or not bonefish lost equilibrium. Loss of equilibrium was defined in this study as inability to swim away immediately upon release and rolling on the side or "nose diving" toward the substrate.

Once released, all fish were visually tracked (by foot or by boat) by following the brightly colored float for up to 1 hr, and their locations during this time period were noted on a map. Successful predation events were recorded, as well as the species and approximate size of the predator. Behaviors were recorded at 30 s intervals. Tracking ceased once a bonefish was followed for 1 hr, when a fish was attacked and killed by a predator, or when the visual float became detached from the fish or when sight of it was lost by the observer.

Multivariate survival analysis (Cox proportional hazard regression) was used to determine the effect of proximity to mangrove cover on mortality risk (see Castro-Santos and Haro, 2003). Comparisons of distances from mangroves were done using Mann Whitney U-test. All statistical analyses were performed using Systat v 10.2 and SAS v 9.1. Associations were considered statistically significant at $P \leq 0.05$.

RESULTS

Eighty-seven bonefish were caught, released, and tracked between March and August 2005. Fifteen bonefish (17%) were preyed upon post-release by lemon sharks (n=13) or great barracuda (n=2). No bonefish were preyed upon while on the line. In total, 80% of the predation events occurred more than 10 m from mangroves. Interestingly, however, bonefish released near cover (i.e. < 10 m away from mangroves) did not experience a lower risk of predation than those released away from cover (p=0.749; Figure 2). Likewise, bonefish that were preyed upon following release did not spend significantly more time further away from mangroves than fish that were not preyed upon (Mann-Whitney U-test, n_1=68, n_2=15, P=0.359). In fact, following release 17 (20%) of bonefish were observed swimming into open water (> 2.5 m deep) rather than staying in close proximity to the shoreline or in shallow water. In four cases, bonefish carcasses that were quickly recovered after a successful predation event revealed that lemon sharks tend to target bonefish posterior to the dorsal fin, often severing the caudal fin from the body prior to attempting to consume the rest of the fish. Conversely, great barracuda that preyed on bonefish post-release did so using rapid burst swimming, and in both cases ate the bonefish whole. Relative size differences between predators and prey (i.e., the barracuda were larger than most of the lemon

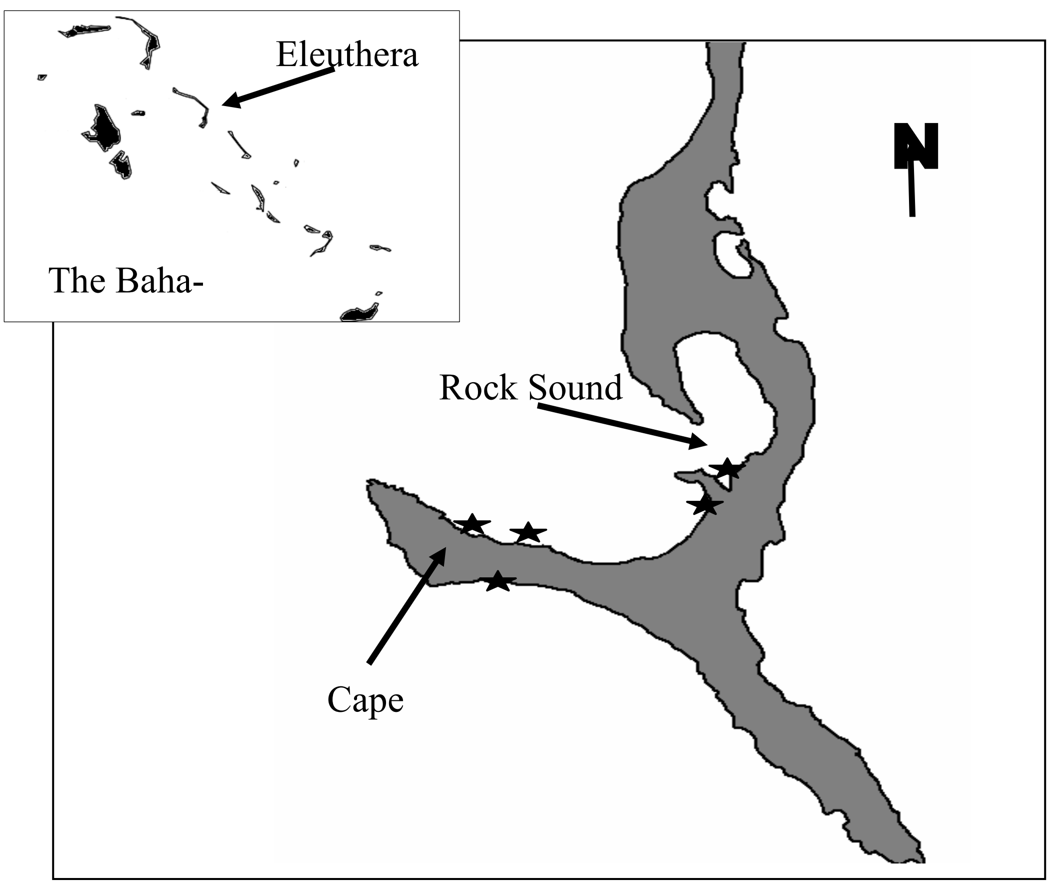

Figure 1. Map of Cape Eleuthera, Eleuthera, The Bahamas, with study sites indicated by black stars.

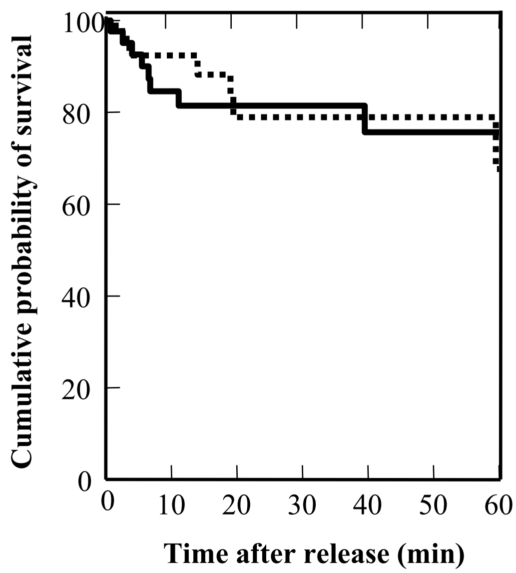

Figure 2. Cumulative survivorship curve for bonefish following catch-and-release angling. Solid line represents bonefish released < 10 m from mangroves while the dotted line represents bonefish released ³ 10m from mangroves.

sharks) could account for differences in predation strategies.

DISCUSSION

Although proximity to mangrove cover at the time of release did not influence the susceptibility of bonefish to predation, mangrove habitat associated with the flats environment may still be important to bonefish. Bonefish are often observed feeding in shallow flats and among the prop roots of red mangroves. Several studies on the diet of bonefish have shown that bonefish feed primarily on benthic invertebrates (crustaceans, mollusks) and occasionally small fishes, many of which are found in mangrove habitats (Colton and Alevizon 1983, Layman and Silliman 2002). Given that there is still very little known about the life history of bonefish, including larval settlement and the juvenile life stage, it is premature to discount mangroves as an essential habitat for bonefish (Danylchuk et al. 2007a).

Other properties of the flats habitat may offer refuge following catch-and-release angling. In our study, some bonefish post-release were observed swimming into deeper water, away from conspecifics and the structure of mangrove prop roots. Studies have shown that shallow flats and mangrove creeks are important nursery grounds for juvenile lemon sharks (Gruber et al., 1988) and that most juvenile lemon sharks are found within 200 m of mangroves (B. Franks, pers. comm.). Although the spatial ecology of bonefish is poorly understood, it is reasonable to postulate that bonefish move away from mangroves following catch-and-release angling, especially when physiologically taxed, as a way to reduce the risk of predation by juvenile lemon sharks that are present in such habitat.

A difference in predator species and/or the seasonal distribution of predators in varying locations likely also plays a role in bonefish habitat use. Humston et al. (2005) found that bonefish in the Florida Keys avoided deep channels and postulated that they did so to reduce the likelihood of encountering potential predators, namely large sharks and dolphins. Conversely, several recent studies in The Bahamas showed that even bonefish in shallow waters (i.e., <50 cm depth) are susceptible to predation, particularly following catch-and-release angling (Cooke and Philipp 2004, Danylchuk et al. 2007a).

Overall, our results indicate that although proximity to mangroves at release does not influence the susceptibility of bonefish to post-release predation, other factors in the angling process may play a role in the post-release survival of bonefish. The primary attraction of mangrove habitats for bonefish may not be protection from predators, but rather other factors (e.g. foraging). Further investigation into the interactions between bonefish and their predators could potentially allow for site or situation-specific guidelines to be developed that could reduce the likelihood of post-release mortality. Furthermore, finding ways to decrease the post-release mortality of bonefish may make catch-and-release bonefishing more compatible with the goals of no-take marine protected areas (Cooke et al., 2006) and lead to greater chances of ecological and economic sustainability in places like The Bahamas (Danylchuk et al. 2007b).

ACKKNOWLEDGEMENTS

We gratefully acknowledge the staff, students, and volunteers of the Cape Eleuthera Institute and The Island School who assisted with fieldwork. We also thank D.B.F. Philipp, R. Hansen, R. Williams, T. Danforth, F. Danforth, B. Hallig, L. Springs, N. Matting, S. Gardiner, B. Richards (Scientific Anglers), J. Huber (Silver Creek Adventures), J. Shulin (Temple Fork Outfitters), T.N. Davidson and R. Fisher (Bonefish and Tarpon Unlimited), M. Braynen and The Bahamas Department of Marine Resources, the Charles A. and Anne Morrow Lindbergh Foundation, the Baldwin Foundation, and particularly Chris Maxey of the Cape Eleuthera Foundation for their financial, logistical, and moral support. Travel support for S.J.C. was provided by the Izaak Walton Killam Fellowship from the University of British Columbia.

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