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Predator-free enclosures improve post-release survival of stocked common snook

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Abstract

Hatchery-reared fish may not be behaviorally competent in the wild, thus increasing mortality rates of fishes stocked into natural environments. The goal of this study was to determine whether in situ acclimation at release sites can increase survival of juvenile hatchery-reared common snook (*Centropomus undecimalis*), a catadromous fish, stocked into an estuary in Sarasota, Florida. Juvenile snook (76–251 mm fork length) were tagged with coded-wire tags and released in four locations distributed along a salinity gradient of North Creek estuary. Three replicate releases were performed at each location. Overall, 1935 snook were acclimated in enclosures for 3 d, then, released simultaneously with 1925 non-acclimated snook (non caged snook transported direct from the laboratory and stocked into the creek). For recaptures of snook at large for 3 d or more, mean recapture rates of experimental release groups were significantly different (multiway ANOVA testing recapture rates by acclimation treatment, release site, and interactions, $P=0.001$). Specifically, mean recapture rates of acclimated groups were 1.92 higher than those for non-acclimated groups ($P=0.002$); hatchery snook recaptured from two of the four release sites represented 70% of total recaptures ($P=0.001$); interactions between acclimation treatment and release site were not significant ($P=0.71$). Site fidelity was approximately 60% regardless of acclimation condition, and did not significantly influence recapture rates. Thus, in situ acclimation has potential to significantly improve both post-release survival and information gained in stocking programs.

Keywords: Acclimation; *Centropomus undecimalis*; Dispersal; Stock enhancement; Snook; Survival

1. Introduction

Common snook *Centropomus undecimalis* (Bloch) (herein referred to as "snook") are a tropical to subtropical estuarine species of the western Atlantic. In Florida, snook is a highly valued marine sport fish (Muller and Taylor, 2002) and although Florida's snook populations once supported a commercial fishery, it was closed in 1957 to prevent over harvest. Continued high recreational popularity and harvest has maintained concern among resource managers (Muller and Taylor, 2002). Widespread habitat loss (Bruger and Haddad, 1986), cataclysmic events such as winter freezes (Story and Gruder, 1936; Marshall, 1958), and fish kills from red tide blooms also threaten snook populations in Florida. These factors have led fishery managers to investigate the feasibility of snook stock enhancement in Florida.

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Although historical evidence supporting successful marine enhancement is sparse, recent studies indicate that stocked fishes survive and contribute to fisheries landings (Svåsand et al., 1990; Kitada et al., 1992; Leber and Arce, 1996; Leber et al., 1996; Kaeriyama, 1999; Friedlander and Ziemann, 2003; Bartley and Leber, 2005). Development of optimal release strategies is an important focus of stock enhancement research and can significantly increase post-release survival (Munroe and Bell, 1997; Yamashita and Yamada, 1999; Mahnken et al., 2004; Kuwada et al., 2004). Specific stocking strategies include determining optimal size-at-release (Tsukamoto et al., 1989; Yamashita et al., 1994; Leber, 1995), release season, and size–season interactions (Leber et al., 1997, 1998; Sanchez-Lamadrid, 2002; Gwak et al., 2003), and release habitat (Solazzi et al., 1991; Leber and Arce, 1996; Russell et al., 2004; Davis et al., 2005; Andersen et al., 2005). In this study we investigate the influence of in situ conditioning in predator-free enclosures on post-release survival.

Successful foraging and predator avoidance are essential behaviors for juvenile fish survival (Werner et al., 1983; Gilliam and Fraser, 1987; Walters and Juanes, 1993). Fish reared in "psychosensory-deprived" hatchery environments however, have demonstrated significant deficits in their abilities to avoid predation (Olla and Davis, 1989; Brown and Smith, 1998; Olla et al., 1998; Berejikian et al., 1999) and in foraging skills (Hossain et al., 2002) that minimize mortality yet maximize prey intake (as in minimizing μ/g, Werner and Gilliam, 1984). Hatchery selection can also influence behavioral performance, and in laboratory trials Berejikian (1995) found F1 generations of wild steelhead trout fry were more successful at avoiding predation than progeny from hatchery broodstock. Nonetheless, many of these behaviors are learned, and laboratory studies of hatchery juveniles exposed to appropriate stimuli have shown improvements in their performance (Chivers and Smith, 1994; Brown and Smith, 1998; Kellison et al., 2000; Hossain et al., 2002).

Whereas actions in the hatchery can address improvements in behavioral deficiencies (e.g. Schlechte et al., 2005), it is logistically difficult to address these in aquaculture tanks. Conditioning fish in predator-free enclosures in situ may accomplish many of the same goals: physiological acclimation to the surrounding environment, begin learning to feed in the wild, expose fish to predation threat (outside of acclimation cages), yet provide a predator-free environment for these adjustments. Possibly the most important benefit is that in situ acclimation enclosures afford stocked fish an opportunity to recover from transport stress unthreatened by predation. Isolating the relative effects of these potential benefits is problematic, but identifying their collective effects on post-release survival is possible.

Strong evidence documenting actual improvements in post-release survival afforded by acclimation is lacking. Cresswell and Williams (1983) found higher percentages of acclimated brown trout *Salmo trutta* groups compared with non-acclimated groups, but non-acclimated groups also had higher dispersal rates from release sites. In a separate study (Jonssonn et al., 1999), recapture rates of acclimated brown trout were significantly higher than recapture rates of non-acclimated trout two months after release. However, a disproportionate amount of non-acclimated trout migrated away from release sites, and possibly influenced survival estimates. In Japan, whereas survival was not addressed, Kuwada et al. (2004) found higher rates of short-term retention of acclimated striped jacks (*Pseudocaranx dentex*) at release sites than non-acclimated fish, and acclimation is now a routine procedure in striped jack marine ranching activities in Japan. Isolating differences in site fidelity of acclimated and non-acclimated stocked fish is an important step toward understanding post-release survival.

As many species develop strong fidelity responses to their natal origin (e.g. Thorrold et al., 2001), the potential for structuring site fidelity in released organisms has important ramifications on meta-population characteristics. Tag-recapture studies with snook have shown evidence of strong site fidelity in adolescents and adults (Volpe, 1959). Preliminary evidence with juvenile snook releases has also indicated strong site fidelity, (even 1-year after stocking, N. Brennan, unpublished data). In our studies, recapture rates of hatchery-reared individuals (randomly selected from source tanks, tagged, and stocked in specific habitats) at release sites, were significantly higher than recapture rates from neighboring sites (N. Brennan, unpublished data). In the current study, acclimation in enclosures may have strong influences on an individual's short- and long-term fidelity behavior, and understanding relative differences in fidelity of acclimated and non-acclimated groups is important for understanding sub-population characteristics and relative survival rates.

In this paper we evaluate the effects of in situ acclimation on short- and long-term survival of hatchery-reared juvenile snook. We also evaluate acclimation effects on site fidelity. Two null hypotheses were specifically tested: (1) survival of snook conditioned in in situ acclimation enclosures would not differ from snook released directly after transport from the hatchery, and (2) dispersal rates and patterns of acclimated and non-acclimated snook would not differ.