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White perch *Morone americana* (Gmelin, 1789) habitat choice and movements: Comparisons between *Phragmites*-invaded and *Spartina* reference marsh creeks based on acoustic telemetry

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ABSTRACT

An investigation of the effects of the *Phragmites* invasion on movements and habitat use focused on ultrasonic telemetry of white perch (*Morone americana*) throughout Alloway Creek, Delaware Bay, New Jersey. Of the individuals tracked (192–266 mm FL), there was high site fidelity (19 out of 30 individuals) but there was also variability in movement patterns, home range size, and habitat use. On average, individual fish spent most of their time stationary (67%), and substantially less time moving (22%) and tended to move up creek with flooding tides, and down creek with ebbing tides. Higher movement levels occurred at mid-ebb and mid-flood stages when water velocity was at its highest. Eighteen individuals had tidal excursions — either long distance movements with the tide or excursions onto the marsh surface or into shallow creeks at high tide. Individuals originally tagged in *Spartina* creeks tended to utilize only *Spartina* areas (12/13 tagged fish stayed in *Spartina*), whereas none of the individuals tagged in *Phragmites* creeks stayed in *Phragmites* areas (0 out of 5 tagged fish). These results suggest that the tagged individuals did not prefer *Phragmites* habitats. Further, this study indicates that it is important to consider animal behavior such as movement patterns, home range area and habitat use when evaluating the effectiveness of restoration programs. Such measures can provide insight into why altered habitats differ from reference sites in terms of quality, identify critical resources for animals and enhance our understanding of how animals contribute to ecosystem function.

1. Introduction

Over the past several decades, marshes formerly dominated by *Spartina* spp. (hereafter *Spartina*) have been invaded by the common reed, *Phragmites australis* (Cav.) Trin. ex Steud (hereafter *Phragmites*), throughout the northeastern United States (Chambers et al., 1999; Havens et al., 1997; Meyerson et al., 2000; Windham and Lathrop, 1999) and including Delaware Bay (Weinstein and Balletto, 1999). The *Phragmites* invasion has resulted in considerable interest in its effects on the ecological functions of marsh habitat. Studies have suggested that the clearest impacts of *Phragmites* occur on the marsh surface (Weinstein and Balletto, 1999; Windham and Lathrop, 1999). The hydrological and physical changes that accompany the conversion of a *Spartina*-dominated marsh to a *Phragmites*-dominated marsh have deleterious effects on the presence of early life stages of mummichog *Fundulus heteroclitus* (Linnaeus, 1766) (Able and Hagan, 2000, 2003; Able et al., 2003, 2008; Hunter et al., 2006; Raichel et al., 2003) and other small prey fishes (e.g. Able and Fahay, 1998; Able et al., 2004; Grothues and Able, 2003a,b; Nemerson and Able, 2004). Few studies have investigated the impact of the *Phragmites* invasion on higher trophic levels, such as piscivorous fishes that utilize the intertidal and subtidal marsh creeks except our own (Nemerson and Able, 2004; Neuman et al., 2004).

Our prior studies have determined that if there are impacts on marsh surface assemblages that are going to be detected in higher trophic levels, white perch would be the best focal species for investigation. This is due to three main reasons: 1) this species is the numerically dominant piscivorous predator in oligohaline marshes of Delaware Bay (Able et al., 2001, 2007, 2009; Jones and Able, in review), 2) they are considered marsh residents for much of the year (Mansueti, 1961) and appear to have a limited home range during certain times of the year (McGrath and Austin, 2009), and 3) fundulids figure more prominently in their diets compared with other predators in marshes (Nemerson and Able, 2004). Our primary objective was to evaluate

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the response of white perch to marsh restoration by investigating differences in home range and movement patterns in habitats that are *Phragmites*-dominated, *Spartina*-dominated, and approximately equal in densities of *Spartina* and *Phragmites* (mixed) by comparing: 1) movement patterns, 2) site fidelity, and 3) home range size. Incorporating measures of animal behavior such as home range and activity patterns into evaluations of restoration success provides critical information about why reference and restoration sites may differ in habitat quality (e.g. Lindell, 2008; Persson and Stenberg, 2006), identifies critical resources for animals, and documents how animals contribute to ecosystem function (Lindell, 2008).

2. Materials and methods

2.1. Study sites

Delaware Bay, one of the largest estuaries on the east coast of the United States is the site of one of the world's largest (5040 ha) tidal marsh restoration projects (Weinstein et al., 2001). It has been designed and implemented by the Estuary Enhancement Program (EEP) of the Public Service Enterprise Group (PSEG) to increase fish production to mitigate the loss of nekton to once-through cooling at the Salem Generating Station in Delaware Bay (Balletto et al., 2005; Weinstein et al., 2001). In the lower salinity portions of the upper Delaware Bay, the restoration focus was on the eradication of the common invasive reed, *P. australis*. Eradication treatments using Rodeo and a surfactant followed by prescribed burning occurred from 1996 throughout the duration of this project, as part of the Public Service Enterprise Group—Estuary Enhancement Program (PSEG—EEP).

This study occurred at Alloway Creek (N 39° 29′ W 75° 31′; Fig. 1), and is described in detail elsewhere (Able et al., 2001) including initial observations of the response to restoration of former *Phragmites* dominated habitats (Jones and Able, in review). All white perch tagged in this study were captured in intertidal or subtidal creeks adjacent to marshes dominated by three types of habitats: 1) monoculture stands of *P. australis* (*Phragmites* sites), 2) monoculture stands of *Spartina* spp. (*Spartina* sites), or 3) a combination of mixed vegetation, i.e. creeks that had different vegetations on either side of the creek, or had heterogeneous patches of *Phragmites*, *Spartina*, and/or marsh treated for *Phragmites* control.

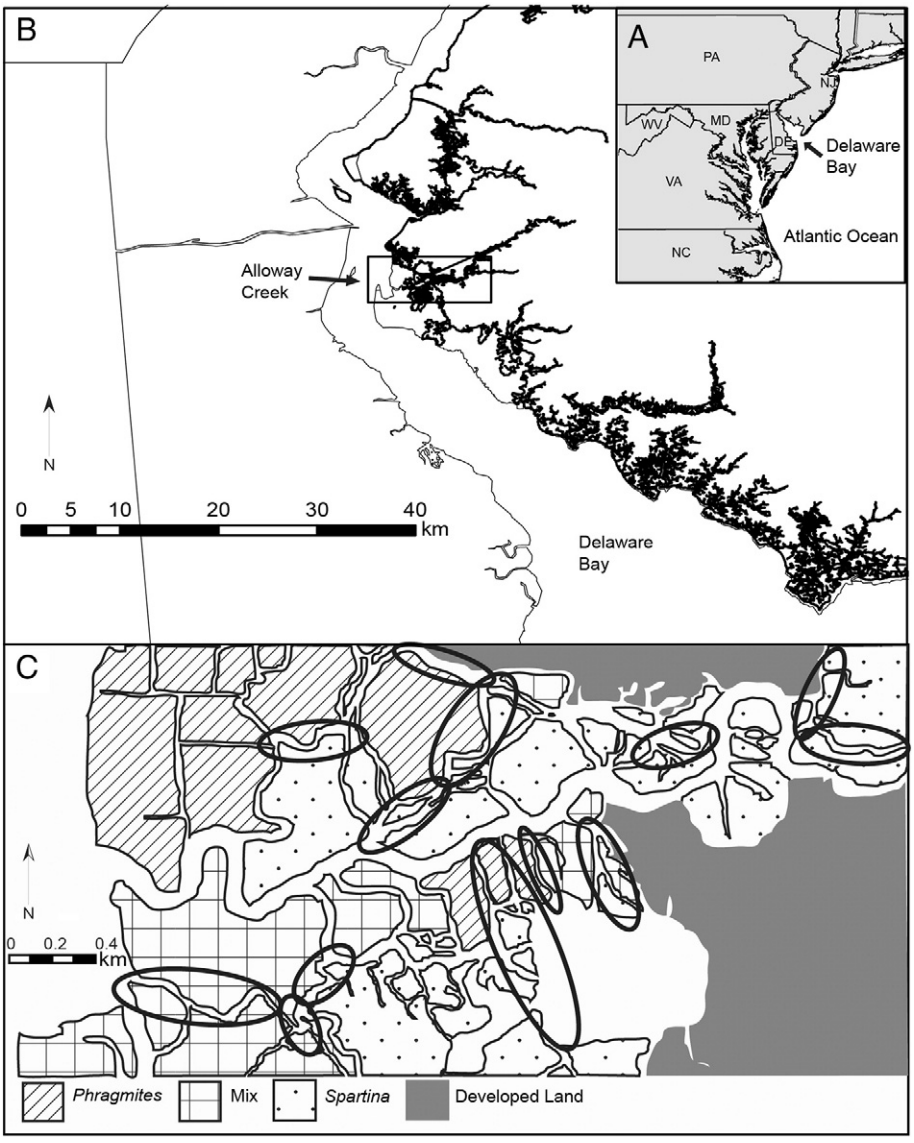

Fig. 1. Delaware Bay study area: A) location of Delaware Bay and B) location of Alloway Creek. C) Marsh vegetation designations within the Alloway Creek system. Locations of fish tracking areas are depicted by ellipses in each habitat type.