Effects of *Phragmites australis* on the early life history stages of *Fundulus heteroclitus* at Iona Island Marsh, Hudson River, New York

A Final Report of the Tibor T. Polgar Fellowship Program

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ABSTRACT

Phragmites australis is an invasive wetland plant impacting tidal marshes in the U.S. Physical changes (increased elevation, reduced microtopography) are accentuated in older *P. australis* stands, possibly reducing resident nekton reproduction during advanced stages of expansion. Hydrogeomorphology of different-aged *P. australis* stands and early life history stages of *F. heteroclitus* were quantified at Iona Island Marsh on the Hudson River. Triplicate treatments (large, medium, small *P. australis,* and *Typha angustifolia* (narrow-leaf cattail) patches) of varying age were sampled for *F. heteroclitus* twice monthly from June to August 2002. Patch area, distance from creek, number of rivulets, and length of aquatic edge were measured along with flooding (depth, duration, and frequency) fore each vegetation type. Mean flooding depth was higher in *T. angustifolia* relative to all *P. australis* patches. Mean flooding duration was greater in the small *P. australis* patches relative to all other treatments except large *P. australis* patches. Mean larval *F. heteroclitus* abundance in *T. angustifolia* was significantly higher compared to the large *P. australis* treatment for August. Larval fish abundance was not different between *T. angustifolia* and the remaining *P. australis* treatments, supporting the hypothesis that only larger patches experienced reduced spawning success. Larval fish abundance was associated with higher flooding depth suggesting hydrology was the primary determinant of larval fish survival. Large numbers of larval and juvenile fish was found in creek pools on low tide. Because larval *F. heteroclitus* are not normally associated with creeks, later stages of *P. australis* invasion may force nekton off the marsh surface. This may be possible in oligohaline marshes where submerged aquatic vegetation (SAV) can serve as refuge from predators on high tide.

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INTRODUCTION

Tidal wetlands are intricate components of the coastal landscape and carry out many important functions from controlling floodwaters to providing nursery and feeding habitat for wildlife (Mitsch and Gosselink 2000). All wetlands can be defined in terms of hydrology, physiochemical environment, and vegetation (Mitsch and Gosselink 2000). Often times these characteristics are in balance so that the wetland functions appropriately. In some cases, however, disturbances can negatively affect that balance and impact wetland function.

Phragmites australis (common reed) is a clonal wetland plant, which can be found throughout the world and has been a part of wetland ecosystems in the United States for thousands of years (Orson 1999). Formally a stable component of wetlands, *P. australis* has taken on invasive qualities and is more widespread in today's wetlands (Chambers et al. 1999). A recent study concludes that the expansion stems, in part, from the introduction of a non-native genetic strain (European) of *P. australis* sometime during the last 200 years (Saltonstall 2002). Expansion by *P. australis* out competes other plants including rare or endangered species (Windham and Lathrop 1999), which in turn affects the use of the wetland by many mammal and bird species (Chambers et al. 1999). Physical changes to the marsh surface have also been documented in *P. australis*-dominated wetlands (Windham and Lathrop 1999).

After the first plant or plants are established in an area, *P. australis* spreads by vegetative growth (Tiner 1998). Its rapid growth and competitive edge allows *P. australis* to form monotypic stands (Marks et al. 1994). High production by *P. australis* also leads to accumulation of litter on the marsh surface. This accumulation contributes to an increase in elevation, flattened surface topography, and reduced flooding (Windham and Lathrop 1999).

Tidal wetland functions are primarily controlled by hydrology (Mitsch and Gosselink 2000). One function inseparable from hydrology in tidal wetlands is access to the marsh surface by resident nekton species including *Fundulus heteroclitus* (common mummichog) and *Paleomonetes pugio* (daggerblade grass shrimp). Resident nekton are defined as those fish and swimming invertebrates that occupy the marsh surface or nearby tidal creeks during most or all of their life cycle (Knieb 1984). Nekton use the marsh for feeding, egg deposition, and nursery habitat (Mitsch and Gosselink 2000). Hatching of *F. heteroclitus* is triggered by tidal synchrony, i.e. regular periodicity between spring tides (Taylor et al. 1977, Taylor et al. 1979) and larvae and small juveniles of resident nekton specifically require microtopographic depressions (small pools) on the marsh surface for low tide refuge (Kneib 1984).

Previous studies have shown that when *P. australis* marshes are adequately flooded, adult nekton utilize the marsh surface (Fell et al. 1998, Hanson et al. 2002, Able and Hagan 2000, Warren et al. 2001, Osgood et al. 2003) and in the case of *F. heteroclitus* will deposit eggs (Raichel et al. 2002). There is growing evidence, however, that larval and juvenile *F. heteroclitus* have lower abundance and density in *P. australis*-dominated marshes relative to other vegetation types (Able and Hagan 2000, Able et al. 2003, Fell et al. 2003, Meyer et al. 2001, Osgood et al. 2003). The lack of smaller size classes has been attributed to lack of microtopography on the marsh surface (Able and Hagan 2000, Able et al. 2003) and altered flooding patterns (Osgood et al. 2003) in *P. australis* marshes.

Hydrogeomorphic changes attributed to *P. australis* are more evident in larger, well established stands of *P. australis* than in smaller stands of *P. australis* (Windham and Lathrop 1999, Rooth and Stevenson 2000). Different marshes exhibit different stages of *P. australis* expansion. In marshes with higher salt and sulfur concentrations *P. australis* stands tend to occur in small, isolated patches and can occur preferentially along creek banks and upland fringes (Warren et al. 2001), while in low salinity marshes such as at Iona Island, expansion can result in contiguous large areas of *P. australis* (Chambers et al. 2002). We proposed that hydrogeomorphic differences cause variation in spawning success (the abundance of smaller size classes of resident nekton) among *P. australis* stands. Further, these differences should vary predictably with the stage of *P. australis* expansion.

Objective

The purpose of this study was to determine the relationship between the distribution of size classes of *F. heteroclitus* and the hydrogeomorphology of *P. australis* stands.

Hypothesis

Larger, more established *P. australis* stands will have a lower abundance of larval and juvenile *F. heteroclitus* on the marsh surface relative to other *P. australis* stands and *T. angustifolia*. Low larval abundance will be credited to a reduced amount of flooding resulting from higher marsh elevations.

MATERIALS AND METHODS

Site Description and Study Design

This study was carried out at Iona Island Marsh, a component of the Hudson River National Estuarine Research Reserve (Figure 1). This intertidal marsh is located on the western shore of the Hudson River and covers an area of 225 ha. Iona Island Marsh is an oligohaline marsh, comprised of *P. australis* (~70%) and *Typha angustifolia* (cattail) (~30%). Other emergent plants are located in the marsh but they are a small part of the community. Within the past 45 years *P. australis* has been expanding its populations in Iona Island Marsh (Winogrond and Kiviat 1997) and at present older and younger stands coexist.

Nekton abundance was documented within each of four marsh surface treatments, small, medium, and large *P. australis*, and *T. angustifolia* stands. The *T. angustifolia* served as a reference as it predates the *P. australis* stands. The four treatments were differentiated into triplicate patches for a total of twelve sampling locations (Figure 1). There were two requirements for each patch belonging to a single size treatment. They had to be completely covered with the designated vegetation, and they needed to have equivalent elevations (as determined through standard topographic surveying techniques).

Biotic Sampling

Marsh Surface Sampling

Nekton were sampled every two weeks, during consecutive spring tides from June 12 to August 22, totaling eight individual tidal events per treatment (Table 1). Fish were collected with eight pit traps in each patch totaling 24 per treatment. Two pit traps each

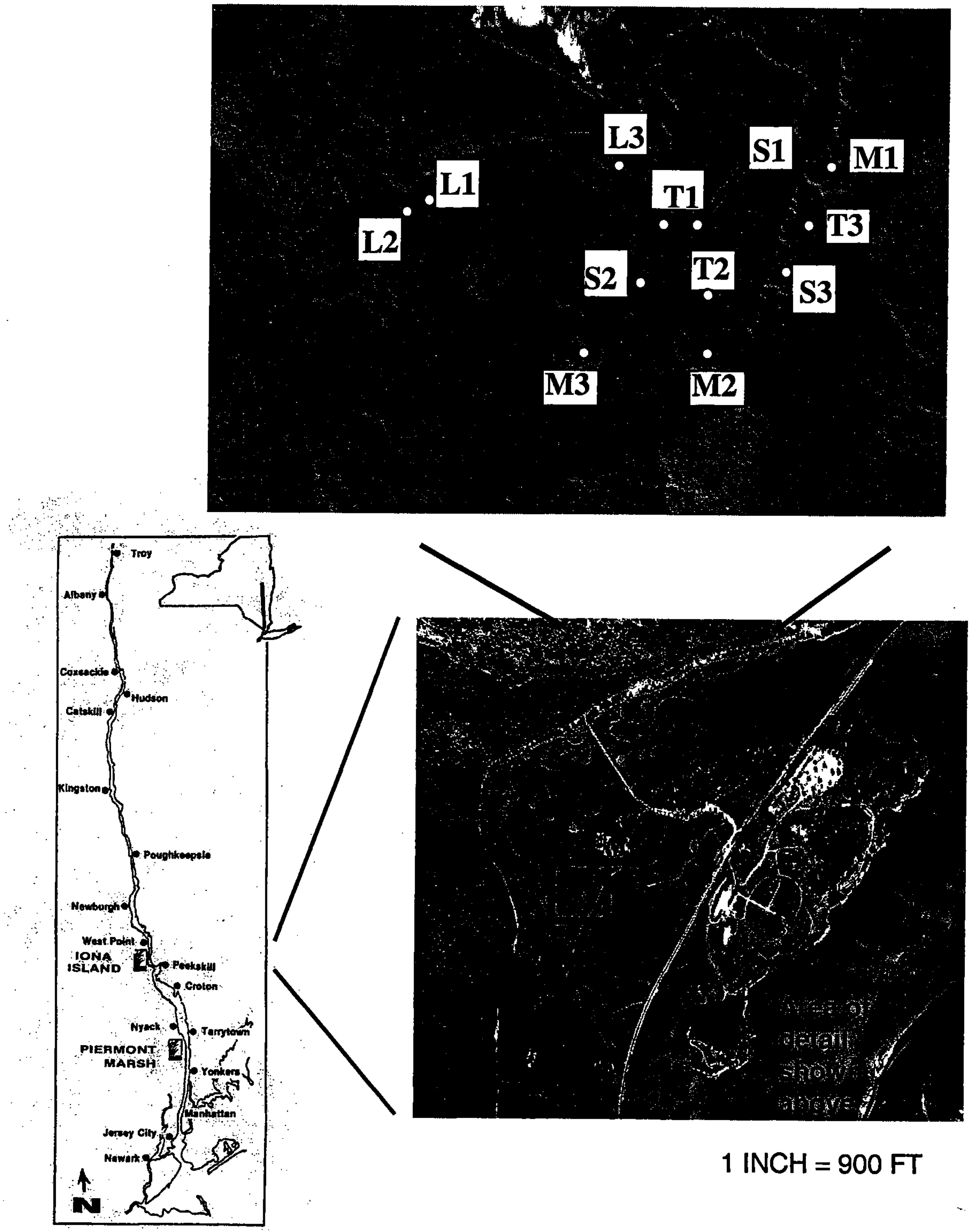

Figure 1. Site Figure of Iona Island, Hudson River, NY. Detailed inset shows location of *Typha angustifolia* (T1-T3), large (L1-L3), medium (M1-M3), and small (S1-S3) *Phragmites australis* sampling sites.