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ANNUAL REPORT ON THE NEKTON SURVEYS FOR THE PAUL S. SARBANES ECOSYSTEM RESTORATION PROJECT AT POPLAR ISLAND

SUBMITTED TO THE
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AND THE
POPLAR ISLAND WORK GROUP

BY

DAVE MEYER

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE
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TABLE OF CONTENTS

EXECUTIVE SUMMARY ii

LIST OF TABLES v

LIST OF FIGURES viii

INTRODUCTION 1

MATERIALS AND METHODS 5

Wetlands Use By Fisheries 5

Fyke Net Collection 5

Marsh Creek Gill Net Collection 8

Environmental Parameters and Sample Disposition 9

Data Analysis 10

RESULTS 10

Wetlands Use By Fisheries 11

Fyke Net Collection 11

Fyke Net Catch Size Class Frequency Distributions 43

Marsh Creek Gill Net Collection 61

Environmental Parameters 64

DISCUSSION 69

CONCLUSIONS 80

HYPOTHESES CONCLUSIONS 85

LITERATURE CITED 91

EXECUTIVE SUMMARY

The Paul S. Sarbanes Ecosystem Restoration Project at Poplar Island (Poplar Island), formerly known as the Poplar Island Environmental Restoration Project (PIERP), located in Talbot County, Maryland, in mid Chesapeake Bay, is a collaborative effort between federal and state agencies. The U.S. Army Corps of Engineers, Baltimore District and the Maryland Department of Transportation Maryland Port Administration are the project sponsors of Poplar Island. This island restoration was planned to re-establish Poplar Island, which as of 1996 had eroded to a few acres due to hydrodynamic influences. Ultimately, the site will be approximately 1,715 acres in size and will provide 68 million cubic yards (mcy) of dredged material placement capacity. The Poplar Island restoration is planned to provide approximately 776 acres of wetland, 829 acres of upland, and 110 acres of open-water embayment habitat. Additional benefits provided by the construction of Poplar Island beyond dredged material placement are habitat restoration for fisheries and wildlife, and the reduction in wave energies within Poplar Harbor, which could ultimately benefit submerged aquatic vegetation colonization and fisheries utilization.

Surveys examining the effect of the Poplar Island restoration on fish, shrimp, and crab (nekton) habitat use were conducted before perimeter dike construction of Poplar Island (1995-1996), after perimeter dike construction (2001-2003), and after the construction of restored wetland salt marsh habitat cells (2004-2014, 2016). Monitoring efforts have been accomplished to examine the effect of the Poplar Island restoration on nekton use of the restored habitats, as well as habitats adjacent to Poplar Island. The objectives of the surveys associated with this portion of the project were to provide a measure of habitat function prior to the restoration of Poplar Island, and after major milestones in the construction plan. Additionally, control sites (reference areas) of each habitat type examined within the immediate vicinity of Poplar Island were similarly sampled. Reference habitat sites were also sampled to examine natural changes in use patterns by the nekton community within the geographic area over time.

During 2016, significant increases in nekton species accumulation were observed during the spring where more species were observed within Cells 1A, 1C, 1B, and 3A compared to the baseline remnant marshes. However, the number of nekton species observed within Cell 1B during spring, Cells 1A, 1C, 1B, and 3A during summer, and Cells 1B and 3A during fall 2016 were significantly lower than observed within the reference marshes.

Cell 1A, 1C, 1B, and 3A marshes in general supported higher (often significantly) abundances of nekton species than the baseline remnant marshes. During 2016, after seven years of maturation for Cell 1A, and since 2014, after two years of maturation for Cell 1B, both marshes had significantly higher abundances of all four target forage marsh nekton species *Cyprinodon variegatus* (sheepshead minnow), *Fundulus heteroclitus* (mummichog), *Fundulus majalis* (striped killifish), and *Palaemonetes pugio* (grass shrimp) compared to the remnant marshes during the 1995-96 pre-construction baseline. Further, during 2016, after five years of maturation for Cell 1C, and one year of marsh maturation for Cell 3A, both marshes had significantly higher abundances of sheepshead minnow, mummichog, and grass shrimp, compared to the remnant marshes during the 1995-96 pre-construction baseline.

Within the first one to three years of marsh maturation for Poplar Island cell marshes surveyed during 2016, abundances for mummichog and grass shrimp were equivalent to, or significantly exceeded those of the mainland reference marshes. However, abundances for striped killifish and sheepshead minnow within Poplar Island marshes continued to be significantly lower compared to reference marshes. While this suggests that the conditions for the establishment of a stable population for striped killifish within Poplar Island wetland cells have yet to be produced, abundances of sheepshead minnow within Poplar Island marshes, contrary to past nekton surveys, demonstrated significant abundance increases within the marshes of Cells 1A, 1C, and 1B during 2016 compared to previous years. Population establishment of sheepshead minnow may have succeeded within these wetland cells. Data from future surveys will help confirm this conclusion.

Comparative size class data from summer 2016 fyke net collections demonstrate mummichog year-one-and-older (Y1+) size classes contributed a larger portion to populations within the reference compared to Cell 1A, 1C, and 3A marshes, while sheepshead minnow and striped killifish Y1+ size classes contributed larger proportions to the populations of reference compared to Cell 1A, 1B, and 1C marshes. However, the relative abundance of Y1+ sized mummichog individuals within Cell 1B was similar to reference marshes, while Cell 1A marshes contained a substantial proportion of Y1+ individuals. During summer 2016, relative abundance of Y1+ sized mummichog individuals within Cell 1B was greater than during summer 2014, while Cell 1A marsh contained a similar, substantial proportion of Y1+ individuals during summer 2016 as also noted during summer 2014. The consistency of a substantial proportion of the Cell 1A mummichog population being comprised of Y1+ individuals based on summer 2014 and 2016 data suggests that the Cell 1A marsh might have developed a sufficient forage base to support a larger proportion of mummichog Y1+ size classes. While Cell 1B is of younger age than Cell 1A, the support of the Y1+ mummichog size classes within Cell 1B might be influenced by the intra-cell connection with Cell 1A, which allows free exchange of intra-cell water for active dispersal of resident marsh fishes, including mummichog, sheepshead minnow, and striped killifish, and planktonic and active dispersal of the resident marsh fish forage base. The occurrence of substantial populations of sheepshead minnow within Cell 1A and 1B marshes further suggests marshes have matured to accommodate this marsh resident, and the importance of the intra-cell connections for dispersion.

Gill net collections from Cell 1A marsh creeks have shown declines in total fish, non-nektonivorous fish, and nektonivorous fish abundances after 2010 that indicate marsh creek fish populations have trended to a lower, more stable equilibrium level, which during 2011, was significantly lower than that within the reference marsh creeks. The subsequent reduction from initial higher marsh creek fish abundances within Cell 1A was also apparent within Cell 3D after an initial colonization pulse that eventually reached a lower stable equilibrium.

No significant differences for total fish, non-nektonivorous fish, or nektonivorous fish abundances within Poplar Island Cell 1A, 1B, 1C, and 3A marsh creeks versus reference marsh creeks were observed during 2016. However, consistent significantly lower abundances of individual nektonivorous fish species were evident within Poplar Island versus reference marsh creeks during 2016; of particular interest were striped bass, within all Poplar Island cells versus reference marsh creeks, and white perch within Cell 1A, 1B, and 1C marsh creeks compared to reference marsh creeks. These along with the consistent patterns of higher nektonivorous, non-nektonivorous, and total fish abundance within the reference versus the restored Poplar Island marsh creeks suggests that restored wetland marsh creeks are supporting lower levels of bait and predator fish use than the reference marsh creeks.

The time frame for assessment of the maturation process for Poplar Island restored marshes related to nekton community might require a time frame longer than the seven year period used within the Cell 1A marsh; a decadal time frame should be considered a more realistic criterion for restored marshes to produce ecological functions related to their ultimate climax stage. The trophic transfer potential from the forage nekton to high order predators within Poplar Island restored wetland habitats appears yet to be fully realized. Inlet and marsh water body morphology within Poplar Island might need to be evaluated regarding its effect upon predator utilization.

LIST OF TABLES

Table Page

1 Table 1. Comparisons among marsh area types for mean number of nekton species collected via fyke nets by time period. Marsh area types are Poplar Island remnant marshes (PR), reference area marshes (RA), and Poplar Island restored marshes in Cell 1A (1A), Cell 1B (1B), Cell 1C (1C), and Cell 3A (3A). Comparisons between area types that are significantly different from one another ($p \leq 0.05$) are indicated by an asterisk....................12

2 Table 2. Comparisons for 2010-2014, 2016 Cell 1A (1A), 2013, 2014, 2016 Cell 1B (1B), 2012-2014, 2016 Cell 1C (1C), and 2016 Cell 3A (3A) collections versus Poplar Island remnant marsh (PR) from the 1995, 1996 collections, for mean number of nekton species collected via fyke nets. Comparisons between area types that are significantly different from one another ($p \leq 0.05$) are indicated by an asterisk....................14

3 Table 3. Interannual comparisons for mean number of nekton species collected via fyke nets during 2010-2014, 2016 for reference area (RA) and Cell 1A (1A) marsh collections, 2012-2014, 2016 for Cell 1C (1C), and 2013, 2014, 2016 for Cell 1B (1B) marsh collections. Comparisons between years for each area type that are significantly different from one another ($p \leq 0.05$) are indicated by a different letter....................15

4 Table 4. Interannual comparison of the mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collected in fyke nets at reference marshes. For each species, collection period date comparisons that significantly differ ($p \leq 0.05$) from one another are designated by a different letter....................18

5 Table 5. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collection at the Poplar Island restored Cell 1A marsh based on seral stage for spring, summer, and fall collection periods. A different letter within specified seasons indicates significantly different ($p \leq 0.05$) abundances among seral stages (years) for that species....................21

6 Table 6. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collection at the Poplar Island restored Cell 1C marsh based on seral stage for spring, summer, and fall collection periods. A different letter within specified seasons indicates significantly different ($p \leq 0.05$) abundances among seral stages (years) for that species....................23

7 Table 7. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collection at the Poplar Island restored Cell 1B marsh based on seral stage for spring, summer, and fall collection periods. A different letter within specified seasons indicates significantly different ($p \leq 0.05$) abundances among seral stages (years) for that species..........................24

8 Table 8. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collected in fyke nets within reference area marshes (RA) and Poplar Island restored Cell 1A (1A) marsh. * Indicates significantly different ($p \leq 0.05$) abundances between areas during that collection period for that species..........................27

9 Table 9. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collected in fyke nets within reference area marshes (RA) and Poplar Island restored Cell 1C (1C) marsh for spring, summer, and fall collection periods. * Indicates significantly different ($p \leq 0.05$) abundances between areas during that collection period for that species................30

10 Table 10. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collected in fyke nets within reference area marshes (RA) and Poplar Island restored Cell 1B (1B) marsh for spring, summer, and fall collection periods. * Indicates significantly different ($p \leq 0.05$) abundances between areas during that collection period for that species..........................32

11 Table 11. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collected in fyke nets within reference area marshes (RA) and Poplar Island restored Cell 3A (3A) marsh for spring, summer, and fall collection periods. * Indicates significantly different ($p \leq 0.05$) abundances between areas during that collection period for that species..........................34

12 Table 12. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collected in fyke nets within Poplar Island remnant marshes (PR) compared to Poplar Island restored Cell 1A (1A) marsh for spring, summer, and fall collection periods. * Indicates significantly different ($p \leq 0.05$) abundances between treatments for that species......................35

13 Table 13. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collected in fyke nets within Poplar Island remnant marshes (PR) compared to Poplar Island restored Cell 1C (1C) marsh for spring, summer, and fall collection periods. * Indicates significantly different ($p \leq 0.05$) abundances between treatments for that species......................38

14 Table 14. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collected in fyke nets within Poplar Island remnant marshes (PR) compared to Poplar Island restored Cell 1B (1B) marsh for spring, summer, and fall collection periods. * Indicates significantly different ($p \leq 0.05$) abundances between treatments for that species....41

15 Table 15. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collected in fyke nets within Poplar Island remnant marshes (PR) compared to Poplar Island restored Cell 3A (3A) marsh for spring, summer, and fall collection periods. * Indicates significantly different ($p \leq 0.05$) abundances between treatments for that species....42

16 Table 16. Mean number of individuals, per 12 hour gill net set within reference marsh creeks (Ref), and Poplar Island Cell 1A (1A) marsh creeks. For each species during each collection date, comparisons for area types between collection years that differ significantly from one another ($p \leq 0.05$) are indicated by a different letter....63

17 Table 17. Mean number of individuals, per 12 hour gill net set within reference marsh creeks (Ref), and within Poplar Island Cell 1A (1A), Cell 1B (1B), Cell 1C (1C), and Cell 3A (3A) marsh creeks. For each species during each collection date, comparisons between area types that are significantly different from one another ($p \leq 0.05$) are indicated by an asterisk....66

18 Table 18. Interannual mean salinity (parts per thousand) comparisons for each fyke and gill net collection time period (spring, summer, and fall) by sample area. (—) indicates no collections were taken at that location type during that time period. Interannual differences that are significantly different ($p \leq 0.05$) per collection type, are indicated by a different letter....67

19 Table 19. Interannual mean water temperature (°C) comparisons of each fyke and gill net collection time period (spring, summer, and fall) by sample area. (—) indicates no collections were taken at that location type during that time period. Interannual differences that are significantly different ($p \leq 0.05$) per collection type, are indicated by a different letter....68

LIST OF FIGURES

Figure Page

1 Figure 1. Location of the Poplar Island Archipelago in Chesapeake Bay..................6

2 Figure 2. Fyke and gill net site locations for the Poplar Island nekton and finfish surveys. Lowes Point and Back Creek reference marshes were not sampled during 2016 collections..7

3 Figure 3. Fyke nets set at a reference site..8

4 Figure 4. Gill net set for predator nekton collection...9

5 Figure 5. Typical catch from a fyke net...11

6 Figure 6. Comparison among collection years, per marsh type, for the mean number of individuals collected per 5 linear meters of marsh via fyke nets. Significant differences ($p \leq 0.05$) between collection years, per marsh type, are indicated by a different letter...16

7 Figure 7. Comparison among marsh types, per collection year, for the mean number of individuals collected per 5 linear meters of marsh via fyke nets. Significant differences ($p \leq 0.05$) between collection marsh types, per collection year, are indicated by a different letter..26

8 Figure 8. Relative size class frequency distribution comparisons between individuals collected in fyke nets at reference and Cell 1A marsh sites during summer 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Cyprinodon variegatus* during summer 2016 were 22.0 mm within Cell 1A and 20.1 mm within reference marshes. Mean standard lengths for *Fundulus majalis* during summer 2016 were 24.2 mm within Cell 1A and 38.0 mm within reference marshes. Mean standard lengths for *Fundulus heteroclitus* during summer 2016 were 24.6 mm within Cell 1A and 31.2 mm within reference marshes...44

9 Figure 9. Relative size class frequency distribution comparisons between individuals collected in fyke nets at reference and Cell 1C marsh sites during summer 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Cyprinodon variegatus* during summer 2016 were 22.3 mm within Cell 1C and 20.1 mm within reference marshes. Mean standard lengths for *Fundulus majalis* during summer 2016 were 16.3 mm within Cell 1C and 38.0 mm within reference marshes. Mean standard lengths for *Fundulus heteroclitus* during summer 2016 were 23.0 mm within Cell 1C and 31.2 mm within reference marshes..45

10 Figure 10. Relative size class frequency distribution comparisons between individuals collected in fyke nets at reference and Cell 1B marsh sites during summer 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Cyprinodon variegatus* during summer 2016 were 22.9 mm within Cell 1B and 20.1 mm within reference marshes. Mean standard lengths for *Fundulus majalis* during summer 2016 were 21.3 mm within Cell 1B and 38.0 mm within reference marshes. Mean standard lengths for *Fundulus heteroclitus* during summer 2016 were 28.4 mm within Cell 1B and 31.2 mm within reference marshes..46

11 Figure 11. Relative size class frequency distribution comparisons between individuals collected in fyke nets at reference and Cell 3A marsh sites during summer 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Fundulus heteroclitus* during summer 2016 were 22.1 mm within Cell 3A and 31.2 mm within reference marshes..47

12 Figure 12. Relative size class frequency distribution comparisons between individuals collected within Cell 1A and Cell 1C via fyke net during summer 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Cyprinodon variegatus* during summer 2016 were 22.0 mm within Cell 1A and 22.3 mm within Cell 1C. Mean standard lengths for *Fundulus majalis* during summer 2016 were 24.2 mm within Cell 1A and 16.3 mm within Cell 1C. Mean standard lengths for *Fundulus heteroclitus* during summer 2016 were 24.6 mm within Cell 1A and 23.0 mm within Cell 1C...49

13 Figure 13. Relative size class frequency distribution comparisons between individuals collected within Cell 1A and Cell 1B via fyke net during summer 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Cyprinodon variegatus* during summer 2016 were 22.0 mm within Cell 1A and 22.9 mm within Cell 1B. Mean standard lengths for *Fundulus majalis* during summer 2016 were 24.2 mm within Cell 1A and 21.3 mm within Cell 1B. Mean standard lengths for *Fundulus heteroclitus* during summer 2016 were 24.6 mm within Cell 1A and 28.4 mm within Cell 1B......................................50

14 Figure 14. Relative size class frequency distribution comparisons between individuals collected within Cell 1B and Cell 1C via fyke net during summer 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Cyprinodon variegatus* during summer 2016 were 22.9 mm within Cell 1B and 22.3 mm within Cell 1C. Mean standard lengths for *Fundulus majalis* during summer 2016 were 21.3 mm within Cell 1B and 16.3 mm within Cell 1C. Mean standard lengths for *Fundulus heteroclitus* during summer 2016 were 28.4 mm within Cell 1B and 23.0 mm within Cell 1C.............................51

15 Figure 15. Relative size class frequency distribution comparisons between individuals collected within Cell 1B and Cell 3A via fyke net during summer 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Fundulus heteroclitus* during summer 2016 were 28.4 mm within Cell 1B and 22.1 mm within Cell 3A..53

16 Figure 16. Relative size class frequency distribution comparisons between individuals collected within Cell 1C and Cell 3A via fyke net during summer 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Fundulus heteroclitus* during summer 2016 were 23.0 mm within Cell 1C and 22.1 mm within Cell 3A..54

17 Figure 17. Relative size class frequency distribution comparisons between individuals collected within Cell 1A and Cell 3A via fyke net during summer 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Fundulus heteroclitus* during summer 2016 were 24.6 mm within Cell 1A and 22.1 mm within Cell 3A..55

18 Figure 18. Relative size class frequency distributions for annual comparisons between individuals collected via fyke net within Cell 1A during summer 2014 and 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Fundulus heteroclitus* were 27.4 mm during summer 2014 and 24.6 mm during summer 2016....56

19 Figure 19. Relative size class frequency distributions for annual comparisons between individuals collected via fyke net within Cell 1C during summer 2014 and 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Fundulus majalis* were 27.1 mm during summer 2014 and 16.3 mm during summer 2016. Mean standard lengths for *Fundulus heteroclitus* were 22.4 mm during summer 2014 and 23.0 mm during summer 2016....57

20 Figure 20. Relative size class frequency distributions for annual comparisons between individuals collected via fyke net within Cell 1B during summer 2014 and 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Fundulus majalis* were 26.1 mm during summer 2014 and 21.3 mm during summer 2016. Mean standard lengths for *Fundulus heteroclitus* were 33.0 mm during summer 2014 and 28.4 mm during summer 2016....58

21 Figure 21. Relative size class frequency distributions for annual comparisons between individuals collected via fyke net within reference area marshes during summer 2014 and 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Cyprinodon variegatus* were 17.4 mm during summer 2014 and 20.1 mm during summer 2016. Mean standard lengths for *Fundulus majalis* were 34.0 mm during summer 2014 and 38.0 mm during summer 2016. Mean standard lengths for *Fundulus heteroclitus* were 37.9 mm during summer 2014 and 31.2 mm during summer 2016....60

22 Figure 22. Representative species from a gill net....61

23 Figure 23. Comparison among collection years, per marsh type, for the mean number of individuals collected, per 12 hour set, via gill nets. Significant differences ($p \leq 0.05$) between collection years, per marsh type, are indicated by a different letter....62

24 Figure 24. Comparison among marsh types, per collection year, for the mean number of individuals collected, per 12 hour set, via gill nets. Significant differences ($p \leq 0.05$) between collection years, per marsh type, are indicated by a different letter......65

INTRODUCTION

A large portion of the United States human population is concentrated along the continental coastal regions, resulting in increased development along coastal rivers, creeks, and sounds. This population growth trend has subsequently impacted the very estuarine habitats prized by humans and that serve as critical transition zones (CTZs) between upland and marine habitats (Levin et al. 2001). From the 1780's through the 1980's estimated wetland losses in the contiguous U. S. approached 53% of initial totals (Dahl 1990; Johnson 1994), with comparable percentage losses of tidal salt marsh (Kennish 2001). Of the estimated 89 million acres of wetlands in the 1780's only 42 million acres were remaining by 1980 (Johnson 1994), of these ~ 5% are encompassed by the remaining emergent marsh (Zedler 1996).

Because of the increased awareness related to estuarine function of CTZs between uplands and marine environments (Levin et al. 2001), their ability to filter terrigenous pollutants and waste, habitat importance for the support of significant portions of commercially valuable fisheries and forage species (Hettler, 1989, Fonseca et al. 1990), and their critical linkage to fishery production (Boesch and Turner, 1984; Zimmerman and Minello, 1984), these habitats, in particular salt marshes, have been targeted by federal, state, and non-government organizations for habitat restoration. The restoration of lost estuarine habitat, through effective coastal resource management, including the beneficial use of dredged material in restorations, can be an important strategy to help maintain the integrity of our estuaries. The Paul S. Sarbanes Ecosystem Restoration Project at Poplar Island (Poplar Island), formerly known as the Poplar Island Environmental Restoration Project (PIERP), is one project that exemplifies the potential for addressing navigational, habitat, and restoration needs. Beyond simply restoring estuarine wetland habitats, it was acknowledged, during the initial planning for the restoration of Poplar

Island, that a well functioning wetland must not only contain vegetated habitat, but it must also be utilized by wildlife, including fishes. The Poplar Island design has incorporated the "fish use is important" concept in an attempt to produce habitats that provide quality fishery habitat.

Poplar Island (located in Talbot County, Maryland, in mid Chesapeake Bay), is a collaborative effort between federal and state agencies. The U.S. Army Corps of Engineers, Baltimore District (USACE) and the Maryland Department of Transportation - Maryland Port Administration (MDOT-MPA) are the project sponsors of Poplar Island. Originally, the site was planned to be approximately 1,140 acres in size and provide 40 million cubic yards (mcy) of dredged material placement capacity. This island restoration would re-establish the approximate 1847 footprint, which as of 1996 had eroded to less than four acres due to hydrodynamic influences. Because of the predicted dredged material placement capacity shortfall, an expansion of the restoration at Poplar Island was authorized in 2006, and re-authorized in 2014, to include the original restoration of 1,140 acres, and an additional 575 acres of remote island habitat that incorporates an open-water embayment. Ultimately, the site will be approximately 1,715 acres in size and will provide 68 mcy of dredged material placement capacity. Poplar Island is planned to eventually provide approximately 776 acres of wetland, 829 acres of upland, and 110 acres of open-water embayment habitat. Ecological benefits provided by the construction of Poplar Island include the beneficial use of dredged material to restore vegetated habitats for fisheries and wildlife, and the reduction in wave energies within Poplar Harbor, which could benefit submerged aquatic vegetation colonization and fisheries utilization.

Nekton surveys were conducted during spring, summer, and fall time periods to assess the fisheries benefits due to the construction of Poplar Island. These surveys included the phases before (1995-1996) and after (2001-2003) perimeter dike construction of Poplar Island, and after construction of restored wetland salt marsh habitat (2004-2014, 2016). Annual monitoring efforts have been accomplished to examine the effect of the Poplar Island restoration on fish, shrimp, and crab (nekton) use of the restored habitats at Poplar Island, as well as periodic monitoring of habitats adjacent to Poplar Island (last conducted during 2011) that has been performed after major Poplar Island milestones (e.g., perimeter dike completion and completion of initial wetland cells) (see Meyer 2011). Reference areas (areas outside of any potential influence of Poplar Island) of each habitat type sampled within the immediate vicinity of Poplar Island were similarly sampled as control sites. These reference habitat sites were also sampled to examine natural changes of the nekton community usage patterns within the geographic area over time.

The focus of this current investigation was to compare the functions of restored habitats, as measured during the 2016 calendar year, to Poplar Island remnant marsh habitats measured during the 1995-96 pre-construction baseline surveys, and to compare restored habitats to reference habitats. The nekton monitoring period for each restored wetland cell has typically encompassed the initial 5 to 6 year period after marsh planting in order to assess initial usage patterns. Monitoring for specific wetland cells beyond the initial time frame is subject to the need to assess longer term nekton use. From 2004 through 2008, surveys were conducted to assess nekton use in the first of the restored Poplar Island wetlands, Cell 4D (which was constructed of sand, not the fine-grained dredged material that would later be used for Poplar Island wetlands). Surveys to assess nekton use of wetland cells constructed entirely of fine-grained dredged material began with Cell 3D (sampled from 2006-2011), followed by Cell 1A (sampled from 2010-2014, 2016), Cell 1C (sampled from 2012-2014, 2016), Cell 1B (sampled 2013, 2014, 2016), and Cell 3A (sampled 2016). During 2016, nekton survey results of the wetland habitats within restored Cells 1A, 1C, 1B, and 3A were compared to concurrent survey results of reference wetland habitats, and survey results of the Poplar Island remnant marshes measured during the 1995-96 pre-construction baseline.

Initial baseline surveys were conducted during fall 1995, spring 1996, and summer 1996, and all surveys thereafter followed a spring, summer, and fall pattern with all collections completed within the same calendar year. Post-construction surveys used in the analyses within this report were conducted during 2010-2014, and 2016. In all cases, the methodologies used for Poplar Island assessments were consistent among pre- and post-construction surveys.

The specific null hypotheses, from section G. Wetlands Use By Fish Monitoring, in the 2015 Framework Monitoring Document (FMD) tested during this survey effort included:

Hypothesis G1. There are no differences between decapod or fish abundance, community species composition, or population size class structure among the Poplar Island restored marsh habitats compared to those prior to restoration.

Hypothesis G2. There are no differences between decapod or fish abundance, community species composition, or population size class structure among restored Poplar Island marsh habitat compared to nearby reference marsh habitat.

Hypothesis G3. There are no differences in decapod or fish abundance, community species composition, or population size class structure associated with age (seral stage) of restored Poplar Island marsh habitats.

The information gained by these efforts will be used to determine the influence that the Poplar Island restoration has had on fisheries within the immediate area, and to determine the necessity of mid-course corrective measures to improve habitat quality of restored habitats. The information obtained will be used to improve fisheries and wildlife usage in future restoration projects.

MATERIALS AND METHODS

Wetlands Use by Fisheries:

Fyke Net Collection:

Sample collections to determine nekton marsh use for the remnant, reference, and Poplar Island restored marshes were performed during the spring, summer, and fall, at and in the vicinity of Poplar Island, Chesapeake Bay (Meyer 1999) (Figure 1) using fyke nets (Meyer et al. 2001). Sites selected for sampling were four replicate island remnant baseline sites (North Point Island, Middle Poplar Island, South Central Poplar, and Coaches Island, during 1995-1996) from the Poplar Island Archipelago, six replicate reference wetland marsh sites (Harbor Cove, Lowes Point, Cabin Creek, Front Creek, Back Creek, and Knapps Narrows, during 1995-1996 and 2001-2011; Harbor Cove, Cabin Creek, Front Creek, and Knapps Narrows during 2012-2013 and 2016; Harbor Cove, Cabin Creek, and Front Creek during 2014), and three replicate restored wetland marsh sites in Cell 1A (2010-2014, 2016), Cell 1C (2012-2014, 2016), Cell 1B (2013, 2014, 2016), and Cell 3A (2016) (Figure 2). A replicate was based on the site level. A site was considered to be a remnant island, reference marsh creek, or independent marsh creek tributary of Cell 1A, 1C, 1B and 3A restored wetlands. Poplar Island remnant marsh sites were all *Spartina* spp. dominated fragments of the former Poplar Island, surrounded by open water and located on the harbor side of the archipelago. Reference and restored marsh sites were second order creek sites (Rozas and Odum 1987), dominated by *Spartina* spp. and located within quiescent areas of each creek or tributary. All sites for each area were originally selected based on observed similarities of gently sloping topography

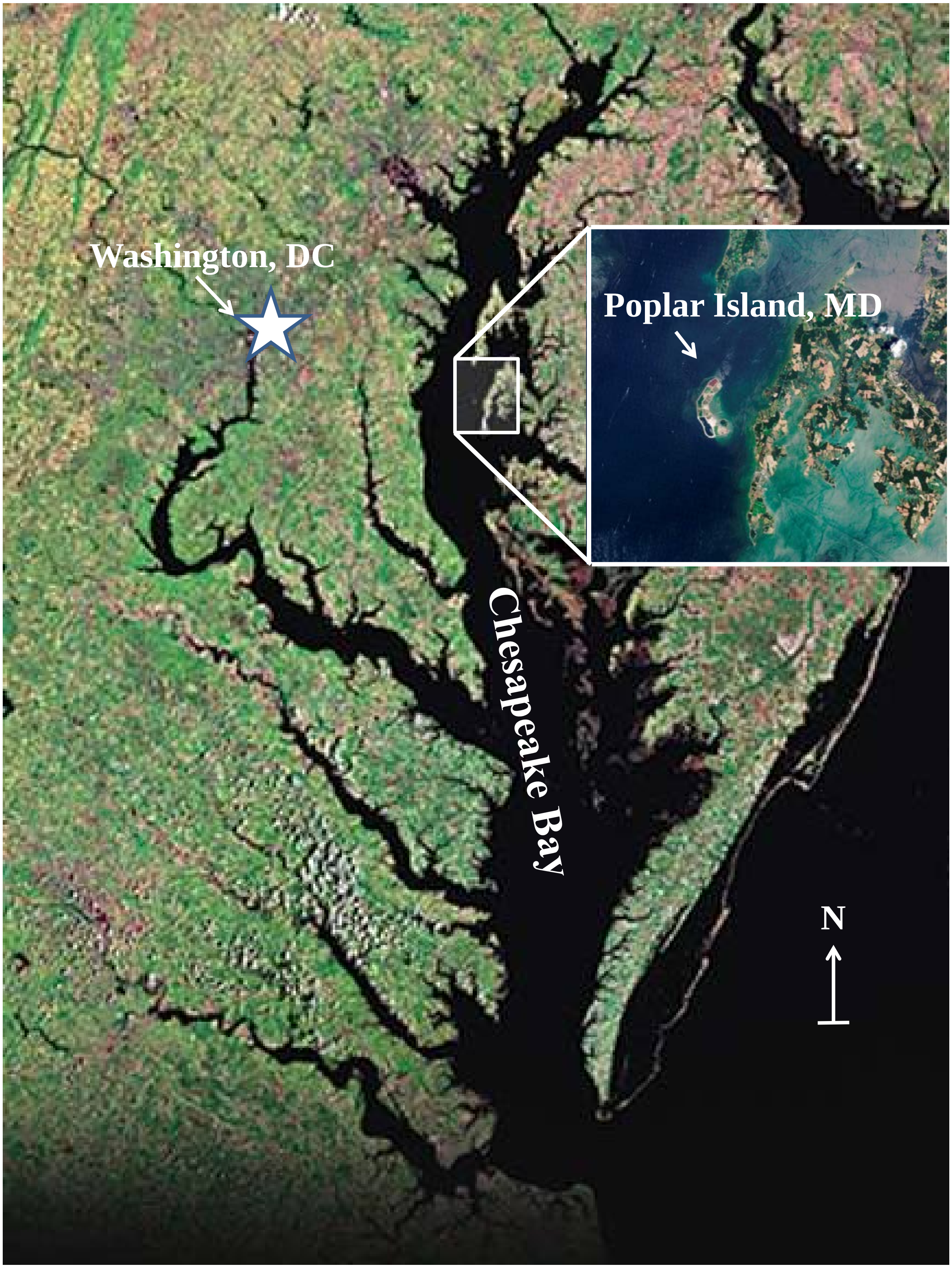

Figure 1. Location of the Poplar Island Archipelago in Chesapeake Bay.

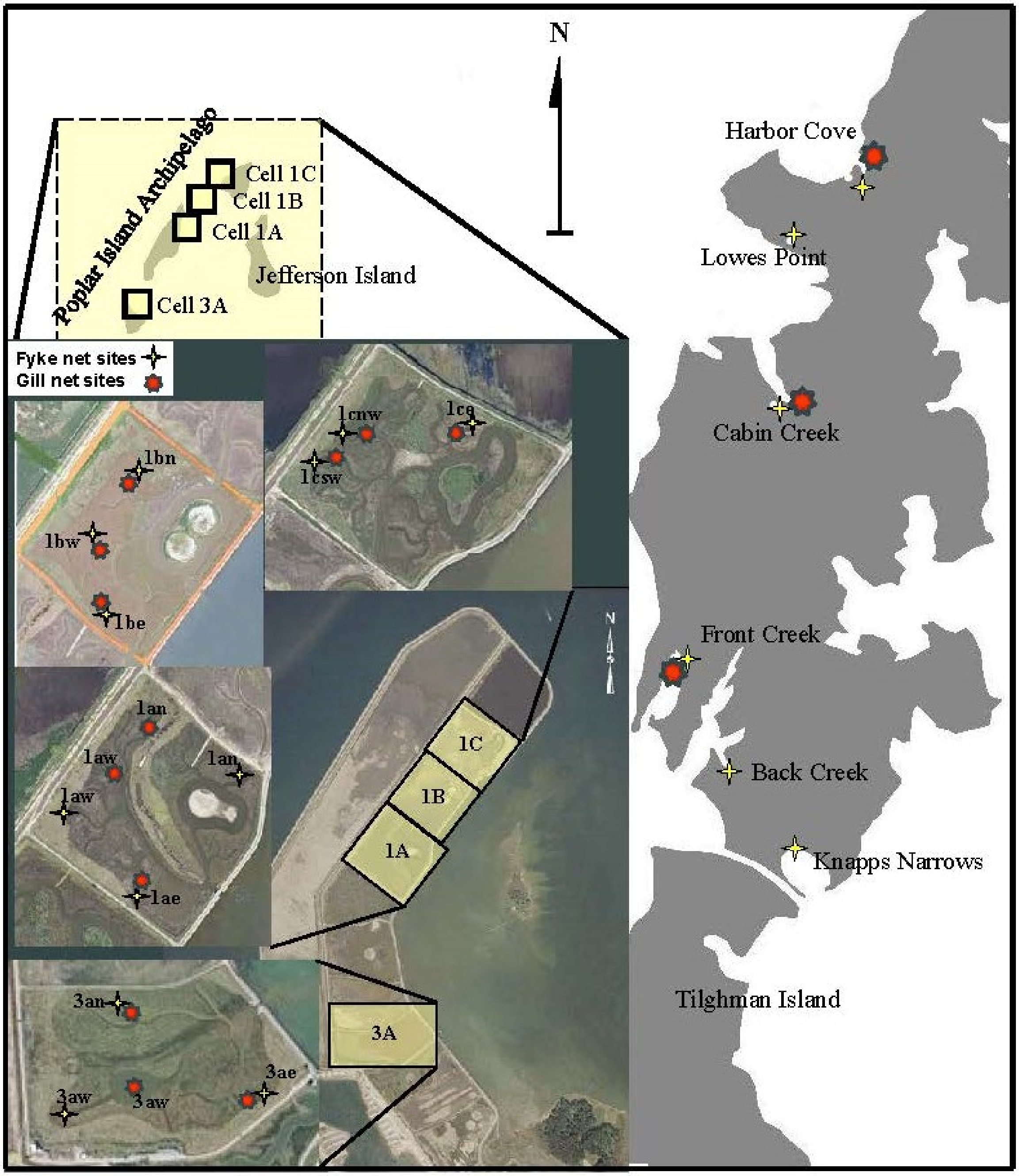

Figure 2. Fyke and gill net site locations for the Poplar Island nekton and finfish surveys. Lowes Point and Back Creek reference marshes were not sampled during 2016 collections.

and dominant vegetation. Sites used for the nekton collections corresponded to areas for vegetation parameter measurements by the U.S. Fish and Wildlife Service. For remnant and reference marshes a replicate was comprised of two contiguous fyke net sets per site, with resulting data and nekton collected averaged for each site. Due to areal constraints within the restored marsh sites only one fyke net comprised a replicate for each of the three sites sampled within each restored cell.

The fyke nets used measured 1.0 meter (m) square at the mouth opening, had 3.0 m wings, and were constructed of black 3.2 millimeter (mm) mesh netting (Figure 3). Sample locations for each fyke net were marked with paired poles, set 5 m apart, to which the fyke net could attach. Fyke net pole pairs were situated along the lower marsh fringe, approximately 1.5 m landward of the perceived low tide line. This ensured that the water would evacuate from the marsh to allow each fyke net to collect nekton from the delineated 5 linear m of marsh edge. All fyke nets were set during morning high slack tide, with nekton collected from each net during the subsequent low tide.

Figure 3. Fyke nets set at a reference site.

Marsh Creek Gill Net Collection:

Gill net sampling was used to assess predator and bait fish species use of wetland marsh creeks (Roundtree and Able 1997, Meyer and Posey 2014a), and was performed during spring, summer, and fall 2010, 2011, and 2016 within reference and Cell 1A marsh creeks, and during 2016 within Cell 1B, 1C, and 3A marsh creeks. Collections were performed within three independent sites in each cell so that site catch would not affect catch at another site. Reference marsh creeks used for these collections included the creeks adjacent to marsh sites at Harbor Cove, Cabin Creek, and Front Creek (Figure 2).

At each site one gill net replicate was fished (n = 3 was the replication level for the reference and restored cells). A gill net consisted of three 10 m long x 1.8 m high panels of monofilament netting. Each panel was of a different stretch mesh size (38, 64, and 89 mm), with 3 m open spaces separating one panel from another (Figure 4). Gill nets were anchored parallel to prevailing tidal current. All nets were set during the late afternoon to early evening hours and were allowed to fish overnight for a period of ~12 - 14 hours. Upon retrieval, catch per site was processed and recorded per net and per mesh size, and was standardized to equal catch per unit effort (CPUE) reflective of a 12 hour (hr) soak time.

Figure 4. Gill net set for predator nekton collection.

Environmental Parameters and Sample Disposition:

Environmental field parameters recorded during sample collection included salinity and water temperature. Water depth at the mouth of each fyke net, water depth at fyke net poles, and distance into the wetland the water had reached from the fyke net poles (essentially the marsh edge) were also recorded for each fyke net. Three water depth and water transparency (using a Secchi disk) measurements were obtained (each gill net end and the middle) during gill net set.

Nekton collected using fyke nets were placed on ice and then frozen upon return from the field. Gill net samples were processed on site. Individuals collected for each method were identified to species, enumerated, measured [standard length (SL) for fishes, total length for shrimps, and width (measurement from tip to tip of anterolateral spines) for crabs] in mm, and when practical, released. All preserved samples were processed [identified to species, enumerated, measured and weighed in grams (g)] in the laboratory.

Data Analysis:

Faunal composition and abundance among dates and area types were examined based on collection method. For collection date and area comparisons, data were ranked and analyzed using analysis of variance and *post hoc* Student-Newman Keuls procedure to detect significant differences between the means for a given date or area comparison (Sokal and Rohlf 1981).

Population size-class frequency analyses for summer 2016 fyke net catch of target resident marsh fish species [e.g., *Cyprinodon variegatus* (sheepshead minnow), *Fundulus heteroclitus* (mummichog), and *Fundulus majalis* (striped killifish)] was assessed among Cell 1A, 1C, 1B, 3A, and the reference marshes, and between summer 2014 fyke net catch for the reference, Cell 1A, 1C, and 1B marshes (when abundances were sufficient) using the non-parametric Kolmogorov-Smirnov two-sample test (Sokal and Rohlf 1981, Kneib and Craig 2001). In addition, Wilcoxon two-sample tests were used to assess whether mean individual size from area and year comparisons differed significantly between one another (Sokal and Rohlf 1981, Kneib and Craig 2001).

For all results, a probability value of $p \leq 0.05$ was used for rejection of the null hypothesis and assessing results to be significantly different.

RESULTS

Results of the previous baseline work (1995-1996), and post-construction work (2001-2014) have been analyzed and previously reported (see Meyer 1999, 2001, 2003, 2004, 2005, 2006a, 2007, 2008, 2009, 2010, 2011, 2012, 2013, and 2014 for previous results and interpretations). Results within this report will focus on the comparison of data collected during the 2016 monitoring year and the comparisons of these data to appropriate previously collected data.

Wetlands Use By Fisheries:

Fyke Net Collection:

Fyke net nekton collections (Figure 5) revealed that the mean number of nekton species occurring within the reference marshes during the baseline were typically higher than within the remnant marshes, while the mean number of nekton species within the reference marshes during the subsequent post-restored marsh period were consistently higher than within Cell 1A, 1C, 1B, and 3A marshes (with the exceptions of fall 2011 in Cell 1A, spring 2014 in Cell 1B, and spring 2016 in Cells 1A and 3A) during annular seasonal time periods (Table 1). Significantly higher numbers of nekton species were observed within the reference marshes compared to remnant marshes during both the spring and summer 1996 (Table 1). Significantly more nekton species were observed within the reference marshes compared to: Cell 1A marsh during spring 2010, 2011, and 2012, summer 2011, 2012, 2013, 2014, and 2016, and fall 2012; Cell 1C marsh during spring 2012, summer 2012, 2013, 2014, and 2016, and fall 2012 and 2014; Cell 1B marsh during spring 2016, summer 2013, 2014, and 2016, and fall 2016; Cell 3A marsh during summer 2016 and fall 2016 (Table 1).

Figure 5. Typical catch from a fyke net.

Seasonal means of the number of nekton species observed within the baseline remnant

Table 1. Comparisons among marsh area types for mean number of nekton species collected via fyke nets by time period. Marsh area types are Poplar Island remnant marshes (PR), reference area marshes (RA), and Poplar Island restored marshes in Cell 1A (1A), Cell 1B (1B), Cell 1C (1C), and Cell 3A (3A). Comparisons between area types that are significantly different from one another ($p \leq 0.05$) are indicated by an asterisk.

Time Period	PR	RA	1A	RA	1B	RA	1C	RA	3A	RA
Spring 1996	2.0*	4.6*	---	---	---	---	---	---	---	---
Spring 2010	---	---	3.7*	7.0*	---	---	---	---	---	---
Spring 2011	---	---	2.3*	7.0*	---	---	---	---	---	---
Spring 2012	---	---	5.0*	7.5*	---	---	3.0*	7.5*	---	---
Spring 2013	---	---	4.7	4.8	3.7	4.8	3.3	4.8	---	---
Spring 2014	---	---	3.3	4.3	4.7	4.3	2.0	4.3	---	---
Spring 2016	---	---	6.0	5.8	4.3*	5.8*	5.0	5.8	6.7	5.8
Summer 1996	5.0*	8.8*	---	---	---	---	---	---	---	---
Summer 2010	---	---	9.0	12.2	---	---	---	---	---	---
Summer 2011	---	---	6.0*	12.2*	---	---	---	---	---	---
Summer 2012	---	---	5.7*	11.2*	---	---	5.7*	11.2*	---	---
Summer 2013	---	---	5.0*	11.5*	6.0*	11.5*	5.3*	11.5*	---	---
Summer 2014	---	---	7.3*	10.0*	6.0*	10.0*	5.7*	10.0*	---	---
Summer 2016	---	---	7.3*	11.0*	6.0*	11.0*	5.7*	11.0*	6.7*	11.0*
Fall 1995	7.8	7.5	---	---	---	---	---	---	---	---
Fall 2010	---	---	7.3	11.6	---	---	---	---	---	---
Fall 2011	---	---	8.0	7.8	---	---	---	---	---	---
Fall 2012	---	---	5.7*	11.0*	---	---	4.0*	11.0*	---	---
Fall 2013	---	---	4.3	8.0	6.0	8.0	4.3	8.0	---	---
Fall 2014	---	---	5.7	8.0	7.0	8.0	4.0*	8.0*	---	---
Fall 2016	---	---	7.3	9.3	4.0*	9.3*	7.7	9.3	4.3*	9.3*

marshes were similar to values recorded for the Poplar Island restored marshes except within: Cell 1A during spring 2012 and 2016; Cell 1C during spring 2016; Cell 1B during spring 2014 and 2016; and Cell 3A during spring 2016; where significantly higher number of nekton species were observed within the cell marshes compared to the remnant marshes (Table 2). No significant differences among collection years for seasonal means of the number of nekton species observed were noted within reference or Cell 1B marshes (Table 3). Similarly no significant differences among collection years for summer and fall seasonal means of the number of nekton species observed were noted within Cell 1A or Cell 1C marshes (Table 3). However, during spring 2016 the mean number of nekton species within Cell 1A and Cell 1C marshes were higher than previous collection years; within Cell 1A marsh significantly more than during 2010, 2011, and 2014; within Cell 1C marsh significantly more than during 2012 and 2014 (Table 3).

Within the reference marshes mean abundances differed significantly among collection years for total nekton where 2012 > 2011, and for transient nekton (species that might utilize salt marsh but do not depend upon them to complete their entire life history) where 2012 > 2010 and 2011, while no significant differences were apparent for resident nekton (species that are known to depend upon, and complete their entire life history within salt marsh habitats) abundances among collections years (Figure 6). For Cell 1A, significant differences were evident for transient nekton abundance where 2012 > 2014, and resident nekton abundance where 2011 and 2016 > 2010, while no significant differences were apparent for total nekton abundances among collection years (Figure 6). For Cell 1C, significant differences were evident for mean transient (2012 > 2014) and resident (2014 > 2012) nekton abundances, while no significant differences were apparent for total nekton abundance between collection years (Figure 6). For Cell 1B, no significant differences were apparent for mean total, transient or resident nekton abundance between collection years (Figure 6).

Table 2. Comparisons for 2010-2014, 2016 Cell 1A (1A), 2013, 2014, 2016 Cell 1B (1B), 2012-2014, 2016 Cell 1C (1C), and 2016 Cell 3A (3A) collections versus Poplar Island remnant marsh (PR) from the 1995, 1996 collections, for mean number of nekton species collected via fyke nets. Comparisons between area types that are significantly different from one another ($p \leq 0.05$) are indicated by an asterisk.

Time Period	1A 2010	PR 1995-96	1A 2011	PR 1995-96	1A 2012	PR 1995-96	1A 2013	PR 1995-96	1A 2014	PR 1995-96	1A 2016	PR 1995-96
Spring	3.7	2.0	2.3	2.0	5.0*	2.0*	4.7	2.0	3.3	2.0	6.0*	2.0*
Summer	9.0	5.0	6.0	5.0	5.7	5.0	5.0	5.0	7.3	5.0	7.3	5.0
Fall	7.3	7.8	8.0	7.8	5.7	7.8	4.3	7.8	5.7	7.8	7.3	7.8

Time Period	1B 2013	PR 1995-96	1B 2014	PR 1995-96	1B 2016	PR 1995-96
Spring	3.7	2.0	4.7*	2.0*	4.3*	2.0*
Summer	6.0	5.0	6.0	5.0	6.0	5.0
Fall	6.0	7.8	7.0	7.8	4.0	7.8

Time Period	1C 2012	PR 1995-96	1C 2013	PR 1995-96	1C 2014	PR 1995-96	1C 2016	PR 1995-96
Spring	3.0	2.0	3.3	2.0	2.0	2.0	5.0*	2.0*
Summer	5.7	5.0	5.3	5.0	5.7	5.0	5.7	5.0
Fall	4.0	7.8	4.3	7.8	4.0	7.8	7.7	7.8

Time Period	3A 2016	PR 1995-96
Spring	6.7*	2.0*
Summer	6.7	5.0
Fall	4.3	7.8

Table 3. Interannual comparisons for mean number of nekton species collected via fyke nets during 2010-2014, 2016 for reference area (RA) and Cell 1A (1A) marsh collections, 2012-2014, 2016 for Cell 1C (1C), and 2013, 2014, 2016 for Cell 1B (1B) marsh collections. Comparisons between years for each area type that are significantly different from one another ($p \leq 0.05$) are indicated by a different letter.

Time Period	2010	2011	2012	2013	2014	2016
			RA			
Spring	7.0	7.0	7.5	4.8	4.3	5.8
Summer	12.2	12.2	11.2	11.5	10.0	11.0
Fall	11.6	7.8	11.0	8.0	8.0	9.3
			1A			
Spring	3.7^{BC}	2.3^{C}	5.0^{AB}	4.7^{AB}	3.3^{BC}	6.0^{A}
Summer	9.0	6.0	5.7	5.0	7.3	7.3
Fall	7.3	8.0	5.7	4.3	5.7	7.3
			1C			
Spring			3.0^{B}	3.3^{AB}	2.0^{B}	5.0^{A}
Summer			5.7	5.3	5.7	5.7
Fall			4.0	4.3	4.0	7.7
				1B		
Spring				3.7	4.7	4.3
Summer				6.0	6.0	6.0
Fall				6.0	7.0	4.0

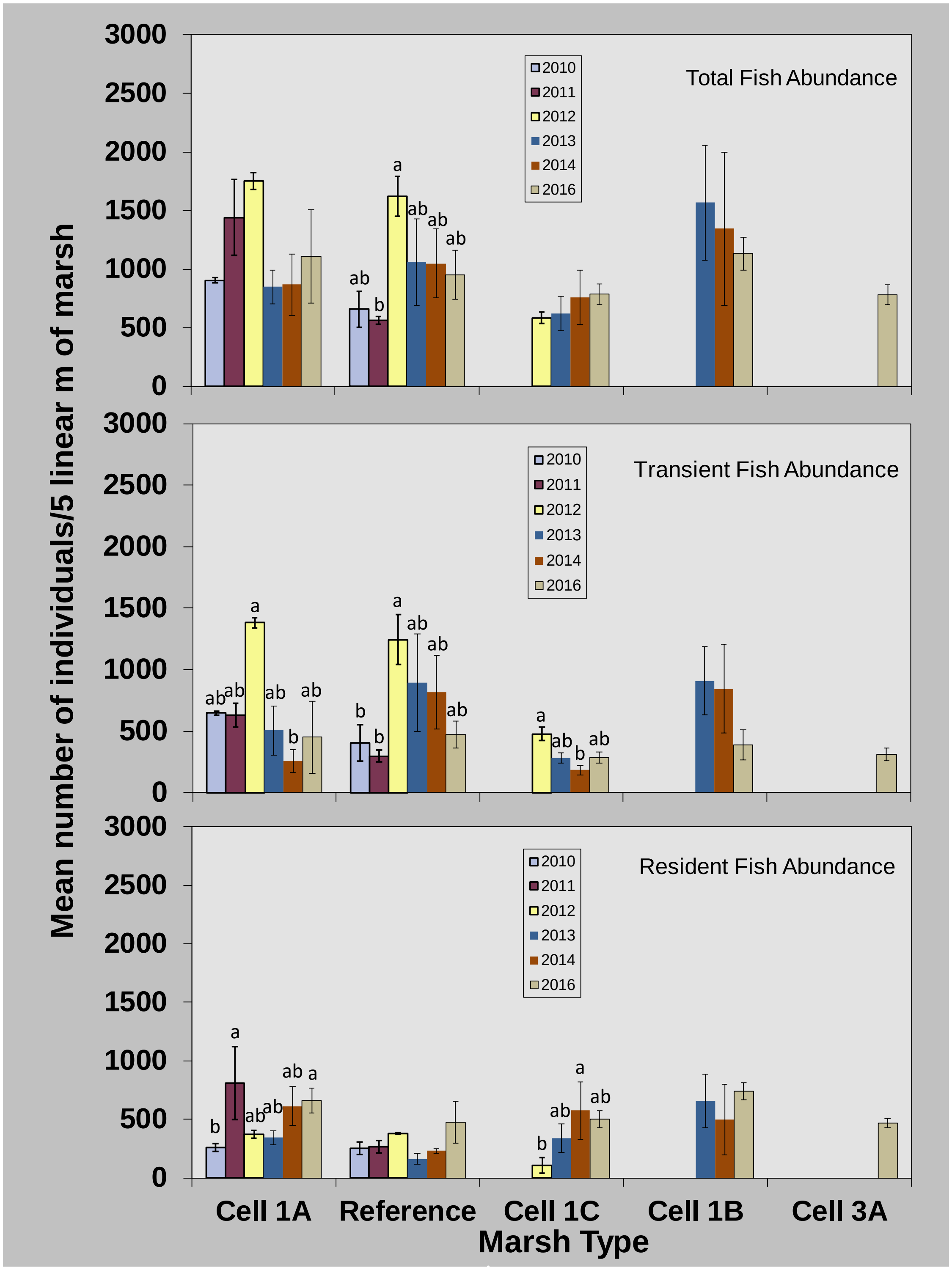

Figure 6. Comparison among collection years, per marsh type, for the mean number of individuals collected per 5 linear meters of marsh via fyke nets. Significant differences ($p \leq 0.05$) between collection years, per marsh type, are indicated by a different letter.

Significant interannual abundance differences within seasonal collection periods were apparent for individual nekton species in reference, Cell 1A, Cell 1C, and Cell 1B marshes (Tables 4, 5, 6, and 7). Within the reference marshes significant interannual abundance variability was observed in the marsh resident species sheepshead minnow, mummichog, and striped killifish, (all target forage marsh nekton species) with single season differences observed (Table 4), while for transient species it was observed in *Menidia beryllina* (inland silverside), *Menidia menidia* (Atlantic silverside), *Morone americana* (white perch), *Scianops ocellatus* (red drum), and *Palaemonetes pugio* (grass shrimp, one of four target forage marsh nekton species) during single seasons, and *Leiostomus xanthurus* (spot) during multiple seasons (Table 4). Within Cell 1A significant interannual abundance variability was observed in the marsh resident species striped killifish, with single season differences, and sheepshead minnow, with multiple season differences, while for transient species it was observed in *Gambusia affinis* (mosquito fish), inland silverside, white perch, *Morone saxatilis* (striped bass), *Callinectes sapidus* (blue crab), and grass shrimp during single seasons, and spot during multiple seasons (Table 5). Within Cell 1C significant interannual abundance differences were observed in the marsh residents sheepshead minnow, *Fundulus diaphanus* (banded killifish), mummichog, and striped killifish during single seasons, while for transient species it was observed in inland silverside and Atlantic silverside during single seasons and multiple seasons for grass shrimp (Table 6). Within Cell 1B significant interannual abundance differences were observed in the marsh residents sheepshead minnow and striped killifish during single seasons, while for transient species it was observed in inland silverside during a single season and multiple seasons for grass shrimp (Table 7).

During 2016, annual mean abundances of total, transient, and resident nekton within the reference marshes and the restored marshes of Cells 1A, 1C, 1B, and 3A did not significantly differ

Table 4. Interannual comparison of the mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collected in fyke nets at reference marshes. For each species, collection period date comparisons that significantly differ ($p \leq 0.05$) from one another are designated by a different letter.

Species	Common Name	Date 4/10	 4/11	 4/12	 4/13	 4/14	 4/16
Fishes:							
Alosa pseudoharangus	alewife	0.0	0.0	0.0	0.0	0.0	0.0
Anchoa mitchilli	bay anchovy	1.2	0.0	2.8	0.4	0.0	0.0
Anguilla rostrata	American eel	0.0	0.0	0.0	0.1	0.0	0.2
Apeltes quadracus	fourspine stickleback	0.0	0.0	0.0	0.0	0.0	0.0
Brevoortia tyrannus	Atlantic menhaden	0.0	0.0	0.1	0.0	0.0	0.0
Chasmodes bosquianus	striped blenny	0.0	0.0	0.0	0.0	0.0	0.0
Cynoscion nebulosus	spotted seatrout	0.0	0.0	0.0	0.0	0.0	0.0
Cynoscion regalis	weakfish	0.0	0.0	0.0	0.0	0.0	0.0
Cyprinella analostana	satinfin shiner	0.0	0.0	0.0	0.0	0.2	0.0
Cyprinodon variegatus	sheepshead minnow	25.6	5.5	40.5	1.6	1.3	33.5
Fundulus diaphanus	banded killifish	0.0	1.8	0.0	0.0	0.0	0.0
Fundulus heteroclitus	mummichog	336.3^{A}	132.2^{B}	412.8^{A}	46.6^{B}	100.5^{B}	95.8^{B}
Fundulus luciae	spotfin killifish	0.1	3.0	0.5	0.0	0.0	0.0
Fundulus majalis	striped killifish	0.5	2.8	0.6	0.2	0.5	1.5
Gobiosoma bosc	naked goby	0.0	0.0	0.0	0.0	0.0	0.0
Gobiesox strumosus	skillet fish	0.0	0.0	0.0	0.0	0.0	0.0
Gambusia affinis	mosquito fish	0.5	0.0	0.0	0.0	0.0	0.0
Leiostomus xanthurus	spot	0.0	0.0	0.9	0.5	0.0	0.0
Lepomis gibbosus	pumpkinseed	0.2	0.5	0.0	0.0	0.2	0.0
Lucania parva	rainwater killifish	2.5	1.0	0.1	2.5	0.0	1.6
Menidia beryllina	inland silverside	0.3^{AB}	3.3^{AB}	17.2^{A}	0.0^{B}	0.2^{AB}	4.9^{AB}
Menidia menidia	Atlantic silverside	0.0	1.5	1.0	0.0	0.2	12.6
Morone americana	white perch	0.0	0.0	0.0	0.0	0.0	0.0
Morone saxatilis	striped bass	0.0	0.0	0.0	0.0	0.0	0.0
Paralichthys dentatus	summer flounder	0.0	0.0	0.0	0.0	0.0	0.0
Pogonias cromis	black drum	0.0	0.0	0.0	0.0	0.0	0.0
Pomatomus saltatrix	bluefish	0.0	0.0	0.0	0.0	0.0	0.0
Sciaenops ocellatus	red drum	0.0	0.0	0.0	0.0	0.0	0.0
Strongylura marina	Atlantic needlefish	0.0	0.0	0.0	0.0	0.0	0.0
Syngnathus louisianae	chained pipefish	0.0	0.0	0.0	0.1	0.0	0.0
Syngnathus fuscus	northern pipefish	0.0	0.0	0.0	0.0	0.0	0.0
Decapods:							
Callinectes sapidus	blue crab	0.2	0.0	0.1	0.0	0.0	0.1
Rhithropanopeus harrisii	white-fingered mud crab	0.3	0.0	0.2	0.0	0.0	0.0
Palaemonetes pugio	grass shrimp	364.9	177.0	393.8	111.1	41.8	43.3
Uca minax	fiddler crab	0.0	0.0	0.0	0.0	0.0	0.0

Table 4. Continued.

Species	Common Name	7/10	7/11	7/12	7/13	7/14	7/16
Fishes:							
Alosa pseudoharangus	alewife	0.0	0.0	0.0	0.0	0.0	0.0
Anchoa mitchilli	bay anchovy	0.0	0.4	0.0	0.4	0.0	0.0
Anguilla rostrata	American eel	1.6	6.9	0.6	2.4	7.3	0.9
Apeltes quadracus	fourspine stickleback	0.0	0.0	0.0	0.0	0.0	0.1
Brevoortia tyrannus	Atlantic menhaden	0.0	0.0	0.0	0.0	0.3	0.2
Chasmodes bosquianus	striped blenny	0.0	0.0	0.1	0.0	0.0	0.0
Cynoscion nebulosus	spotted seatrout	0.1	0.1	0.8	0.0	0.0	0.0
Cynoscion regalis	weakfish	0.0	0.0	0.0	0.1	0.0	0.0
Cyprinella analostana	satinfin shiner	0.0	0.0	0.0	0.0	0.0	0.0
Cyprinodon variegatus	sheepshead minnow	22.9^{B}	49.0^{B}	109.1^{AB}	22.6^{B}	115.7^{AB}	732.4^{A}
Fundulus diaphanus	banded killifish	0.0	0.0	0.0	0.2	0.0	0.2
Fundulus heteroclitus	mummichog	206.1	170.6	210.4	184.0	236.8	270.6
Fundulus luciae	spotfin killifish	0.1	2.5	1.1	2.1	0.0	0.6
Fundulus majalis	striped killifish	16.8^{AB}	2.6^{B}	14.2^{B}	33.5^{AB}	36.3^{AB}	62.1^{A}
Gobiosoma bosc	naked goby	0.0	0.4	0.9	0.0	0.0	0.0
Gobiesox strumosus	skillet fish	0.0	0.0	0.1	0.0	0.0	0.0
Gambusia affinis	mosquito fish	1.5	0.1	0.6	0.0	0.0	0.0
Leiostomus xanthurus	spot	21.1^{A}	0.0^{B}	0.8^{B}	1.2^{B}	0.0^{B}	0.2^{B}
Lepomis gibbosus	pumpkinseed	0.0	0.0	0.0	0.0	0.0	0.0
Lucania parva	rainwater killifish	2.1	1.0	3.4	0.2	19.8	12.9
Menidia beryllina	inland silverside	9.1	97.1	37.8	95.4	148.5	31.1
Menidia menidia	Atlantic silverside	78.5	53.0	7.4	40.5	354.8	11.0
Morone americana	white perch	0.5^{B}	19.6^{A}	0.4^{B}	1.2^{B}	2.7^{B}	0.2^{B}
Morone saxatilis	striped bass	0.6	0.8	0.0	0.2	0.0	0.0
Paralichthys dentatus	summer flounder	0.0	0.0	0.2	0.0	0.0	0.0
Pogonias cromis	black drum	0.0	0.0	0.0	0.2	0.0	0.0
Pomatomus saltatrix	bluefish	0.0	0.1	0.0	0.0	0.0	0.0
Sciaenops ocellatus	red drum	0.0	0.0	0.0	0.0	0.0	0.0
Strongylura marina	Atlantic needlefish	0.1	0.2	0.1	0.2	0.0	0.6
Syngnathus louisianae	chained pipefish	0.0	0.0	0.0	0.2	0.0	0.0
Syngnathus fuscus	northern pipefish	0.0	0.0	0.0	0.0	0.0	0.0
Decapods:							
Callinectes sapidus	blue crab	27.8	12.5	36.8	14.9	4.7	8.2
Rhithropanopeus harrisii	white-fingered mud crab	0.2	0.5	1.0	0.0	0.7	0.5
Palaemonetes pugio	grass shrimp	440.4	239.8	790.3	1724.5	448.0	559.1
Uca minax	fiddler crab	0.0	0.1	0.0	0.0	0.0	0.0

Table 4. Continued.

Species	Common Name	Date					
		10/10	10/11	10/12	11/13	10/14	10/16
Fishes:							
Alosa pseudoharangus	alewife	0.1	0.0	0.0	0.0	0.0	0.0
Anchoa mitchilli	bay anchovy	0.7	0.0	8.1	0.0	0.0	0.0
Anguilla rostrata	American eel	1.1	1.2	0.2	0.7	3.3	0.3
Apeltes quadracus	fourspine stickleback	0.0	0.0	0.0	0.0	0.0	0.0
Brevoortia tyrannus	Atlantic menhaden	0.0	0.0	0.0	0.0	0.0	0.0
Chasmodes bosquianus	striped blenny	0.2	0.0	0.0	0.0	0.0	0.2
Cynoscion nebulosus	spotted seatrout	0.0	0.0	1.6	0.0	0.0	0.0
Cynoscion regalis	weakfish	0.0	0.0	0.0	0.0	0.0	0.0
Cyprinella analostana	satinfin shiner	0.0	0.0	0.0	0.0	0.0	0.0
Cyprinodon variegatus	sheepshead minnow	39.8	187.0	136.5	10.5	43.7	176.7
Fundulus diaphanus	banded killifish	0.1	0.6	0.0	0.0	0.0	1.8
Fundulus heteroclitus	mummichog	157.7	236.9	207.0	235.7	194.3	138.7
Fundulus luciae	spotfin killifish	0.1	0.0	0.6	0.0	0.0	0.0
Fundulus majalis	striped killifish	21.0	1.2	10.4	8.0	94.7	13.8
Gobiosoma bosc	naked goby	0.1	0.1	8.0	1.2	0.2	2.0
Gobiesox strumosus	skillet fish	0.8	0.0	0.0	0.2	0.0	0.8
Gambusia affinis	mosquito fish	1.1	1.1	0.2	0.0	0.0	0.0
Leiostomus xanthurus	spot	12.2^{A}	0.0^{B}	0.0^{B}	0.0^{B}	0.0^{B}	0.0^{B}
Lepomis gibbosus	pumpkinseed	0.0	0.0	0.0	0.0	0.0	0.0
Lucania parva	rainwater killifish	1.0	1.5	1.2	0.5	4.3	2.5
Menidia beryllina	inland silverside	14.0	15.6	2.9	5.0	0.0	15.5
Menidia menidia	Atlantic silverside	130.0^{A}	3.5^{B}	3.9^{B}	0.3^{B}	463.0^{A}	6.0^{B}
Morone americana	white perch	0.7	0.0	0.2	0.5	0.0	0.0
Morone saxatilis	striped bass	0.0	0.1	0.0	0.0	0.0	0.0
Paralichthys dentatus	summer flounder	0.0	0.0	0.1	0.0	0.0	0.0
Pogonias cromis	black drum	0.0	0.0	0.0	0.0	0.0	0.0
Pomatomus saltatrix	bluefish	0.0	0.0	0.0	0.0	0.0	0.0
Sciaenops ocellatus	red drum	0.0^{B}	0.0^{B}	4.2^{A}	0.0^{B}	0.5^{B}	2.3^{B}
Strongylura marina	Atlantic needlefish	0.0	0.0	0.0	0.0	0.0	0.0
Syngnathus louisianae	chained pipefish	0.0	0.0	0.0	0.0	0.0	0.0
Syngnathus fuscus	northern pipefish	0.0	0.0	0.0	0.0	0.0	0.3
Decapods:							
Callinectes sapidus	blue crab	12.4	1.0	5.1	3.0	0.0	2.0
Rhithropanopeus harrisii	white-fingered mud crab	0.1	0.5	0.1	0.8	0.7	0.0
Palaemonetes pugio	grass shrimp	242.9^{B}	183.5^{B}	2387.6^{A}	723.8^{B}	343.0^{B}	630.3^{B}
Uca minax	fiddler crab	0.0	0.0	0.0	0.0	0.0	0.0

Table 5. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collection at the Poplar Island restored Cell 1A marsh based on seral stage for spring, summer, and fall collection periods. A different letter within specified seasons indicates significantly different ($p \leq 0.05$) abundances among seral stages (years) for that species.

		Date						Date					
Species	Common Name	4/10	4/11	4/12	4/13	4/14	4/16	7/10	7/11	7/12	7/13	7/14	7/16
Fishes:													
Anguilla rostrata	American eel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.7	0.0	0.0
Brevoortia tyrannus	Atlantic menhaden	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cynoscion regalis	weakfish	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Cyprinodon variegatus	sheepshead minnow	0.0^{C}	0.0^{C}	1.7^{B}	0.0^{C}	0.0^{C}	5.7^{A}	0.3^{B}	0.0^{B}	0.0^{B}	0.3^{B}	2.0^{B}	224.0^{A}
Dorosoma cepedianum	gizzard shad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus diaphanus	banded killifish	2.3	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus heteroclitus	mummichog	100.7	345.7	470.7	23.0	77.0	315.7	450.3	1754.0	380.3	830.3	895.0	1132.3
Fundulus luciae	spotfin killifish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Fundulus majalis	striped killifish	0.3	0.0	0.0	0.3	2.3	0.7	18.3^{A}	0.3^{B}	6.3^{AB}	0.0^{B}	0.3^{B}	30.3^{A}
Gambusia affinis	mosquito fish	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.3	0.0
Gobiosoma bosc	naked goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leiostomus xanthurus	spot	0.0^{B}	0.0^{B}	9.3^{A}	2.0^{B}	0.0^{B}	0.0^{B}	41.0^{A}	0.0^{B}	0.0^{B}	0.0^{B}	0.0^{B}	0.0^{B}
Lepomis gibbosus	pumpkinseed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lepomis macrochrius	bluegill sunfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lucania parva	rainwater killifish	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.0
Menidia beryllina	inland silverside	0.0	0.0	0.3	3.7	0.7	1.3	45.0	7.0	72.3	19.0	23.7	13.0
Menidia menidia	Atlantic silverside	0.0	0.0	9.0	1.3	0.0	3.3	70.0	13.0	77.0	53.7	105.7	5.7
Morone americana	white perch	0.0	0.0	0.0	0.0	0.7	0.3	1.7	4.7	0.0	0.0	1.0	0.0
Morone saxatilis	striped bass	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.0
Paralichthys dentatus	summer flounder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sciaenops ocellatus	red drum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Decapods:													
Callinectes sapidus	blue crab	1.3	0.0	0.7	0.7	1.0	0.7	31.7	11.3	23.3	7.3	9.0	2.3
Rhithropanopeus harrisii	white-fingered mud crab	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Palaemonetes pugio	grass shrimp	156.0	319.0	210.0	63.3	162.3	68.0	480.0	1389.3	1533.0	601.7	188.0	270.3

Table 5. Continued.

Species	Common Name	Date 10/10	10/11	10/12	11/13	10/14	10/16
Fishes:							
Anguilla rostrata	American eel	0.0	1.3	0.0	0.0	0.0	0.3
Brevoortia tyrannus	Atlantic menhaden	0.0	0.0	0.0	0.0	0.0	0.7
Cynoscion regalis	weakfish	0.0	0.0	0.0	0.0	0.0	0.0
Cyprinodon variegatus	sheepshead minnow	0.0^{B}	0.3^{B}	4.3^{AB}	2.0^{B}	2.7^{B}	31.7^{A}
Dorosoma cepedianum	gizzard shad	0.0	0.3	0.0	0.0	0.0	0.0
Fundulus diaphanus	banded killifish	0.0	0.3	0.0	0.0	0.0	0.0
Fundulus heteroclitus	mummichog	216.0	329.0	260.7	173.0	856.7	263.0
Fundulus luciae	spotfin killifish	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus majalis	striped killifish	97.7	1.0	11.7	0.0	10.7	18.7
Gambusia affinis	mosquito fish	2.0^{A}	0.0^{B}	0.0^{B}	0.0^{B}	0.0^{B}	0.7^{B}
Gobiosoma bosc	naked goby	0.0	0.0	1.7	0.0	0.3	0.0
Leiostomus xanthurus	spot	20.0^{A}	0.0^{B}	0.0^{B}	0.0^{B}	0.0^{B}	0.0^{B}
Lepomis gibbosus	pumpkinseed	0.3	0.0	0.0	0.0	0.0	0.0
Lepomis macrochrius	bluegill sunfish	0.7	0.0	0.0	0.0	0.0	0.0
Lucania parva	rainwater killifish	0.0	0.0	0.0	0.0	0.0	0.0
Menidia beryllina	inland silverside	2.0^{C}	3.0^{BC}	1.0^{C}	102.7^{A}	47.0^{A}	8.0^{B}
Menidia menidia	Atlantic silverside	1.7	6.7	0.0	13.7	8.7	0.7
Morone americana	white perch	0.0^{B}	15.0^{A}	0.0^{B}	0.0^{B}	0.0^{B}	0.0^{B}
Morone saxatilis	striped bass	0.7^{B}	1.0^{A}	0.0^{B}	0.0^{B}	0.0^{B}	0.0^{B}
Paralichthys dentatus	summer flounder	0.0	0.0	0.3	0.0	0.0	0.0
Sciaenops ocellatus	red drum	0.0	0.0	0.3	0.0	0.0	0.3
Decapods:							
Callinectes sapidus	blue crab	12.0^{A}	0.7^{AB}	0.3^{AB}	0.0^{B}	0.3^{AB}	3.0^{AB}
Rhithropanopeus harrisii	white-fingered mud crab	0.0	0.0	0.0	0.0	0.3	0.0
Palaemonetes pugio	grass shrimp	960.3^{AB}	118.0^{B}	2187.3^{A}	645.7^{AB}	208.7^{B}	926.0^{AB}

Table 6. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collection at the Poplar Island restored Cell 1C marsh based on seral stage for spring, summer, and fall collection periods. A different letter within specified seasons indicates significantly different ($p \leq 0.05$) abundances among seral stages (years) for that species.

		Date				Date				Date			
Species	Common Name	4/12	4/13	4/14	4/16	7/12	7/13	7/14	7/16	10/12	11/13	10/14	10/16
Fishes:													
Anchoa mitchilli	bay anchovy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0
Anguilla rostrata	American eel	0.3	0.0	0.0	0.0	0.3	0.7	0.0	0.0	0.0	0.0	0.0	0.0
Cyprinodon variegatus	sheepshead minnow	0.3	0.3	0.0	1.3	1.0^{B}	1.0^{B}	0.3^{B}	46.7^{A}	1.3	3.3	1.7	44.7
Fundulus diaphanus	banded killifish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0^{B}	0.0^{B}	0.0^{B}	3.7^{A}
Fundulus heteroclitus	mummichog	8.7^{B}	9.3^{B}	73.3^{A}	252.0^{A}	275.3	767.3	857.3	848.0	33.0	237.7	791.3	301.3
Fundulus majalis	striped killifish	0.0	1.0	0.0	3.3	0.7^{B}	0.0^{B}	32.3^{A}	12.0^{AB}	0.0	0.0	1.0	1.3
Gobiosoma bosc	naked goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.3
Leiostomus xanthurus	spot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Lucania parva	rainwater killifish	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0
Menidia beryllina	inland silverside	0.3	0.0	0.0	2.0	27.7	4.0	49.7	6.0	0.3^{B}	22.0^{A}	28.3^{A}	2.0^{B}
Menidia menidia	Atlantic silverside	0.0^{B}	0.0^{B}	0.0^{B}	8.3^{A}	86.3	21.3	0.0	5.0	0.0	2.0	0.0	1.0
Micropogon undulatus	Atlantic croaker	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Morone americana	white perch	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syngnathus fuscus	northern pipefish	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Decapods:													
Callinectes sapidus	blue crab	0.0	0.0	0.0	0.3	3.7	2.0	2.0	1.3	0.0	0.0	0.0	1.7
Palaemonetes pugio	grass shrimp	162.7^{AB}	144.3^{AB}	22.7^{B}	496.0^{A}	382.0	132.7	293.3	173.0	763.3^{A}	517.3^{A}	122.3^{B}	143.3^{B}

Table 7. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collection at the Poplar Island restored Cell 1B marsh based on seral stage for spring, summer, and fall collection periods. A different letter within specified seasons indicates significantly different ($p \leq 0.05$) abundances among seral stages (years) for that species.

Species	Common Name	---------- Date ----------			---------- Date ----------			----------- Date ----------		
		4/13	4/14	4/16	7/13	7/14	7/16	11/13	10/14	10/16
Fishes:										
Anguilla rostrata	American eel	0.0	0.3	0.0	0.0	0.0	0.0	0.3	0.3	0.0
Cyprinodon variegatus	sheepshead minnow	0.0	0.3	1.7	7.3^{B}	0.0^{B}	209.7^{A}	2.7	2.3	13.0
Fundulus diaphanus	banded killifish	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
Fundulus heteroclitus	mummichog	70.0	150.7	267.3	1282.7	1021.7	1351.7	608.0	321.7	380.0
Fundulus majalis	striped killifish	2.3	0.0	1.0	0.0^{B}	22.7^{A}	15.0^{A}	11.0	3.0	0.7
Gobiosoma bosc	naked goby	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Gobiesox strumosus	skillet fish	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Lucania parva	rainwater killifish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0
Menidia beryllina	inland silverside	0.7	0.7	2.7	168.7	74.0	16.0	4.7^{B}	203.7^{A}	0.0^{C}
Menidia menidia	Atlantic silverside	0.0	0.3	1.0	266.7	28.0	2.3	2.0	21.0	0.0
Morone americana	white perch	0.7	0.7	0.0	0.7	1.0	0.0	0.0	0.0	0.0
Morone saxatilis	striped bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Decapods:										
Callinectes sapidus	blue crab	0.0	3.7	0.0	7.7	9.0	1.3	0.3	0.3	0.7
Rhithropanopeus harrisii	white-fingered mud crab	0.0	0.0	0.0	0.0	0.3	0.0	0.0	1.0	0.0
Palaemonetes pugio	grass shrimp	211.0^{B}	614.0^{A}	82.7^{B}	479.0^{A}	175.7^{B}	30.7^{C}	1572.0	1374.7	1017.0

from one another (Figure 7).

Abundance comparisons during 2016 for individual nekton species between reference and Cell 1A marshes demonstrated that no significant differences were apparent during the spring, however, significant differences were apparent during the summer for mummichog where Cell 1A > reference, and for striped killifish where reference > Cell 1A (Table 8). During fall 2016, significant differences were only apparent for abundances of sheepshead minnow where reference > Cell 1A (Table 8).

During 2016, abundance comparisons for individual nekton species between reference and Cell 1C marshes revealed significant differences during the spring for sheepshead minnow where reference > Cell 1C, and for mummichog and grass shrimp where Cell 1C > reference. During summer 2016 significant abundance differences occurred for sheepshead minnow and striped killifish where reference > Cell 1C, and for mummichog where Cell 1C > reference (Table 9). During fall 2016, significant differences were only apparent for abundances of striped killifish where reference > Cell 1C (Table 9).

Abundance comparisons during 2016 for individual nekton species between reference and Cell 1B marshes revealed significant differences during the spring for sheepshead minnow where reference > Cell 1B, and mummichog where Cell 1B > reference (Table 10). During summer 2016, significant abundance differences occurred for striped killifish where reference > Cell B, and for mummichog where Cell 1B > reference (Table 10). During fall 2016, significant abundance differences occurred for sheepshead minnow and striped killifish where reference > Cell 1B (Table 10).

Abundance comparisons during 2016 for individual nekton species between reference and Cell 3A marshes demonstrated significant differences during the spring for sheepshead minnow

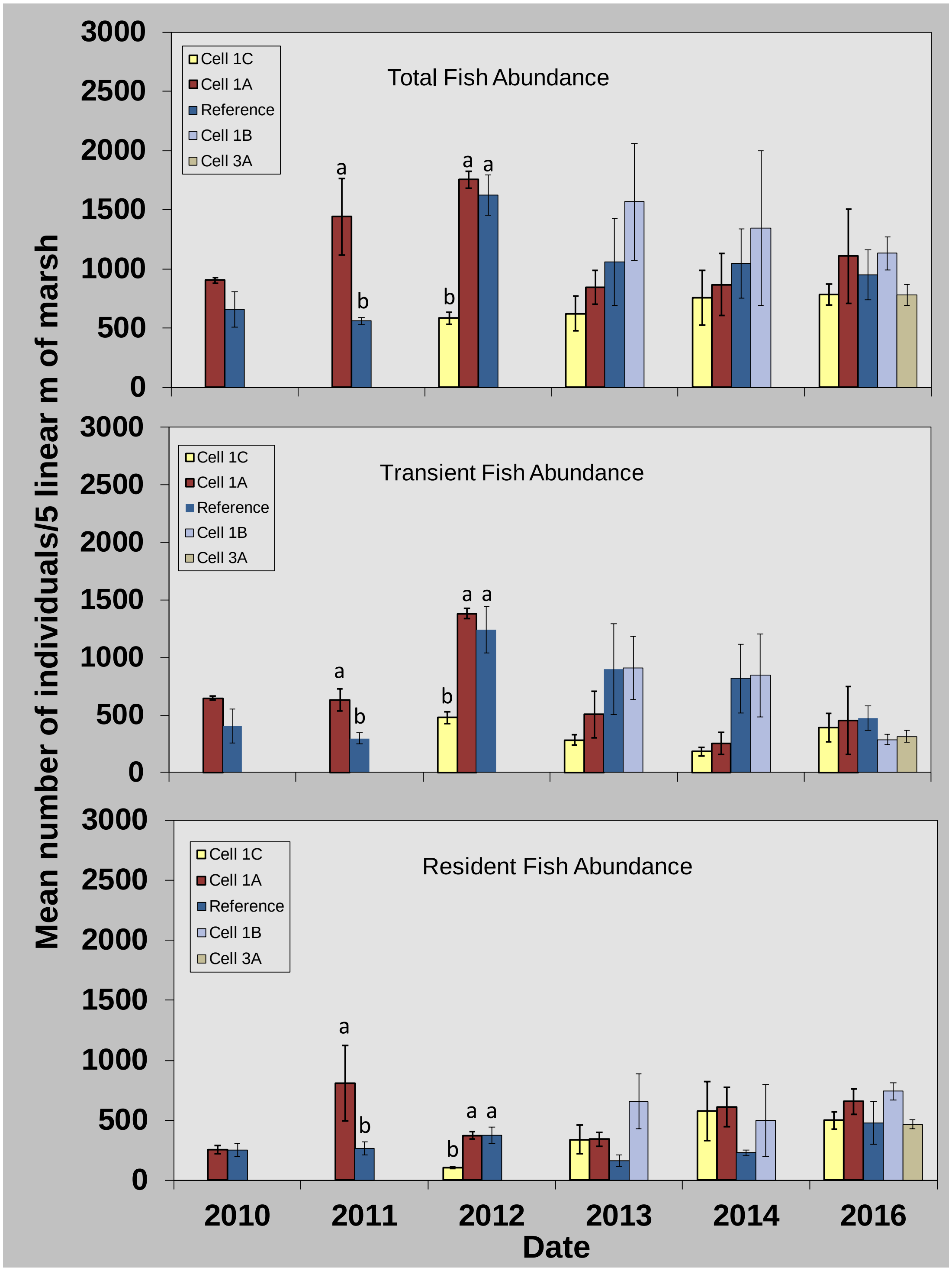

Figure 7. Comparison among marsh types, per collection year, for the mean number of individuals collected per 5 linear meters of marsh via fyke nets. Significant differences ($p \leq 0.05$) between collection marsh types, per collection year, are indicated by a different letter.

Table 8. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collected in fyke nets within reference area marshes (RA) and Poplar Island restored Cell 1A (1A) marsh. * Indicates significantly different ($p \leq 0.05$) abundances between areas during that collection period for that species.

		4/10		4/11		4/12		4/13		4/14		4/16	
Species	Common Name	RA	1A	RA	1A	RA	1A	RA	1A	RA	1A	RA	1A
Fishes:													
Alosa pseudoharangus	alewife	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anchoa mitchilli	bay anchovy	1.2	0.0	0.0	0.0	2.8	0.0	0.4	0.0	0.0	0.0	0.0	0.0
Anguilla rostrata	American eel	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.0
Apeltes quadracus	fourspine stickleback	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brevoortia tyrannus	Atlantic menhaden	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chasmodes bosquianus	striped blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cynoscion nebulosus	spotted seatrout	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cynoscion regalis	weakfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyprinella analostana	satinfin shiner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Cyprinodon variegatus	sheepshead minnow	25.6*	0.0*	5.5*	0.0*	40.5	1.1	1.6	0.0	1.3	0.0	33.5	5.7
Dorosoma cepedianum	gizzard shad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus diaphanus	banded killifish	0.0*	2.3*	1.8	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus heteroclitus	mummichog	336.3*	100.7*	132.2	345.7	412.8	470.7	46.6	23.0	100.5	77.0	95.8	315.7
Fundulus luciae	spotfin killifish	0.1	0.0	3.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus majalis	striped killifish	0.5	0.3	2.8	0.0	0.6	0.0	0.2	0.3	0.5	2.3	1.5	0.7
Gobiosoma bosc	naked goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gobiesox strumosus	skillet fish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gambusia affinis	mosquito fish	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leiostomus xanthurus	spot	0.0	0.0	0.0	0.0	0.9*	9.3*	0.5	2.0	0.0	0.0	0.0	0.0
Lepomis gibbosus	pumpkinseed	0.2	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Lepomis macrochrius	bluegill sunfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lucania parva	rainwater killifish	2.5	0.3	1.0	0.0	0.1	0.0	2.5	0.0	0.0	0.0	1.6	0.0
Menidia beryllina	inland silverside	0.3	0.0	3.3	0.0	17.2	0.3	0.0	3.7	0.2	0.7	4.9	1.3
Menidia menidia	Atlantic silverside	0.0	0.0	1.5	0.0	1.0	9.0	0.0	1.3	0.2	0.0	12.6	3.3
Morone americana	white perch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0
Morone saxatilis	striped bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Paralichthys dentatus	summer flounder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pogonias cromis	black drum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pomatomus saltatrix	bluefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sciaenops ocellatus	red drum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strongylura marina	Atlantic needlefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syngnathus fuscus	northern pipefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syngnathus louisianae	chained pipefish	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Decapods:													
Callinectes sapidus	blue crab	0.2	1.3	0.0	0.0	0.1	0.7	0.0	0.7	0.0	1.0	0.1	0.7
Rhithropanopeus harrisii	white-fingered mud crab	0.3	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Palaemonetes pugio	grass shrimp	364.9	156.0	177.0	319.0	393.8	210.0	111.1	63.3	41.8	162.3	43.3	68.0
Uca minax	fiddler crab	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 8. Continued.

Species	Common Name	7/10 RA	7/10 1A	7/11 RA	7/11 1A	7/12 RA	7/12 1A	7/13 RA	7/13 1A	7/14 RA	7/14 1A	7/16 RA	7/16 1A
Fishes:													
Alosa pseudoharangus	alewife	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anchoa mitchilli	bay anchovy	0.0	0.0	0.4	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
Anguilla rostrata	American eel	1.6	0.0	6.9	0.0	0.6	0.3	2.4	0.7	7.3*	0.0*	0.9	0.0
Apeltes quadracus	fourspine stickleback	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Brevoortia tyrannus	Atlantic menhaden	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.2	0.0
Chasmodes bosquianus	striped blenny	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cynoscion nebulosus	spotted seatrout	0.1	0.0	0.1	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cynoscion regalis	weakfish	0.0	0.3	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Cyprinella analostana	satinfin shiner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyprinodon variegatus	sheepshead minnow	22.9	0.3	49.0*	0.0*	109.1*	0.0*	22.6*	0.3*	115.7*	2.0*	732.4	224.0
Dorosoma cepedianum	gizzard shad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus diaphanus	banded killifish	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2	0.0
Fundulus heteroclitus	mummichog	206.1	450.3	170.6*	1754.0*	210.4	380.3	184.0*	830.3*	236.8*	895.0*	270.6*	1132.3*
Fundulus luciae	spotfin killifish	0.1	0.0	2.5	0.0	1.1	0.0	2.1	0.0	0.0	0.0	0.6	0.3
Fundulus majalis	striped killifish	16.8	18.3	2.6	0.3	14.2	6.3	33.5*	0.0*	36.3*	0.3*	62.1*	30.3*
Gobiosoma bosc	naked goby	0.0	0.0	0.4	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gobiesox strumosus	skillet fish	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gambusia affinis	mosquito fish	1.5	0.0	0.1	0.3	0.6	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Leiostomus xanthurus	spot	21.1	41.0	0.0	0.0	0.8	0.0	1.2	0.0	0.0	0.0	0.2	0.0
Lepomis gibbosus	pumpkinseed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lepomis macrochrius	bluegill sunfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lucania parva	rainwater killifish	2.1	0.3	1.0	0.0	3.4	0.0	0.2	0.0	19.8	0.3	12.9	0.0
Menidia beryllina	inland silverside	9.1	45.0	97.1	7.0	37.8	72.3	95.4	19.0	148.5	23.7	31.1	13.0
Menidia menidia	Atlantic silverside	78.5	70.0	53.0	13.0	7.4	77.0	40.5	53.7	354.8	105.7	11.0	5.7
Morone americana	white perch	0.5	1.7	19.6	4.7	0.4	0.0	1.2	0.0	2.7	1.0	0.2	0.0
Morone saxatilis	striped bass	0.6	0.3	0.8	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0
Paralichthys dentatus	summer flounder	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pogonias cromis	black drum	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Pomatomus saltatrix	bluefish	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sciaenops ocellatus	red drum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strongylura marina	Atlantic needlefish	0.1	0.0	0.2	0.0	0.1	0.0	0.2	0.0	0.0	0.0	0.6	0.0
Syngnathus fuscus	northern pipefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syngnathus louisianae	chained pipefish	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Decapods:													
Callinectes sapidus	blue crab	27.8	31.7	12.5	11.3	36.8	23.3	14.9	7.3	4.7	9.0	8.2	2.3
Rhithropanopeus harrisii	white-fingered mud crab	0.2	0.0	0.5	0.0	1.0	0.0	0.0	0.0	0.7	0.0	0.5	0.0
Palaemonetes pugio	grass shrimp	440.4	480.0	239.8*	1389.3*	790.3	1533.0	1724.5	601.7	448.0	188.0	559.1	270.3
Uca minax	fiddler crab	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 8. Continued.

Species	Common Name	10/10 RA	10/10 1A	10/11 RA	10/11 1A	10/12 RA	10/12 1A	11/13 RA	11/13 1A	10/14 RA	10/14 1A	10/16 RA	10/16 1A
Fishes:													
Alosa pseudoharangus	alewife	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anchoa mitchilli	bay anchovy	0.7	0.0	0.0	0.0	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anguilla rostrata	American eel	1.1	0.0	1.2	1.3	0.2	0.0	0.7	0.0	3.3*	0.0*	0.3	0.3
Apeltes quadracus	fourspine stickleback	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brevoortia tyrannus	Atlantic menhaden	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Chasmodes bosquianus	striped blenny	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Cynoscion nebulosus	spotted seatrout	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cynoscion regalis	weakfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyprinella analostana	satinfin shiner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyprinodon variegatus	sheepshead minnow	39.8*	0.0*	187.0*	0.3*	136.5	4.3	10.5	2.0	43.7*	2.7*	176.7*	31.7*
Dorosoma cepedianum	gizzard shad	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus diaphanus	banded killifish	0.1	0.0	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0
Fundulus heteroclitus	mummichog	157.7	216.0	236.9	329.0	207.0	260.7	235.7	173.0	194.3	856.7	138.7	263.0
Fundulus luciae	spotfin killifish	0.1	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus majalis	striped killifish	21.0	97.7	1.2	1.0	10.4	11.7	8.0*	0.0*	94.7	10.7	13.8	18.7
Gobiosoma bosc	naked goby	0.1	0.0	0.1	0.0	8.0	1.7	1.2	0.0	0.2	0.3	2.0	0.7
Gobiesox strumosus	skillet fish	0.8*	0.0*	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.8	0.0
Gambusia affinis	mosquito fish	1.1	2.0	1.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leiostomus xanthurus	spot	12.2	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lepomis gibbosus	pumpkinseed	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lepomis macrochrius	bluegill sunfish	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lucania parva	rainwater killifish	1.0	0.0	1.5	0.0	1.2	0.0	0.5	0.0	4.3	0.0	2.5	0.0
Menidia beryllina	inland silverside	14.0	2.0	15.6	3.0	2.9	1.0	5.0*	102.7*	0.0*	47.0*	15.5	8.0
Menidia menidia	Atlantic silverside	130.0*	1.7*	3.5	6.7	3.9	0.0	0.3	13.7	463.0	8.7	6.0	0.7
Morone americana	white perch	0.7	0.0	0.0*	15.0*	0.2	0.0	0.5	0.0	0.0	0.0	0.0	0.0
Morone saxatilis	striped bass	0.0	0.7	0.1*	1.0*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Paralichthys dentatus	summer flounder	0.0	0.0	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Pogonias cromis	black drum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pomatomus saltatrix	bluefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sciaenops ocellatus	red drum	0.0	0.0	0.0	0.0	4.2*	0.3*	0.0	0.0	0.5	0.0	2.3	0.3
Strongylura marina	Atlantic needlefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syngnathus fuscus	northern pipefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Syngnathus louisianae	chained pipefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Decapods:													
Callinectes sapidus	blue crab	12.4	12.0	1.0	0.7	5.1*	0.3*	3.0	0.0	0.0	0.3	2.0	3.0
Rhithropanopeus harrisii	white-fingered mud crab	0.1	0.0	0.5	0.0	0.1	0.0	0.8	0.0	0.7	0.3	0.0	0.0
Palaemonetes pugio	grass shrimp	242.9	960.3	183.5	118.0	2387.6	2187.3	723.8	645.7	343.0	208.7	630.3	926.0
Uca minax	fiddler crab	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 9. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collected in fyke nets within reference area marshes (RA) and Poplar Island restored Cell 1C (1C) marsh for spring, summer, and fall collection periods. * Indicates significantly different ($p \leq 0.05$) abundances between areas during that collection period for that species.

		4/12		4/13		4/14		4/16		7/12		7/13		7/14		7/16	
Species	Common Name	RA	1C	RA	1C	RA	1C	RA	1C	RA	1C	RA	1C	RA	1C	RA	1C
Fishes:																	
Alosa pseudoharangus	alewife	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anchoa mitchilli	bay anchovy	2.8	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
Anguilla rostrata	American eel	0.0	0.3	0.1	0.0	0.0	0.0	0.2	0.0	0.6	0.3	2.4	0.7	7.3*	0.0*	0.9	0.0
Apeltes quadracus	fourspine stickleback	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Brevoortia tyrannus	Atlantic menhaden	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Chasmodes bosquianus	striped blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cynoscion nebulosus	spotted seatrout	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cynoscion regalis	weakfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Cyprinella analostana	satinfin shiner	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyprinodon variegatus	sheepshead minnow	40.5*	0.3*	1.6	0.3	1.3	0.0	33.5*	1.3*	109.1*	1.0*	22.6*	1.0*	115.7*	0.3*	732.4*	46.7*
Dorosoma cepedianum	gizzard shad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus diaphanus	banded killifish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2	0.0
Fundulus heteroclitus	mummichog	412.8*	8.7*	46.6	9.3	100.5	73.3	95.8*	252.0*	210.4	275.3	184.0*	767.3*	236.8	857.3	270.6*	848.0*
Fundulus luciae	spotfin killifish	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	2.1	0.0	0.0	0.0	0.6	0.0
Fundulus majalis	striped killifish	0.6	0.0	0.2	1.0	0.5	0.0	1.5	3.3	14.2	0.7	33.5*	0.0*	36.3	32.3	62.1*	12.0*
Gobiosoma bosc	naked goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gobiesox strumosus	skillet fish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gambusia affinis	mosquito fish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leiostomus xanthurus	spot	0.9	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.8	0.0	1.2	0.0	0.0	0.0	0.2	0.0
Lepomis gibbosus	pumpkinseed	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lepomis macrochrius	bluegill sunfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lucania parva	rainwater killifish	0.1	0.0	2.5	0.0	0.0	0.0	1.6	0.0	3.4	0.0	0.2	0.0	19.8	1.3	12.9	0.0
Menidia beryllina	inland silverside	17.2	0.3	0.0	0.0	0.2	0.0	4.9	2.0	37.8	27.7	95.4*	4.0*	148.5	49.7	31.1	6.0
Menidia menidia	Atlantic silverside	1.0	0.0	0.0	0.0	0.2	0.0	12.6	8.3	7.4	86.3	40.5	21.3	354.8*	0.0*	11.0	5.0
Micropogon undulatus	Atlantic croaker	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Morone americana	white perch	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.4	0.0	1.2	0.0	2.7	0.0	0.2	0.0
Morone saxatilis	striped bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Paralichthys dentatus	summer flounder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pogonias cromis	black drum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Pomatomus saltatrix	bluefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sciaenops ocellatus	red drum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0
Strongylura marina	Atlantic needlefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Syngnathus fuscus	northern pipefish	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syngnathus louisianae	chained pipefish	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Decapods:																	
Callinectes sapidus	blue crab	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.3	36.8	3.7	14.9	2.0	4.7	2.0	8.2	1.3
Rhithropanopeus harrisii	white-fingered mud crab	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.7	0.0	0.5	0.0
Palaemonetes pugio	grass shrimp	393.8	162.7	111.1	144.3	41.8	22.7	43.3*	496.0*	790.3	382.0	1724.5*	132.7*	448.0	293.3	559.1	173.0
Uca minax	fiddler crab	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 9. Continued.

Species	Common Name	10/12 RA	10/12 1C	11/13 RA	11/13 1C	10/14 RA	10/14 1C	10/16 RA	10/16 1C
Fishes:									
Alosa pseudoharangus	alewife	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anchoa mitchilli	bay anchovy	8.1	3.0	0.0	0.0	0.0	0.0	0.0	0.0
Anguilla rostrata	American eel	0.2	0.0	0.7	0.0	3.3*	0.0*	0.3	0.0
Apeltes quadracus	fourspine stickleback	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brevoortia tyrannus	Atlantic menhaden	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chasmodes bosquianus	striped blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Cynoscion nebulosus	spotted seatrout	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cynoscion regalis	weakfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyprinella analostana	satinfin shiner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyprinodon variegatus	sheepshead minnow	136.5	1.3	10.5	3.3	43.7*	1.7*	176.7	44.7
Dorosoma cepedianum	gizzard shad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus diaphanus	banded killifish	0.0	0.0	0.0	0.0	0.0	0.0	1.8	3.7
Fundulus heteroclitus	mummichog	207.0	33.0	235.7	237.7	194.3	791.3	138.7	301.3
Fundulus luciae	spotfin killifish	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus majalis	striped killifish	10.4	0.0	8.0*	0.0*	94.7*	1.0*	13.8*	1.3*
Gobiosoma bosc	naked goby	8.0	1.0	1.2	0.0	0.2	0.0	2.0	0.3
Gobiesox strumosus	skillet fish	0.0	0.0	0.2	0.0	0.0	0.0	0.8	0.0
Gambusia affinis	mosquito fish	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leiostomus xanthurus	spot	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Lepomis gibbosus	pumpkinseed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lepomis macrochrius	bluegill sunfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lucania parva	rainwater killifish	1.2	0.0	0.5	0.0	4.2	0.0	2.5	0.0
Menidia beryllina	inland silverside	2.9	0.3	5.0	22.0	0.0*	28.3*	15.5	2.0
Menidia menidia	Atlantic silverside	3.9	0.0	0.3	2.0	463.0*	0.0*	6.0	1.0
Micropogon undulatus	Atlantic croaker	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Morone americana	white perch	0.2	0.0	0.5	0.0	0.0	0.0	0.0	0.0
Morone saxatilis	striped bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Paralichthys dentatus	summer flounder	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pogonias cromis	black drum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pomatomus saltatrix	bluefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sciaenops ocellatus	red drum	4.2*	0.0*	0.0	0.0	0.5	0.0	2.3	0.0
Strongylura marina	Atlantic needlefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syngnathus fuscus	northern pipefish	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Syngnathus louisianae	chained pipefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Decapods:									
Callinectes sapidus	blue crab	5.1*	0.0*	3.0	0.0	0.0	0.0	2.0	1.7
Rhithropanopeus harrisii	white-fingered mud crab	0.1	0.0	0.8	0.0	0.7	0.0	0.0	0.0
Palaemonetes pugio	grass shrimp	2387.6*	763.3*	723.8	517.3	343.0	122.3	630.3	143.3
Uca minax	fiddler crab	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 10. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collected in fyke nets within reference area marshes (RA) and Poplar Island restored Cell 1B (1B) marsh for spring, summer, and fall collection periods. * Indicates significantly different ($p \leq 0.05$) abundances between areas during that collection period for that species.

		4/13		4/14		4/16		7/13		7/14		7/16		11/13		10/14		10/16	
Species	Common Name	RA	1B	RA	1B	RA	1B	RA	1B	RA	1B	RA	1B	RA	1B	RA	1B	RA	1B
Fishes:																			
Anchoa mitchilli	bay anchovy	0.4	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anguilla rostrata	American eel	0.1	0.0	0.0	0.3	0.2	0.0	2.4	0.0	7.3*	0.0*	0.9	0.0	0.7	0.3	3.3	0.3	0.3	0.0
Apeltes quadracus	fourspine stickleback	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brevoortia tyrannus	Atlantic menhaden	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chasmodes bosquianus	striped blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Cynoscion regalis	weakfish	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyprinella analostana	satinfin shiner	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyprinodon variegatus	sheepshead minnow	1.6	0.0	1.3	0.3	33.5*	1.7*	22.6	7.3	115.7*	0.0*	732.4	209.7	10.5	2.7	43.7*	2.3*	176.7*	13.0*
Fundulus diaphanus	banded killifish	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.0	2.0	0.0	0.0	1.8	0.0
Fundulus heteroclitus	mummichog	46.6	70.0	100.5	150.7	95.8*	267.3*	184.0*	1282.7*	236.8*	1021.7*	270.6*	1351.7*	235.7	608.0	194.3	321.7	138.7	380.0
Fundulus luciae	spotfin killifish	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus majalis	striped killifish	0.2	2.3	0.5	0.0	1.5	1.0	33.5*	0.0*	36.3	22.7	62.1*	15.0*	8.0	11.0	94.7	3.0	13.8*	0.7*
Gobiosoma bosc	naked goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.3	0.2	0.0	2.0	0.0
Gobiesox strumosus	skillet fish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.8	0.0
Leiostomus xanthurus	spot	0.5	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lepomis gibbosus	pumpkinseed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lucania parva	rainwater killifish	2.5	0.0	0.0	0.0	1.6	0.0	0.2	0.0	19.8	0.0	12.9	0.0	0.5	0.0	4.3	0.7	2.5	0.0
Menidia beryllina	inland silverside	0.0	0.7	0.2	0.7	4.9	2.7	95.4	168.7	148.5	74.0	31.1	16.0	5.0	4.7	0.0*	203.7*	15.5	0.0
Menidia menidia	Atlantic silverside	0.0	0.0	0.2	0.3	12.6	1.0	40.5	266.7	354.8	28.0	11.0	2.3	0.3	2.0	463.0	21.0	6.0	0.0
Morone americana	white perch	0.0	0.7	0.0	0.7	0.0	0.0	1.2	0.7	2.7	1.0	0.2	0.0	0.5	0.0	0.0	0.0	0.0	0.0
Morone saxatilis	striped bass	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pogonias cromis	black drum	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sciaenops ocellatus	red drum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0
Strongylura marina	Atlantic needlefish	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syngnathus fuscus	northern pipefish	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Syngnathus louisianae	chained pipefish	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Decapods:																			
Callinectes sapidus	blue crab	0.0	0.0	0.0	3.7	0.1	0.0	14.9	7.7	4.7	9.0	8.2	1.3	3.0	0.3	0.0	0.3	2.0	0.7
Rhithropanopeus harrisii	white-fingered mud crab	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.3	0.5	0.0	0.8	0.0	0.7	1.0	0.0	0.0
Palaemonetes pugio	grass shrimp	111.1	211.0	41.8*	614.0*	43.3	82.7	1724.5	479.0	448.0	175.7	559.1	30.7	723.8	1572.0	343.0	1347.7	630.3	1017.0

where reference > Cell 3A, and grass shrimp where Cell 3A > reference (Table 11). During summer 2016, significant abundance differences occurred for sheepshead minnow and striped killifish where reference > Cell 3A, and for mummichog where Cell 3A > reference (Table 11). During fall 2016, significant abundance differences occurred for sheepshead minnow and striped killifish where reference > Cell 3A (Table 11).

Individual species abundance comparison between baseline (remnant marshes, 1995-96) and Cell 1A 2016 marsh collections revealed significant abundance increases for marsh resident and transient nekton species during post- versus pre-restoration (Table 12). During 2016, the nekton species sheepshead minnow, mummichog, and grass shrimp - three of the four target forage marsh nekton species (sheepshead minnow, mummichog, striped killifish, and grass shrimp) targeted in the Poplar Island 2015 FMD to benefit from the Poplar Island restoration over baseline conditions - were significantly more abundant within Cell 1A marsh during spring, summer, and fall than within the remnant marshes while striped killifish were significantly more abundant within Cell 1A marsh during summer than within the remnant marshes (Table 12). During spring 2016, the abundance of the transient species Atlantic silverside was significantly greater within Cell 1A marsh compared to the remnant marsh baseline (Table 12). The opposite occurred during summer 2016, where Atlantic silverside abundance was significantly greater within the remnant marsh baseline compared to Cell 1A marsh. During fall 2016, abundance of the transient species inland silverside was significantly greater within Cell 1A compared to the remnant marsh baseline (Table 12).

Comparison of 2016 Cell 1C collections to the baseline remnant marsh collections demonstrated that the target species mummichog and grass shrimp, as well as the transient species Atlantic silverside, were significantly more abundant within Cell 1C marsh during spring than within the remnant marshes during baseline (Table 13). During summer 2016, the target species

Table 11. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collected in fyke nets within reference area marshes (RA) and Poplar Island restored Cell 3A (3A) marsh for spring, summer, and fall collection periods. * Indicates significantly different ($p \leq 0.05$) abundances between areas during that collection period for that species.

		4/16		7/16		10/16	
Species	Common Name	RA	3A	RA	3A	RA	3A
Fishes:							
Anguilla rostrata	American eel	0.2	0.7	0.9	2.7	0.3	0.7
Apeltes quadracus	fourspine stickleback	0.0	0.0	0.1	0.0	0.0	0.0
Brevoortia tyrannus	Atlantic menhaden	0.0	0.0	0.2	0.0	0.0	0.0
Chasmodes bosquianus	striped blenny	0.0	0.0	0.0	0.0	0.2	0.0
Cyprinodon variegatus	sheepshead minnow	33.5*	3.7*	732.4*	2.0*	176.7*	0.0*
Fundulus diaphanus	banded killifish	0.0	0.3	0.2	0.0	1.8	0.0
Fundulus heteroclitus	mummichog	95.8	75.3	270.6*	888.0*	138.7	423.3
Fundulus luciae	spotfin killifish	0.0	0.0	0.6	0.0	0.0	0.0
Fundulus majalis	striped killifish	1.5	0.3	62.1*	3.7*	13.8*	0.0*
Gobiosoma bosc	naked goby	0.0	0.0	0.0	0.0	2.0	0.3
Gobiesox strumosus	skillet fish	0.0	0.0	0.0	0.0	0.8	0.0
Leiostomus xanthurus	spot	0.0	0.3	0.2	0.0	0.0	0.0
Lucania parva	rainwater killifish	1.6	0.3	12.9	5.0	2.5	1.7
Menidia beryllina	inland silverside	4.9	8.7	31.1	8.7	15.5	1.3
Menidia menidia	Atlantic silverside	12.6	6.7	11.0	2.3	6.0	0.0
Morone americana	white perch	0.0	0.7	0.2	0.0	0.0	0.0
Sciaenops ocellatus	red drum	0.0	0.0	0.0	0.0	2.3	0.0
Strongylura marina	Atlantic needlefish	0.0	0.0	0.6	0.0	0.0	0.0
Syngnathus fuscus	northern pipefish	0.0	0.0	0.0	0.0	0.3	0.0
Decapods:							
Callinectes sapidus	blue crab	0.1	0.3	8.2	2.3	2.0	0.7
Rhithropanopeus harrisii	white-fingered mud crab	0.0	0.0	0.5	0.0	0.0	0.0
Palaemonetes pugio	grass shrimp	43.3*	502.2*	559.1	95.0	630.3	305.7

Table 12. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collected in fyke nets within Poplar Island remnant marshes (PR) compared to Poplar Island restored Cell 1A (1A) marsh for spring, summer, and fall collection periods. * Indicates significantly different (p $\leq$ 0.05) abundances between treatments for that species.

		Spring											
Species	Common Name	PR (1996)	1A (2010)	PR (1996)	1A (2011)	PR (1996)	1A (2012)	PR (1996)	1A (2013)	PR (1996)	1A (2014)	PR (1996)	1A (2016)
Fishes:													
Anchoa mitchilli	bay anchovy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anguilla rostrata	American eel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brevoortia tyrannus	Atlantic menhaden	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chasmodes bosquianus	striped blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cynoscion regalis	weakfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyprinodon variegatus	sheepshead minnow	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0*	5.7*
Dorosoma cepedianum	gizzard shad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus diaphanus	banded killifish	0.0	2.3	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus heteroclitus	mummichog	0.1*	100.7*	0.1*	345.7*	0.1*	470.7*	0.1*	23.0*	0.1*	77.0*	0.1*	315.7*
Fundulus luciae	spotfin killifish	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Fundulus majalis	striped killifish	0.2	0.3	0.2	0.0	0.2	0.0	0.2	0.3	0.2	2.3	0.2	0.7
Gambusia affinis	mosquito fish	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gobiosoma bosc	naked goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gobiesox strumosus	skillet fish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leiostomus xanthurus	spot	0.0	0.0	0.0	0.0	0.0*	9.3*	0.0	2.0	0.0	0.0	0.0	0.0
Lepomis gibbosus	pumpkinseed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lepomis macrochrius	bluegill sunfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lucania parva	rainwater killifish	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Menidia beryllina	inland silverside	0.0	0.0	0.0	0.0	0.0	0.3	0.0	3.7	0.0	0.7	0.0	1.3
Menidia menidia	Atlantic silverside	0.0	0.0	0.0	0.0	0.0	9.0	0.0	1.3	0.0	0.0	0.0*	3.3*
Morone americana	white perch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.3
Morone saxatilis	striped bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Paralichthys dentatus	summer flounder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pogonias cromis	black drum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sciaenops ocellatus	red drum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syngnathus fuscus	northern pipefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Decapods:													
Callinectes sapidus	blue crab	0.0	1.3	0.0	0.0	0.0	0.7	0.0	0.7	0.0	1.0	0.0	0.7
Eurypanopeus depressus	flat mud crab	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhithropanopeus harrisii	white-fingered mud crab	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Crangon septemspinosa	sand shrimp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Palaemonetes pugio	grass shrimp	0.9	156.0	0.9*	319.0*	0.9*	210.0*	0.9*	63.3*	0.9*	162.3*	0.9*	68.0*
Palaemonetes vulgaris	grass shrimp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 12. Continued.

Species	Common Name	Summer											
		PR (1996)	1A (2010)	PR (1996)	1A (2011)	PR (1996)	1A (2012)	PR (1996)	1A (2013)	PR (1996)	1A (2014)	PR (1996)	1A (2016)
Fishes:													
Anchoa mitchilli	bay anchovy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anguilla rostrata	American eel	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.7	0.0	0.0	0.0	0.0
Brevoortia tyrannus	Atlantic menhaden	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chasmodes bosquianus	striped blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cynoscion regalis	weakfish	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyprinodon variegatus	sheepshead minnow	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.0	2.0	0.0*	224.0*
Dorosoma cepedianum	gizzard shad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus diaphanus	banded killifish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus heteroclitus	mummichog	4.0*	450.3*	4.0*	1754.0*	4.0*	380.3*	4.0*	830.3*	4.0*	895.0*	4.0*	1132.3*
Fundulus luciae	spotfin killifish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus majalis	striped killifish	0.6*	18.3*	0.6	0.3	0.6	6.3	0.6	0.0	0.6	0.3	0.6*	30.3*
Gambusia affinis	mosquito fish	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Gobiosoma bosc	naked goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gobiesox strumosus	skillet fish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leiostomus xanthurus	spot	0.0*	41.0*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lepomis gibbosus	pumpkinseed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lepomis macrochrius	bluegill sunfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lucania parva	rainwater killifish	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Menidia beryllina	inland silverside	6.5	45.0	6.5	7.0	6.5	72.3	6.5	19.0	6.5	23.7	6.5	13.0
Menidia menidia	Atlantic silverside	145.3	70.0	145.3*	13.0*	145.3	77.0	145.3	53.7	145.3	105.7	145.3*	5.7*
Morone americana	white perch	2.0	1.7	2.0	4.7	2.0	0.0	2.0	0.0	2.0	1.0	2.0	0.0
Morone saxatilis	striped bass	4.9	0.3	4.9	0.0	4.9	0.0	4.9	0.0	4.9	0.3	4.9	0.0
Paralichthys dentatus	summer flounder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sciaenops ocellatus	red drum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syngnathus fuscus	northern pipefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Decapods:													
Callinectes sapidus	blue crab	7.0*	31.7*	7.0	11.3	7.0*	23.3*	7.0	7.3	7.0	9.0	7.0	2.3
Eurypanopeus depressus	flat mud crab	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhithropanopeus harrisii	white-fingered mud crab	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crangon septemspinosa	sand shrimp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Palaemonetes pugio	grass shrimp	0.1*	480.0*	0.1*	1389.3*	0.1*	1533.0*	0.1*	601.7*	0.1*	188.0*	0.1*	270.3*
Palaemonetes vulgaris	grass shrimp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 12. Continued.

Species	Common Name	Fall PR (1996)	Fall 1A (2010)	Fall PR (1996)	Fall 1A (2011)	Fall PR (1996)	Fall 1A (2012)	Fall PR (1996)	Fall 1A (2013)	Fall PR (1996)	Fall 1A (2014)	Fall PR (1996)	Fall 1A (2016)
Fishes:													
Anchoa mitchilli	bay anchovy	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Anguilla rostrata	American eel	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brevoortia tyrannus	Atlantic menhaden	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Chasmodes bosquianus	striped blenny	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Cynoscion regalis	weakfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyprinodon variegatus	sheepshead minnow	0.0	0.0	0.0	0.3	0.0*	4.3*	0.0	2.0	0.0	2.7	0.0*	31.7*
Dorosoma cepedianum	gizzard shad	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus diaphanus	banded killifish	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus heteroclitus	mummichog	0.4	216.0	0.4*	329.0*	0.4*	260.7*	0.4*	173.0*	0.4*	856.7*	0.4*	263.0*
Fundulus luciae	spotfin killifish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus majalis	striped killifish	1.0*	97.7*	0.1	1.0	1.0	11.7	1.0	0.0	1.0	10.7	1.0	18.7
Gambusia affinis	mosquito fish	0.0	2.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0
Gobiosoma bosc	naked goby	0.8	0.0	0.8	0.0	0.8	0.0	0.8	0.0	0.8	0.3	0.8	0.7
Gobiesox strumosus	skillet fish	2.0	0.0	2.0	0.0	2.0	0.0	2.0	0.0	2.0	0.0	2.0	0.0
Leiostomus xanthurus	spot	0.0*	20.0*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lepomis gibbosus	pumpkinseed	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lepomis macrochrius	bluegill sunfish	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lucania parva	rainwater killifish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Menidia beryllina	inland silverside	0.0	2.0	0.0*	3.0*	0.0	1.0	0.0*	102.7*	0.0*	47.0*	0.0*	8.0*
Menidia menidia	Atlantic silverside	13.2	1.7	13.2	6.7	13.2	0.0	13.2	13.7	13.2	8.7	13.2	0.7
Morone americana	white perch	0.0	0.0	0.0*	15.0*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Morone saxatilis	striped bass	0.0	0.7	0.0*	1.0*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Paralichthys dentatus	summer flounder	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Sciaenops ocellatus	red drum	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3
Syngnathus fuscus	northern pipefish	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Decapods:													
Callinectes sapidus	blue crab	8.4	12.0	8.4*	0.7*	8.4*	0.3*	8.4*	0.0	8.4*	0.3*	8.4	3.0
Eurypanopeus depressus	flat mud crab	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Rhithropanopeus harrisii	white-fingered mud crab	1.1	0.0	1.1	0.0	1.1	0.0	1.1	0.0	1.1	0.3	1.1	0.0
Crangon septemspinosa	sand shrimp	2.2	0.0	2.2	0.0	2.2	0.0	2.2	0.0	2.2	0.0	2.2	0.0
Palaemonetes pugio	grass shrimp	3.8*	960.3*	3.8*	118.0*	3.8*	2187.3*	3.8*	645.7*	3.8*	208.7*	3.8*	926.0*
Palaemonetes vulgaris	grass shrimp	0.2	0.0	0.2	0.0	0.2	0.0	0.2	0.0	0.2	0.0	0.2	0.0

Table 13. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collected in fyke nets within Poplar Island remnant marshes (PR) compared to Poplar Island restored Cell 1C (1C) marsh for spring, summer, and fall collection periods. * Indicates significantly different ($p \leq 0.05$) abundances between treatments for that species.

		Spring								Summer							
Species	Common Name	PR (1996)	1C (2012)	PR (1996)	1C (2013)	PR (1996)	1C (2014)	PR (1996)	1C (2016)	PR (1996)	1C (2012)	PR (1996)	1C (2013)	PR (1996)	1C (2014)	PR (1996)	1C (2016)
Fishes:																	
Anchoa mitchilli	bay anchovy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anguilla rostrata	American eel	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.7	0.0	0.0	0.0	0.0
Chasmodes bosquianus	striped blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyprinodon variegatus	sheepshead minnow	0.0	0.3	0.0	0.3	0.0	0.0	0.0	1.3	0.0	1.0	0.0	1.0	0.0	0.3	0.0*	46.7*
Fundulus diaphanus	banded killifish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus heteroclitus	mummichog	0.1*	8.7*	0.1*	9.3*	0.1*	73.3*	0.1*	252.0*	4.0*	275.3*	4.0*	767.3*	4.0*	857.3*	4.0*	848.0*
Fundulus luciae	spotfin killifish	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus majalis	striped killifish	0.2	0.0	0.2	1.0	0.2	0.0	0.2	3.3	0.6	0.7	0.6	0.0	0.6*	32.3*	0.6	12.0
Gobiosoma bosc	naked goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gobiesox strumosus	skillet fish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leiostomus xanthurus	spot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lucania parva	rainwater killifish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0
Menidia beryllina	inland silverside	0.0	0.3	0.0	0.0	0.0	0.0	0.0	2.0	6.5	27.7	6.5	4.0	6.5	49.7	6.5	6.0
Menidia menidia	Atlantic silverside	0.0	0.0	0.0	0.0	0.0	0.0	0.0*	8.3*	145.3	86.3	145.3*	21.3*	145.3*	0.0*	145.3*	5.0*
Micropogon undulatus	Atlantic croaker	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Morone americana	white perch	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	2.0	0.0	2.0	0.0	2.0	0.0	2.0	0.0
Morone saxatilis	striped bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	0.0	4.9	0.0	4.9	0.0	4.9	0.0
Syngnathus fuscus	northern pipefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Decapods:																	
Callinectes sapidus	blue crab	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	7.0	3.7	7.0*	2.0*	7.0*	2.0*	7.0*	1.3*
Eurypanopeus depressus	flat mud crab	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhithropanopeus harrisii	white-fingered mud crab	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crangon septemspinosa	sand shrimp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Palaemonetes pugio	grass shrimp	0.9*	162.7*	0.9*	144.3*	0.9*	22.7*	0.9*	496.0*	0.1*	382.0*	1.0*	132.7*	0.1*	293.3*	0.1*	173.0*
Palaemonetes vulgaris	grass shrimp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 13. Continued.

Species	Common Name	Fall							
		PR (1996)	1C (2012)	PR (1996)	1C (2013)	PR (1996)	1C (2014)	PR (1996)	1C (2016)
Fishes:									
Anchoa mitchilli	bay anchovy	0.1	3.0	0.1	0.0	0.1	0.0	0.1	0.0
Anguilla rostrata	American eel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chasmodes bosquianus	striped blenny	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Cyprinodon variegatus	sheepshead minnow	0.0	1.3	0.0	3.3	0.0	1.7	0.0*	44.7*
Fundulus diaphanus	banded killifish	0.0	0.0	0.0	0.0	0.0	0.0	0.0*	3.7*
Fundulus heteroclitus	mummichog	0.4*	33.0*	0.4*	237.7*	0.4*	791.3*	0.4*	301.3*
Fundulus luciae	spotfin killifish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus majalis	striped killifish	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.3
Gobiosoma bosc	naked goby	0.8	1.0	0.8	0.0	0.8	0.0	0.8	0.3
Gobiesox strumosus	skillet fish	2.0	0.0	2.0	0.0	2.0	0.0	2.0	0.0
Leiostomus xanthurus	spot	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Lucania parva	rainwater killifish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Menidia beryllina	inland silverside	0.0	0.3	0.0*	22.0*	0.0*	28.3*	0.0*	2.0*
Menidia menidia	Atlantic silverside	13.2	0.0	13.2	2.0	13.2	0.0	13.2	1.0
Micropogon undulatus	Atlantic croaker	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Morone americana	white perch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Morone saxatilis	striped bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syngnathus fuscus	northern pipefish	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Decapods:									
Callinectes sapidus	blue crab	8.4*	0.0*	8.4*	0.0*	8.4*	0.0*	8.4*	1.7*
Eurypanopeus depressus	flat mud crab	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Rhithropanopeus harrisii	white-fingered mud crab	1.1	0.0	1.1	0.0	1.1	0.0	1.1	0.0
Crangon septemspinosa	sand shrimp	2.2	0.0	2.2	0.0	2.2	0.0	2.2	0.0
Palaemonetes pugio	grass shrimp	3.8*	763.3*	3.8*	517.3*	3.8	122.3	3.8*	143.3*
Palaemonetes vulgaris	grass shrimp	0.2	0.0	0.2	0.0	0.2	0.0	0.2	0.0

sheepshead minnow, mummichog, and grass shrimp were significantly more abundant within Cell 1C compared to the remnant marshes, while the transient species Atlantic silverside and blue crab abundances were significantly greater within the remnant marshes during the baseline compared to Cell 1C. During fall 2016, sheepshead minnow, mummichog, and grass shrimp, the marsh resident banded killifish and the transient species inland silverside were significantly more abundant within Cell 1C marsh versus the remnant marshes during the baseline, while blue crab abundance was significantly greater within the remnant marshes during the baseline versus Cell 1C (Table 13).

During spring 2016, the target species mummichog and the transient species inland silverside were significantly more abundant within Cell 1B marsh versus the remnant marshes during baseline (Table 14). During summer 2016, all four target species (sheepshead minnow, mummichog, striped killifish and grass shrimp) were significantly more abundant within Cell 1B marsh versus the remnant marshes during baseline, while abundances of the transient species Atlantic silverside and blue crab were significantly greater within the remnant marshes during the baseline versus Cell 1B (Table 14). During fall 2016, mummichog and grass shrimp were significantly more abundant within Cell 1B marsh compared to the remnant marshes during the baseline, while blue crab abundance was significantly greater within the remnant marshes during the baseline versus Cell 1B (Table 14).

During spring 2016, the target species sheepshead minnow, mummichog, and grass shrimp were significantly more abundant within Cell 3A marsh versus the remnant marshes during baseline (Table 15). During summer 2016, sheepshead minnow, mummichog, and grass shrimp, as well as the transient species *Lucania parva* (rainwater killifish) were significantly more abundant within Cell 3A marsh versus the remnant marshes during baseline, while the transient species Atlantic silverside abundance was significantly greater within the remnant marshes during the baseline

Table 14. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collected in fyke nets within Poplar Island remnant marshes (PR) compared to Poplar Island restored Cell 1B (1B) marsh for spring, summer, and fall collection periods. * Indicates significantly different ($p \leq 0.05$) abundances between treatments for that species.

Species	Common Name	Spring						Summer						Fall					
		PR (1996)	1B (2013)	PR (1996)	1B (2014)	PR (1996)	1B (2016)	PR (1996)	1B (2013)	PR (1996)	1B (2014)	PR (1996)	1B (2016)	PR (1996)	1B (2013)	PR (1996)	1B (2014)	PR (1996)	1B (2016)
Fishes:																			
Anchoa mitchilli	bay anchovy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Anguilla rostrata	American eel	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3	0.0	0.0
Chasmodes bosquianus	striped blenny	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Cyprinodon variegatus	sheepshead minnow	0.0	0.0	0.0	0.3	0.0	1.7	0.0	7.3	0.0	0.0	0.0*	209.7*	0.0*	2.7*	0.0*	2.3*	0.0	13.0
Fundulus diaphanus	banded killifish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0
Fundulus heteroclitus	mummichog	0.1*	70.0*	0.1*	150.7*	0.1*	267.3*	0.4*	1282.7*	4.0*	1021.7*	4.0*	1351.7*	0.4*	608.0*	0.4*	321.7*	0.4*	380.0*
Fundulus luciae	spotfin killifish	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus majalis	striped killifish	0.2	2.3	0.2	0.0	0.2	1.0	0.6	0.0	0.6*	22.7*	0.6*	15.0*	1.0	11.0	1.0	3.0	1.0	0.7
Gobiosoma bosc	naked goby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.3	0.8	0.0	0.8	0.0
Gobiesox strumosus	skillet fish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	2.0	0.0	2.0	0.0	2.0	0.0
Lucania parva	rainwater killifish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0
Menidia beryllina	inland silverside	0.0	0.7	0.0	0.7	0.0*	2.7*	6.5	168.7	6.5	74.0	6.5	16.0	0.0*	4.7*	0.0*	203.7*	0.0	0.0
Menidia menidia	Atlantic silverside	0.0	0.0	0.0	0.3	0.0	1.0	145.3	266.7	145.3	28.0	145.3*	2.3*	13.2	2.0	13.2	21.0	13.2	0.0
Morone americana	white perch	0.0	0.7	0.0	0.7	0.0	0.0	2.0	0.7	2.0	1.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Morone saxatilis	striped bass	0.0	0.0	0.0	0.0	0.0	0.0	4.9	0.0	4.9	0.0	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syngnathus fuscus	northern pipefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Decapods:																			
Callinectes sapidus	blue crab	0.0	0.0	0.0	3.7	0.0	0.0	7.0	7.7	7.0	9.0	7.0*	1.3*	8.4*	0.3*	8.4*	0.3*	8.4*	0.7*
Eurypanopeus depressus	flat mud crab	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Rhithropanopeus harrisii	white-fingered mud crab	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	1.1	0.0	1.1	1.0	1.1	0.0
Crangon septemspinosa	sand shrimp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	2.2	0.0	2.2	0.0
Palaemonetes pugio	grass shrimp	0.9*	211.0*	0.7*	614.0*	0.7	82.7	0.1*	479.0*	0.1*	175.7*	0.1*	30.7*	3.8*	1572.0*	3.8*	1374.7*	3.8*	1017.0*
Palaemonetes vulgaris	grass shrimp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.2	0.0

Table 15. Mean number of individuals, per 5 linear meters of marsh fringe, for fish and decapod species collected in fyke nets within Poplar Island remnant marshes (PR) compared to Poplar Island restored Cell 3A (3A) marsh for spring, summer, and fall collection periods. * Indicates significantly different ($p \leq 0.05$) abundances between treatments for that species.

Species	Common Name	----- Spring----		--- Summer---		------Fall------	
		PR (1996)	3A (2016)	PR (1996)	3A (2016)	PR (1996)	3A (2016)
Fishes:							
Anchoa mitchilli	bay anchovy	0.0	0.0	0.0	0.0	0.1	0.0
Anguilla rostrata	American eel	0.0	0.7	0.0	2.7	0.0	0.7
Chasmodes bosquianus	striped blenny	0.0	0.0	0.0	0.0	0.1	0.0
Cyprinodon variegatus	sheepshead minnow	0.0*	3.7*	0.0*	2.0*	0.0	0.0
Fundulus diaphanus	banded killifish	0.0	0.3	0.0	0.0	0.0	0.0
Fundulus heteroclitus	mummichog	0.1*	75.3*	4.0*	888.0*	0.4*	423.3*
Fundulus luciae	spotfin killifish	0.1	0.0	0.0	0.0	0.0	0.0
Fundulus majalis	striped killifish	0.2	0.3	0.6	3.7	1.0	0.0
Gobiosoma bosc	naked goby	0.0	0.0	0.0	0.0	0.8	0.3
Gobiesox strumosus	skillet fish	0.0	0.0	0.0	0.0	2.0	0.0
Leiostomus xanthurus	spot	0.0	0.3	0.0	0.0	0.0	0.0
Lucania parva	rainwater killifish	0.0	0.3	0.0*	5.0*	0.0*	1.7*
Menidia beryllina	inland silverside	0.0	8.7	6.5	8.7	0.0	1.3
Menidia menidia	Atlantic silverside	0.0	6.7	145.3*	2.3*	13.2	0.0
Morone americana	white perch	0.0	0.7	2.0	0.0	0.0	0.0
Morone saxatilis	striped bass	0.0	0.0	4.9	0.0	0.0	0.0
Syngnathus fuscus	northern pipefish	0.0	0.0	0.0	0.0	0.1	0.0
Decapods:							
Callinectes sapidus	blue crab	0.0	0.3	7.0	2.3	8.4*	0.7*
Eurypanopeus depressus	flat mud crab	0.0	0.0	0.0	0.0	0.1	0.0
Rhithropanopeus harrisii	white-fingered mud crab	0.0	0.0	0.0	0.0	1.1	0.0
Crangon septemspinosa	sand shrimp	0.0	0.0	0.0	0.0	2.2	0.0
Palaemonetes pugio	grass shrimp	0.9*	502.0*	0.1*	95.0*	3.8*	305.7*
Palaemonetes vulgaris	grass shrimp	0.0	0.0	0.0	0.0	0.2	0.0

compared to Cell 3A (Table 15). During fall 2016, mummichog and grass shrimp, as well as rainwater killifish were significantly more abundant within Cell 3A marsh compared to the remnant marshes during the baseline, while the transient species blue crab abundance was significantly greater within the remnant marshes during the baseline versus Cell 3A (Table 15).

Fyke Net Catch Size Class Frequency Distributions:

Relative size class frequency distributions from summer 2016 fyke net collections for sheepshead minnow, striped killifish, and mummichog revealed that the population size structure within the reference marshes differed significantly from these species that occurred within Cells 1A, 1C, 1B, and 3A (Figures 8, 9, 10, and 11). A larger contribution of year-one-and-older (Y1+) sheepshead minnow individuals were present within reference marshes during summer 2016 compared to Cell 1A, 1C, and 1B restored marshes (Y1+ were sheepshead minnow individuals $\geq$ 31 mm SL for the reference and Cells 1A, 1C, and 1B during summer 2016) (Figures 8, 9, and 10). However, during summer 2016 the mean size of sheepshead minnow individuals within Cells 1A, 1C, and 1B were significantly larger than the mean size of individuals within the reference marshes (22.0 mm, 22.3 mm, 22.9 mm, and 20.1 mm, respectively) which were predominantly influenced by young-of-year (YOY) size differences (Figures 8, 9, and 10). While there was a larger contribution Y1+ striped killifish individuals present within reference marshes during summer 2016 compared to Cell 1A, 1C, and 1B restored marshes (Y1+ were striped killfish individuals $\geq$ 37 mm SL for the reference and Cells 1A, 1C, and 1B during summer 2016), Y1+ individuals were relatively scarce in all marshes (Figures 8, 9, and 10). The mean size of striped killifish individuals within Cells 1A, 1C, and 1B were significantly smaller than within the reference marshes during summer 2016 (24.2 mm, 16.3 mm, 21.3 mm, and 38.0 mm, respectively) and mean size difference was also

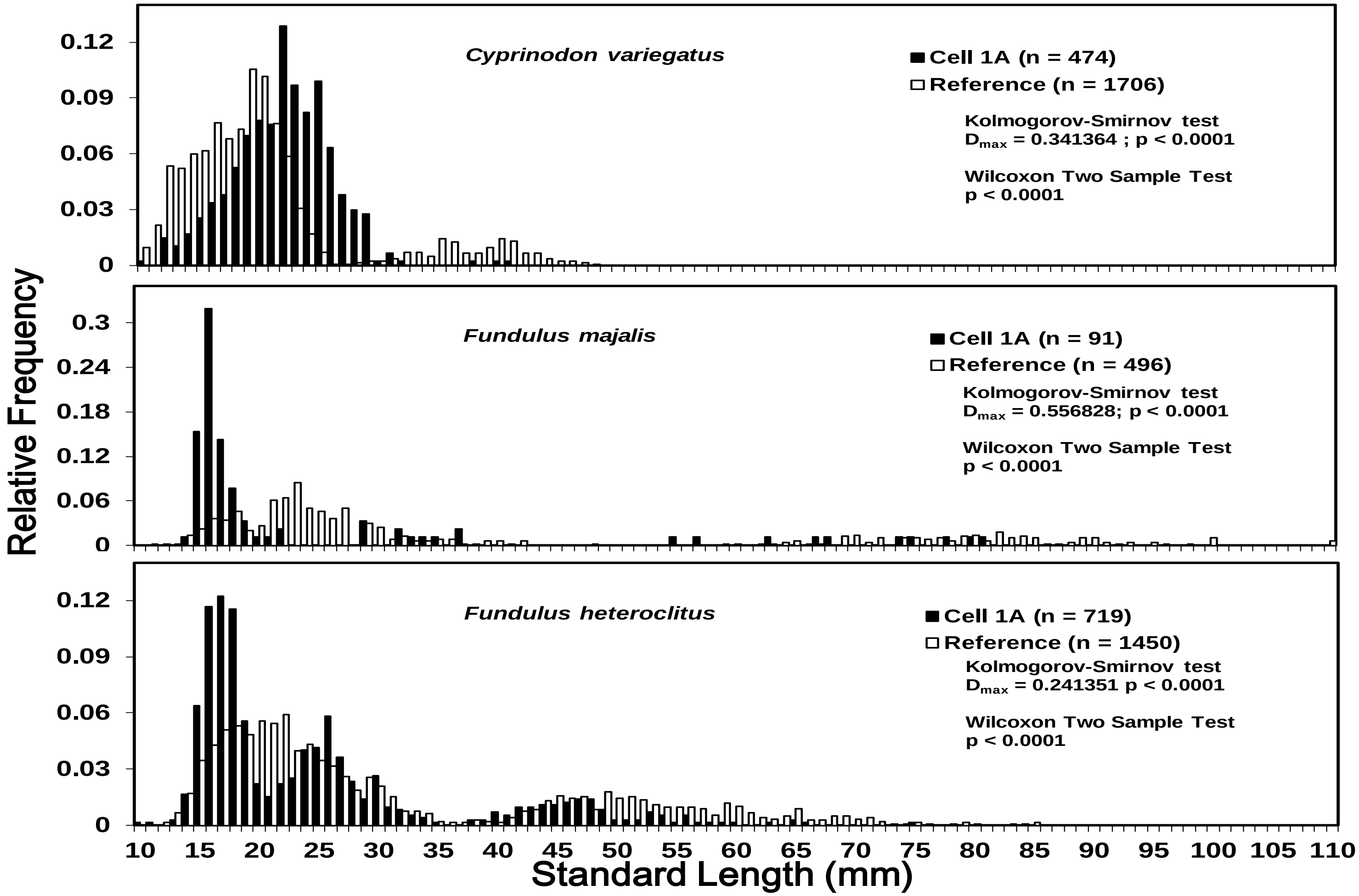

Figure 8. Relative size class frequency distribution comparisons between individuals collected in fyke nets at reference and Cell 1A marsh sites during summer 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Cyprinodon variegatus* during summer 2016 were 22.0 mm within Cell 1A and 20.1 mm within reference marshes. Mean standard lengths for *Fundulus majalis* during summer 2016 were 24.2 mm within Cell 1A and 38.0 mm within reference marshes. Mean standard lengths for *Fundulus heteroclitus* during summer 2016 were 24.6 mm within Cell 1A and 31.2 mm within reference marshes.

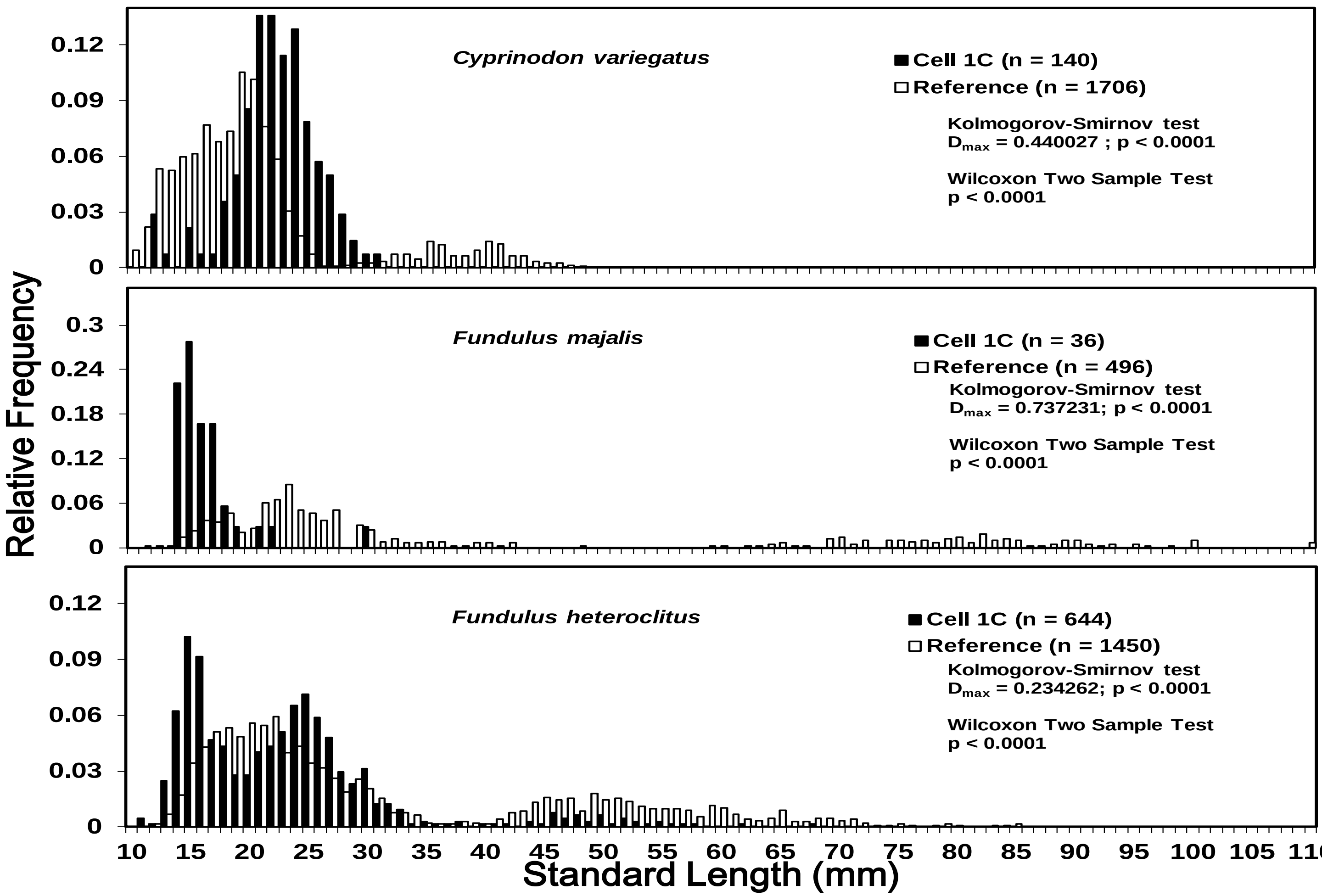

Figure 9. Relative size class frequency distribution comparisons between individuals collected in fyke nets at reference and Cell 1C marsh sites during summer 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Cyprinodon variegatus* during summer 2016 were 22.3 mm within Cell 1C and 20.1 mm within reference marshes. Mean standard lengths for *Fundulus majalis* during summer 2016 were 16.3 mm within Cell 1C and 38.0 mm within reference marshes. Mean standard lengths for *Fundulus heteroclitus* during summer 2016 were 23.0 mm within Cell 1C and 31.2 mm within reference marshes.

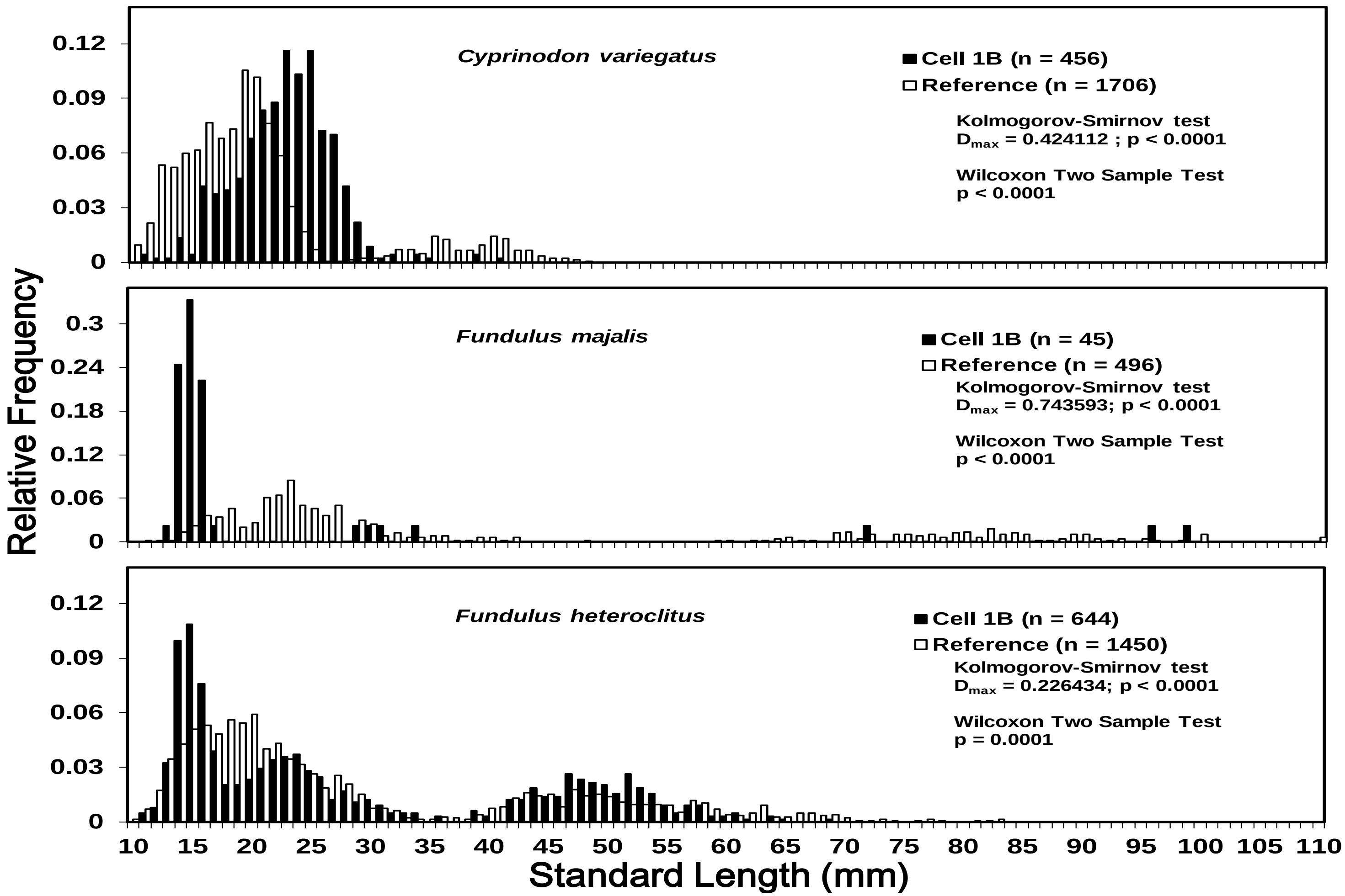

Figure 10. Relative size class frequency distribution comparisons between individuals collected in fyke nets at reference and Cell 1B marsh sites during summer 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Cyprinodon variegatus* during summer 2016 were 22.9 mm within Cell 1B and 20.1 mm within reference marshes. Mean standard lengths for *Fundulus majalis* during summer 2016 were 21.3 mm within Cell 1B and 38.0 mm within reference marshes. Mean standard lengths for *Fundulus heteroclitus* during summer 2016 were 28.4 mm within Cell 1B and 31.2 mm within reference marshes.

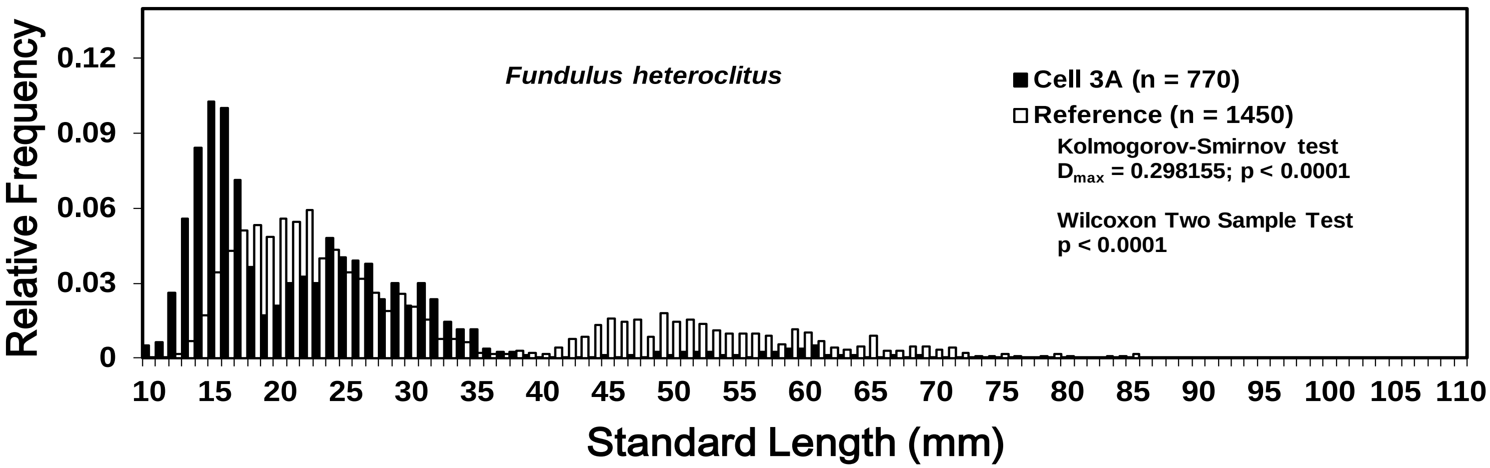

Figure 11. Relative size class frequency distribution comparisons between individuals collected in fyke nets at reference and Cell 3A marsh sites during summer 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Fundulus heteroclitus* during summer 2016 were 22.1 mm within Cell 3A and 31.2 mm within reference marshes.

predominantly influenced by YOY size (Figures 8, 9, and 10). Population size class structure for mummichog significantly differed between Cells 1A, 1C, 1B, and 3A versus the reference marsh populations (Figures 8, 9, 10, and 11) and a larger contribution of Y1+ individuals were present within reference marshes during summer 2016 compared to Cell 1A, 1C, and 3A restored marshes (Y1+ were mummichog individuals $\geq$ 37 mm SL for the reference, Cells 1A, 1C, 1B, and 3A during summer 2016) (Figures 8, 9, 10, and 11). However, differences in the proportion of Y1+ cohorts within the reference marshes and Cell 1A during summer 2016 were less substantial than previous collection years (see Meyer 2013, 2014), and were similar between the reference and Cell 1B marshes during summer 2016 (Figures 8 and 10). During summer 2016, the mean size of mummichog individuals within Cell 1A, 1C, 1B and 3A marshes were significantly smaller than within the reference marshes (24.6 mm, 23.0 mm, 28.4 mm, 22.1 mm, and 31.2 mm, respectively) (Figures 8, 9, 10, and 11).

Relative size class frequency distributions from summer 2016 fyke net collections for sheepshead minnow revealed that the population size class structures between Cells 1A, 1B, and 1C were similar related to YOY and Y1+ contributions with only Cell 1A versus Cell 1B differing significantly among Cell 1A, 1B, and 1C comparisons (Figures 12, 13, and 14). Further, during summer 2016 the mean size of sheepshead minnow between Cells 1A and 1B was the only comparison to significantly differ among Cell 1A, 1C, and 1B comparisons (mean sizes were 22.0 mm, 22.3 mm, and 22.9 mm SL for Cells 1A, 1C, and 1B, respectively) (Figures 12, 13, and 14). Summer 2016 fyke net collections for striped killifish revealed that the population size class structures between Cells 1A, 1B, and 1C were similar related to YOY and Y1+ contributions, and significant differences between cells only involved comparisons with Cell 1A (Figures 12, 13, and 14). Further, during summer 2016 the mean size comparisons among cells for striped killifish were

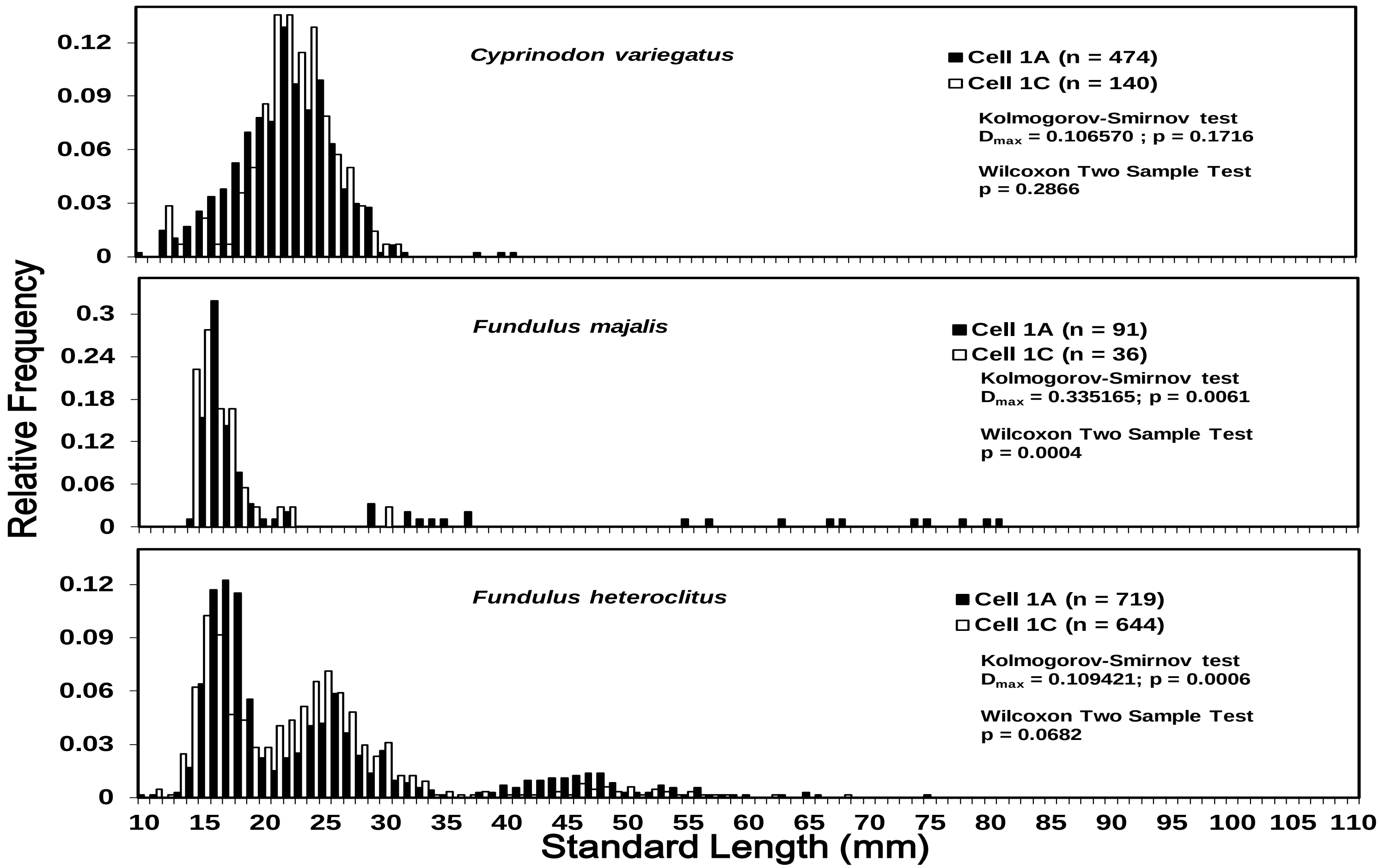

Figure 12. Relative size class frequency distribution comparisons between individuals collected within Cell 1A and Cell 1C via fyke net during summer 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Cyprinodon variegatus* during summer 2016 were 22.0 mm within Cell 1A and 22.3 mm within Cell 1C. Mean standard lengths for *Fundulus majalis* during summer 2016 were 24.2 mm within Cell 1A and 16.3 mm within Cell 1C. Mean standard lengths for *Fundulus heteroclitus* during summer 2016 were 24.6 mm within Cell 1A and 23.0 mm within Cell 1C.

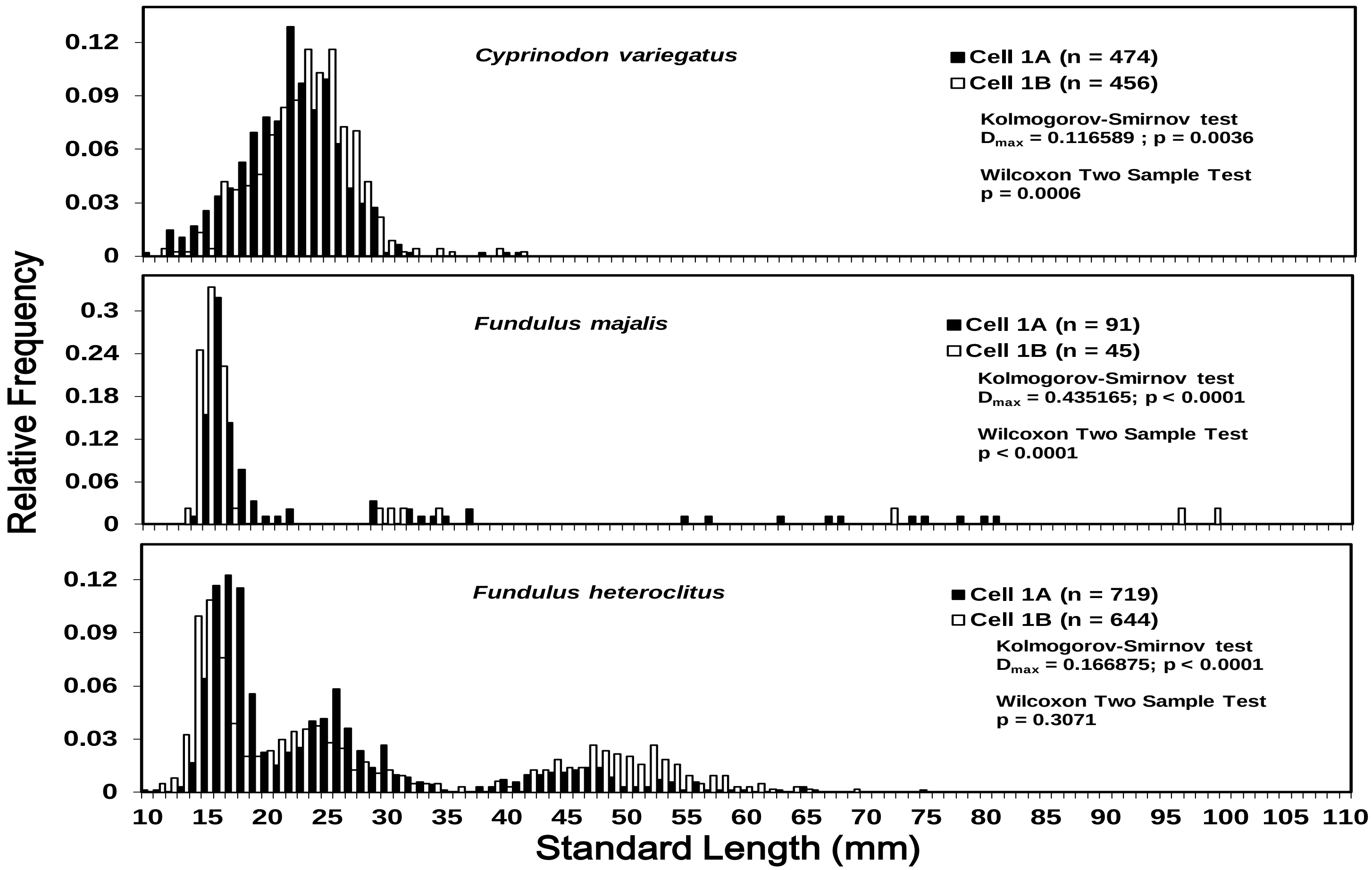

Figure 13. Relative size class frequency distribution comparisons between individuals collected within Cell 1A and Cell 1B via fyke net during summer 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Cyprinodon variegatus* during summer 2016 were 22.0 mm within Cell 1A and 22.9 mm within Cell 1B. Mean standard lengths for *Fundulus majalis* during summer 2016 were 24.2 mm within Cell 1A and 21.3 mm within Cell 1B. Mean standard lengths for *Fundulus heteroclitus* during summer 2016 were 24.6 mm within Cell 1A and 28.4 mm within Cell 1B.

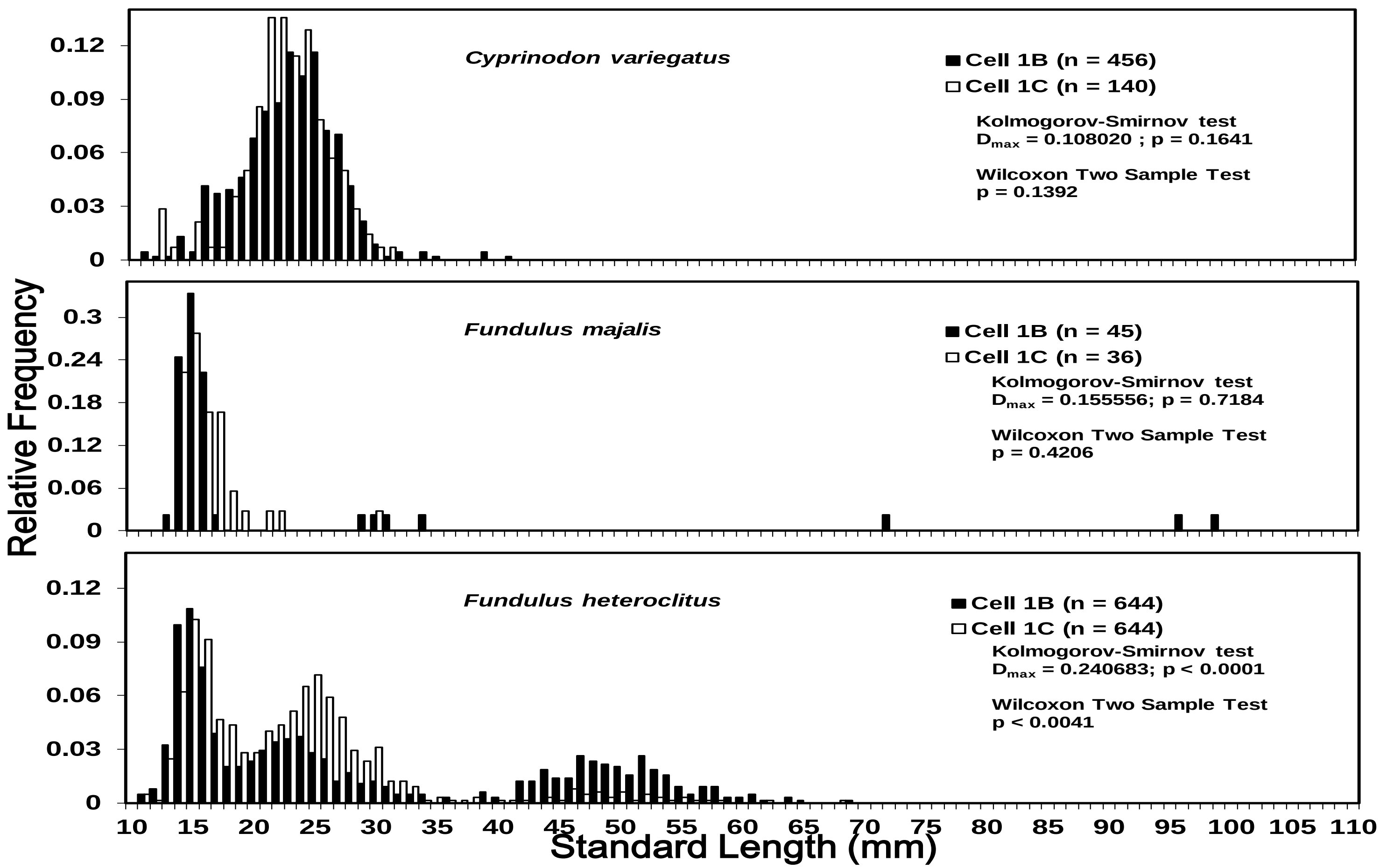

Figure 14. Relative size class frequency distribution comparisons between individuals collected within Cell 1B and Cell 1C via fyke net during summer 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Cyprinodon variegatus* during summer 2016 were 22.9 mm within Cell 1B and 22.3 mm within Cell 1C. Mean standard lengths for *Fundulus majalis* during summer 2016 were 21.3 mm within Cell 1B and 16.3 mm within Cell 1C. Mean standard lengths for *Fundulus heteroclitus* during summer 2016 were 28.4 mm within Cell 1B and 23.0 mm within Cell 1C.

only significant involving Cell 1A comparisons (mean sizes were 24.2 mm, 16.3 mm, and 21.3 mm SL for Cells 1A, 1C, and 1B, respectively) (Figures 12, 13, and 14). Summer 2016 fyke net collections for mummichog revealed that the population size structure was significantly different among all restored cells (Figures 12, 13, 14, 15, 16, and 17). While size class structures among the cells were more similar than compared to reference marshes, significant differences related to increased Y1+ population contributions for Cells 1B and 1A were apparent in all comparisons. During summer 2016, the mean size of mummichog individuals within Cells 1A versus 1C, and 1A versus 1B did not significantly differ, while mean size for mummichog between the remaining cell comparisons did (mean sizes were 24.6 mm, 23.0 mm, 28.4 mm, and 22.1 mm SL for Cells 1A, 1C, 1B, and 3A, respectively) (Figures 12, 13, 14, 15, 16, and 17).

Population size class structures differed significantly between summer 2016 and 2014 mummichog populations within Cells 1A, 1C, and 1B (Figures 18, 19, and 20). Mummichog Y1+ (individuals $\geq$ 37 mm during summer 2016, and individuals $\geq$ 42 mm SL during summer 2014 for Cells 1A, 1C, and 1B) contribution within Cells 1A and 1C during both summer 2016 and 2014 represented a small portion of each cell's mummichog population (Figures 18 and 19), while within Cell 1B during summer 2016, mummichog Y1+ contribution to the population substantially increased versus 2014 (Figure 20). During summer 2016, mean size of mummichog individuals were significantly smaller than during summer 2014 within Cell 1A (24.6 mm versus 27.4 mm, respectively) (Figure 18) and within Cell 1B (28.4 mm versus 33.0 mm, respectively), primarily due to smaller size of YOY during 2016 (Figure 20). However, Cell 1C mean size of mummichog individuals during summer 2016 versus 2014 did not significantly differ (23.0 mm versus 22.4 mm, respectively) (Figure 19).

Population size class structures differed significantly between summer 2016 and 2014

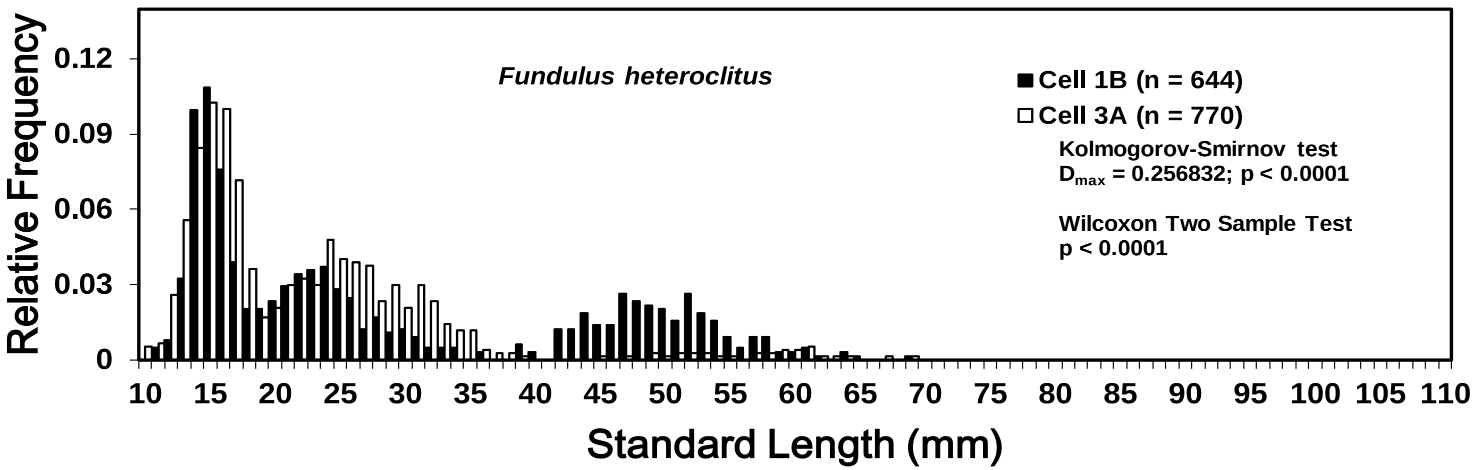

Figure 15. Relative size class frequency distribution comparisons between individuals collected within Cell 1B and Cell 3A via fyke net during summer 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Fundulus heteroclitus* during summer 2016 were 28.4 mm within Cell 1B and 22.1 mm within Cell 3A.

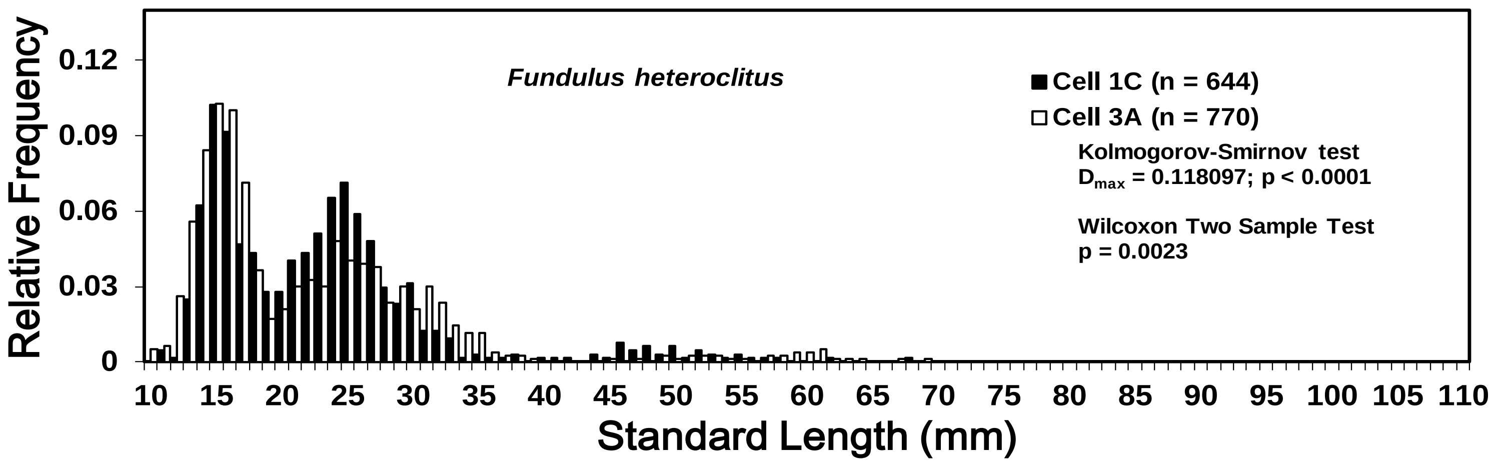

Figure 16. Relative size class frequency distribution comparisons between individuals collected within Cell 1C and Cell 3A via fyke net during summer 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Fundulus heteroclitus* during summer 2016 were 23.0 mm within Cell 1C and 22.1 mm within Cell 3A.

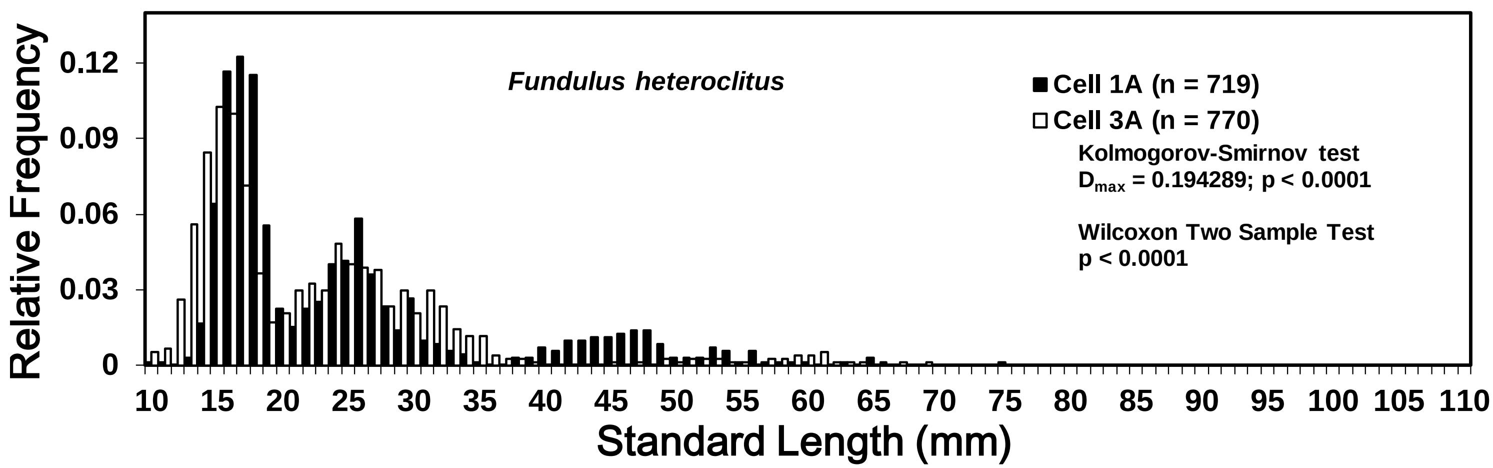

Figure 17. Relative size class frequency distribution comparisons between individuals collected within Cell 1A and Cell 3A via fyke net during summer 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Fundulus heteroclitus* during summer 2016 were 24.6 mm within Cell 1A and 22.1 mm within Cell 3A.

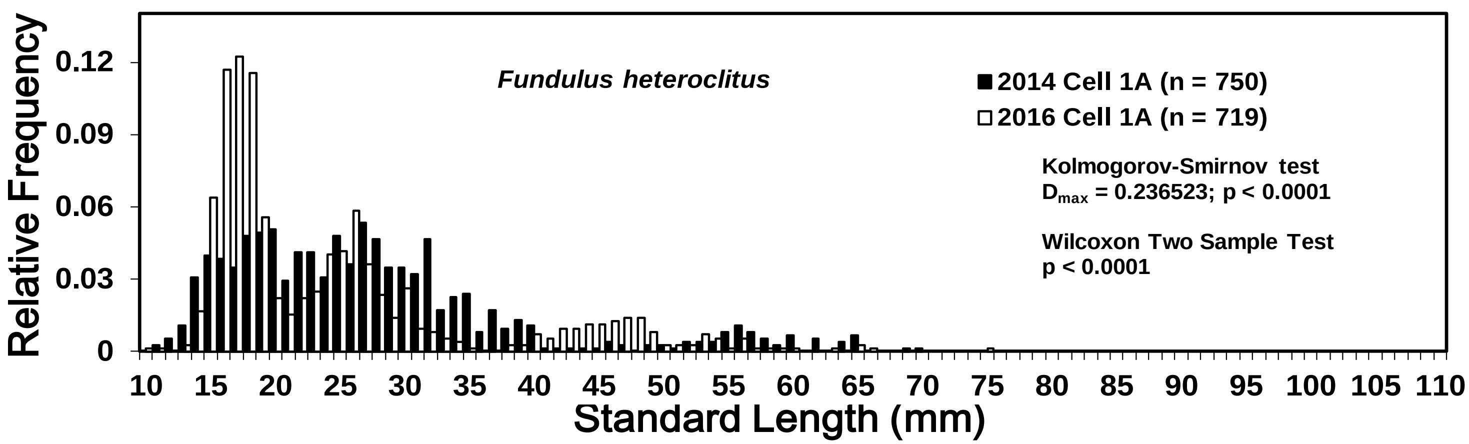

Figure 18. Relative size class frequency distributions for annual comparisons between individuals collected via fyke net within Cell 1A during summer 2014 and 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Fundulus heteroclitus* were 27.4 mm during summer 2014 and 24.6 mm during summer 2016.

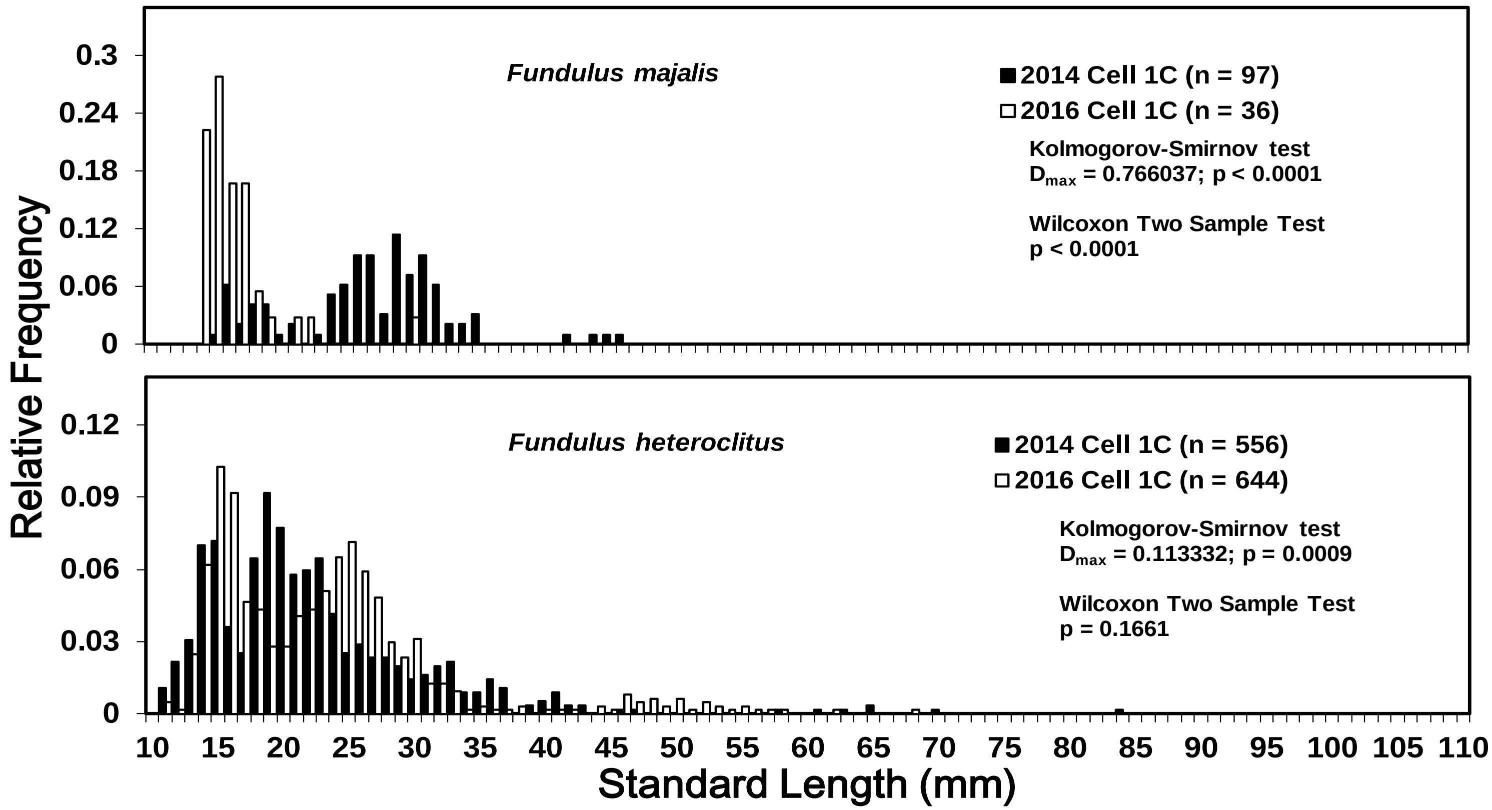

Figure 19. Relative size class frequency distributions for annual comparisons between individuals collected via fyke net within Cell 1C during summer 2014 and 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Fundulus majalis* were 27.1 mm during summer 2014 and 16.3 mm during summer 2016. Mean standard lengths for *Fundulus heteroclitus* were 22.4 mm during summer 2014 and 23.0 mm during summer 2016.

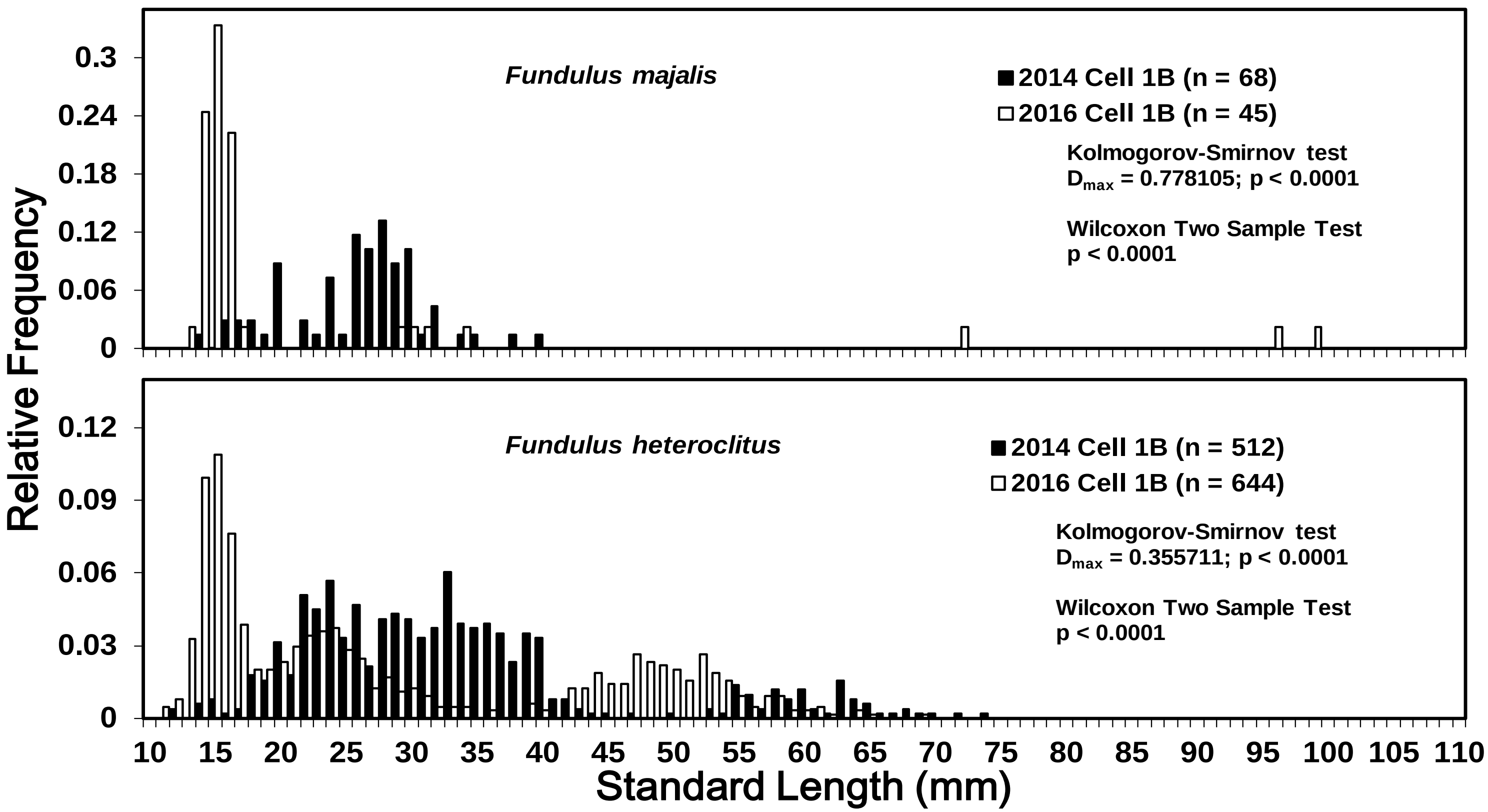

Figure 20. Relative size class frequency distributions for annual comparisons between individuals collected via fyke net within Cell 1B during summer 2014 and 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Fundulus majalis* were 26.1 mm during summer 2014 and 21.3 mm during summer 2016. Mean standard lengths for *Fundulus heteroclitus* were 33.0 mm during summer 2014 and 28.4 mm during summer 2016.

striped killifish populations within Cells 1C and 1B. Striped killifish Y1+ (individuals $\geq$ 37 mm SL for Cells 1C and 1B during summer 2016 and 2014) population contribution within Cells 1C and 1B during both summer 2016 and 2014 represented a small portion of each cell's population (Figures 19 and 20). During summer 2016, Cell 1C and Cell 1B mean size of striped killifish individuals were significantly smaller than during summer 2014 (16.3 mm versus 27.1 mm, respectively within Cell 1C; and 21.3 mm versus 26.1 mm, respectively within Cell 1B) (Figures 19 and 20).

The comparison of 2014 versus 2016 sheepshead minnow populations for the reference marshes noted a significant difference in size class frequency structure between summer 2014 versus 2016, with the summer 2016 population containing a higher proportion of Y1+ individuals than the 2014 population (Y1+ were individuals $\geq$ 30 mm SL during summer 2014 and $\geq$ 31 mm SL during summer 2016) (Figure 21). Further, mean size comparison of sheepshead minnow between summer 2014 and 2016 for the reference marshes indicated the 2014 population was composed of significantly smaller sized individuals than during 2016 (17.4 mm versus 20.1 mm, respectively) (Figure 21). The comparison of summer 2014 versus 2016 striped killifish populations for the reference marshes indicated a significant difference between size class frequency structure during summer 2014 compared to summer 2016 (Y1+ were individuals $\geq$ 37 mm during summer 2014 and 2016) (Figure 21). Further, a significant difference in mean size of striped killifish between summer 2014 and 2016 was observed (34.0 mm versus 38.0 mm, respectively) (Figure 21). Within the reference marshes similar contributions of Y1+ mummichog (Y1+ were individuals $\geq$ 42 mm SL during summer 2014 and $\geq$ 37 mm SL during summer 2016) were present during summer 2014 compared to summer 2016; however, significant differences between size class frequency structures were evident (Figure 21). The mean size of mummichog was significantly larger during summer 2014 than during summer 2016 within the reference marshes (37.9 mm versus 31.2 mm,

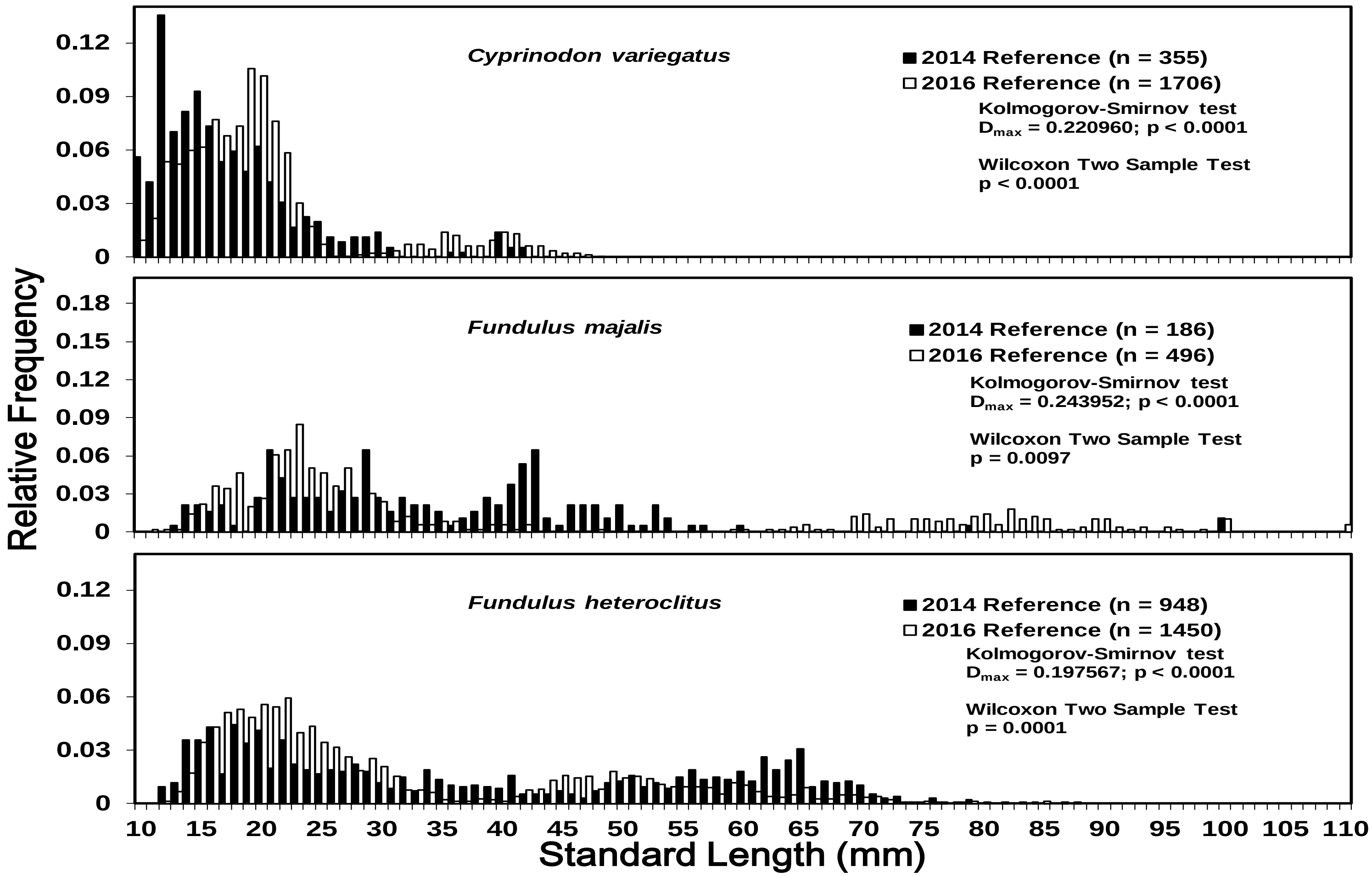

Figure 21. Relative size class frequency distributions for annual comparisons between individuals collected via fyke net within reference area marshes during summer 2014 and 2016. D_{max} and p values based on Kolmogorov-Smirnov two sample test for distribution differences, and p values for the Wilcoxon two sample test for mean size comparisons are represented. Mean standard lengths for *Cyprinodon variegatus* were 17.4 mm during summer 2014 and 20.1 mm during summer 2016. Mean standard lengths for *Fundulus majalis* were 34.0 mm during summer 2014 and 38.0 mm during summer 2016. Mean standard lengths for *Fundulus heteroclitus* were 37.9 mm during summer 2014 and 31.2 mm during summer 2016.

respectively) (Figure 21).

Marsh Creek Gill Net Collection:

Gill net catch (Figure 22) for non-nektonivorous fish abundances within Cell 1A marsh creeks were significantly lower after 2010 (Figure 23). No significant interannual differences in total fish or nektonivorous (fishes that primarily feed on nekton) abundance were evident within Cell 1A and reference marsh creeks, or for non-nektonivorous fishes within reference marsh creeks (Figure 23).

Significant interannual abundance differences within summer and fall seasonal collection periods were apparent for individual nekton species within reference and Cell 1A marsh creeks (Table 16). During summer 2016, abundances were significantly lower for Atlantic menhaden versus 2010 within Cell 1A, and versus 2011 within reference marsh creeks (Table 16). During fall 2016, abundances within Cell 1A marsh creeks were significantly lower for Atlantic menhaden and spot versus 2010, and for *Dorosoma cepedianum* (gizzard shad) versus 2011 (Table 16). Abundances during fall 2016 collections within reference marsh creeks contained significantly fewer Atlantic menhaden and bluefish than during 2011, and significantly more white perch than 2011 (Table 16).

Figure 22. Representative species from a gill net.

Among the reference, Cells 1A, 1C, 1B, and 3A marsh creeks no significant differences were observed for total fish, non-nektonivorous fish, or nektonivorous fish abundances during 2016

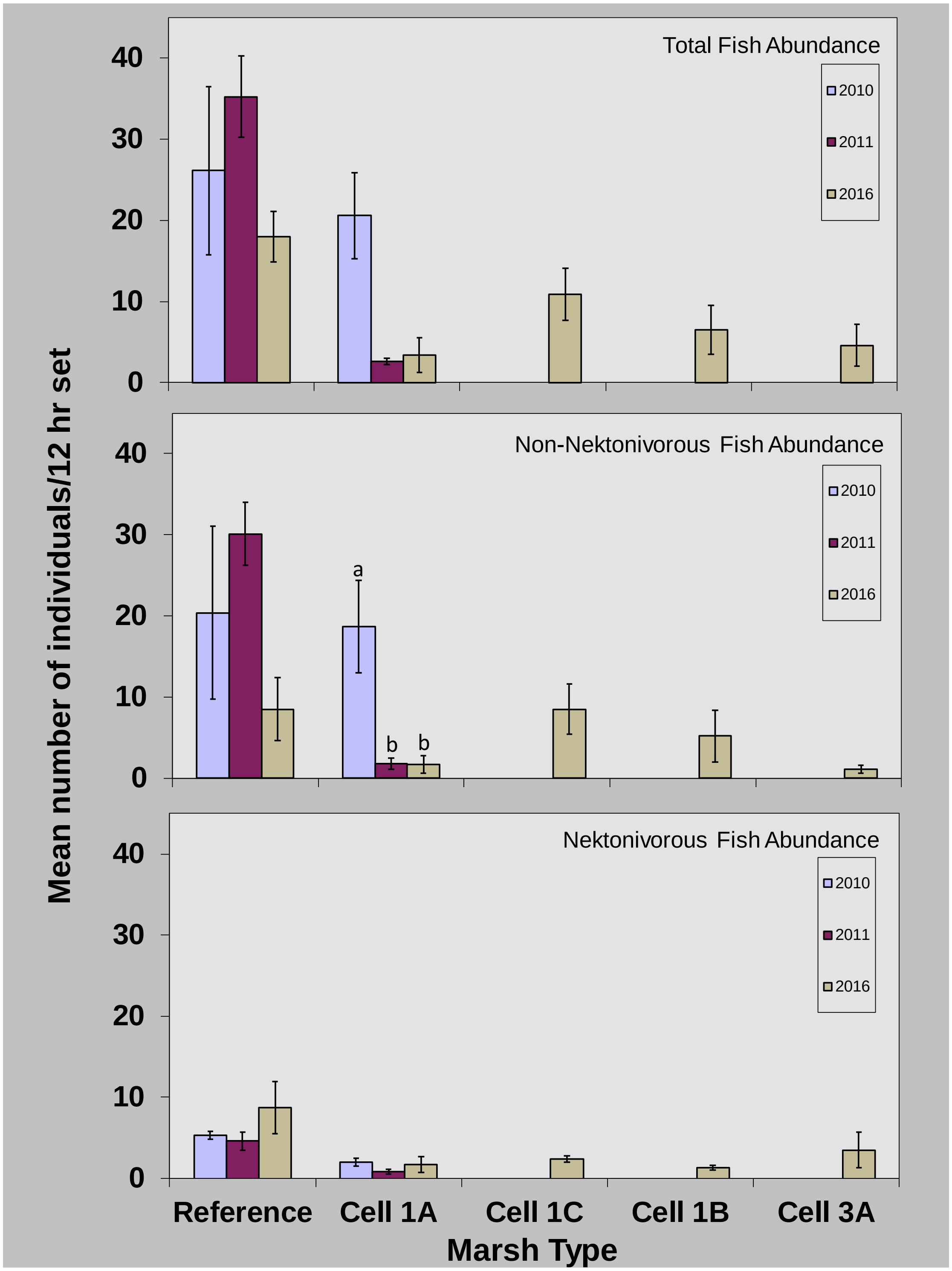

Figure 23. Comparison among collection years, per marsh type, for the mean number of individuals collected, per 12 hour set, via gill nets. Significant differences ($p \leq 0.05$) between collection years, per marsh type, are indicated by a different letter.

Table 16. Mean number of individuals, per 12 hour gill net set within reference marsh creeks (Ref), and Poplar Island Cell 1A (1A) marsh creeks. For each species during each collection date, comparisons for area types between collection years that differ significantly from one another ($p \leq 0.05$) are indicated by a different letter.

		Ref			Ref			Ref		
Species	Common Name	4/10	4/11	4/16	7/10	7/11	7/16	10/10	10/11	10/16
Alosa pseudoharangus	alewife	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Brevoortia tyrannus	Atlantic menhaden	0.9	0.0	0.0	0.0^{B}	23.8^{A}	0.3^{B}	20.8^{AB}	45.5^{A}	14.0^{B}
Cynoscion nebulosus	spotted seatrout	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.5	0.0
Cynoscion regalis	weakfish	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Cyprinus carpio	common carp	0.0	0.0	0.0	0.0	3.0	0.0	0.0	1.2	0.0
Dorosoma cepedianum	gizzard shad	0.0	0.5	0.0	3.0	1.7	2.1	0.0	1.2	0.3
Fundulus heteroclitus	mummichog	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fundulus majalis	striped killifish	0.0	2.2	6.1	0.0	0.0	0.0	0.0	0.0	0.0
Leiostomus xanthurus	spot	0.0	0.0	0.0	9.9	10.9	0.0	5.6	0.0	1.9
Lepomis gibbosus	pumpkinseed	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Micropogon undulatus	Atlantic croaker	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0
Morone americana	white perch	0.6	0.2	0.8	5.4	3.0	2.1	3.5^{A}	0.2^{B}	16.6^{A}
Morone saxatilis	striped bass	1.7	1.2	3.0	1.4	1.2	1.8	1.4	0.5	1.6
Pomatomus saltatrix	bluefish	0.0	0.0	0.0	1.1	1.7	0.0	0.0^{B}	5.6^{A}	0.0^{B}
Strongylura marina	Atlantic needlefish	0.0	0.5	1.9	0.3	0.0	0.0	0.9	0.0	0.5
Trinectes maculatus	hogchoker	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0

		1A			1A			1A		
Species	Common Name	4/10	4/11	4/16	7/10	7/11	4/16	10/10	10/11	4/16
Brevoortia tyrannus	Atlantic menhaden	0.0	0.0	0.0	1.6^{A}	0.0^{B}	0.3^{B}	41.5^{A}	0.0^{C}	3.6^{B}
Cyprinus carpio	common carp	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
Dorosoma cepedianum	gizzard shad	0.0	0.7	0.0	0.9	0.8	1.1	0.3^{B}	2.7^{A}	0.0^{B}
Fundulus majalis	striped killifish	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Leiostomus xanthurus	spot	0.0	0.0	0.0	0.9	0.0	0.0	9.1^{A}	0.0^{B}	0.0^{B}
Morone americana	white perch	2.2	0.0	0.4	1.6	0.2	1.6	1.3	0.8	2.1
Morone saxatilis	striped bass	0.0	0.0	0.0	0.0	1.0	0.8	0.8	0.3	0.0

(Figure 24).

During spring 2016, striped killifish abundance was significantly greater within reference compared to Cell 1A and 3A marsh creeks, white perch abundance was significantly greater within reference compared to Cell 1B marsh creeks, while striped bass abundance was significantly greater within the reference compared to Cell 1A, 1C, 1B, and 3A marsh creeks (Table 17). During summer 2016, Atlantic menhaden abundance was significantly greater within Cell 1C versus reference marsh creeks, gizzard shad was significantly more abundant within reference versus Cell 1C marsh creeks, white perch were significantly more abundant within reference versus Cell 1B marsh creeks, and striped bass were significantly more abundant within reference versus Cell 1C and 3A marsh creeks (Table 17). During fall 2016, Atlantic menhaden abundance was significantly greater within reference versus Cell 3A marsh creeks, white perch were significantly more abundant within reference versus Cell 1A, 1B, and 1C marsh creeks, and striped bass were significantly more abundant within reference versus Cell 1A, 1B, 1C, and 3A marsh creeks (Table 17).

Environmental Parameters:

Mean salinity and water temperatures from 1995-1996, 2010-2014, and 2016 revealed numerous significant interannual differences. Salinity differences were significant for all collection periods at multiple area types. In particular, recorded salinities were significantly lower during 1996 summer collections compared to the same time period during all other collection years. Also, salinities observed for fall 2011 were significantly lower than those observed during the same time period during all other collection years (Table 18). Water temperature comparisons demonstrated significant interannual differences due to stochastic weather related events. However, water temperature patterns during a collection period were less rigid than observed for salinity (Table 19).

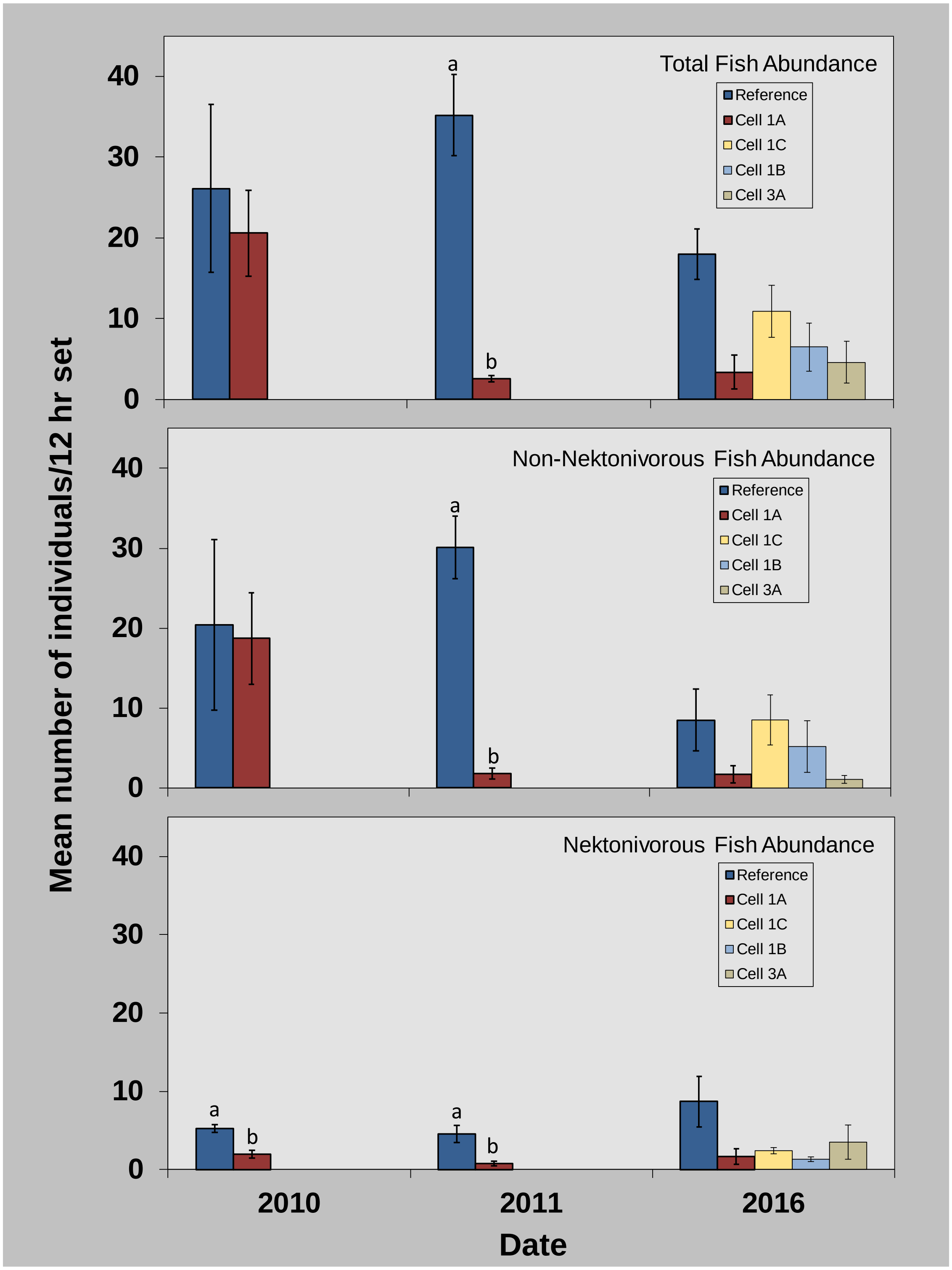

Figure 24. Comparison among marsh types, per collection year, for the mean number of individuals collected, per 12 hour set, via gill nets. Significant differences ($p \leq 0.05$) between collection years, per marsh type, are indicated by a different letter.

Table 17. Mean number of individuals, per 12 hour gill net set within reference marsh creeks (Ref), and within Poplar Island Cell 1A (1A), Cell 1B (1B), Cell 1C (1C), and Cell 3A (3A) marsh creeks. For each species during each collection date, comparisons between area types that are significantly different from one another ($p \leq 0.05$) are indicated by an asterisk.

		4/16		7/16		10/16		4/16		7/16		10/16	
Species	Common Name	Ref	1A	Ref	1A	Ref	1A	Ref	1B	Ref	1B	Ref	1B
Alosa pseudoharangus	alewife	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Brevoortia tyrannus	Atlantic menhaden	0.0	0.0	0.3	0.3	14.0	3.6	0.0	0.0	0.3	2.0	14.0	5.7
Dorosoma cepedianum	gizzard shad	0.0	0.0	2.1	1.1	0.3	0.0	0.0	0.0	2.1	1.4	0.3	2.6
Fundulus majalis	striped killifish	6.1*	0.2*	0.0	0.0	0.0	0.0	6.1	3.6	0.0	0.0	0.0	0.0
Leiostomus xanthurus	spot	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.3	1.9	0.0
Lepomis gibbosus	pumpkinseed	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Morone americana	white perch	0.8	0.4	2.1	1.6	16.6*	2.1*	0.8*	0.2*	2.1*	0.8*	16.6*	2.1*
Morone saxatilis	striped bass	3.0*	0.0*	1.8	0.8	1.6*	0.0*	3.0*	0.0*	1.8	0.6	1.6*	0.2*
Strongylura marina	Atlantic needlefish	1.9	0.0	0.0	0.0	0.5	0.0	1.9	0.0	0.0	0.0	0.5	0.0

		4/16		7/16		10/16		4/16		7/16		10/16	
Species	Common Name	Ref	1C	Ref	1C	Ref	1C	Ref	3A	Ref	3A	Ref	3A
Alosa pseudoharangus	alewife	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Brevoortia tyrannus	Atlantic menhaden	0.0	0.0	0.3*	5.0*	14.0	17.1	0.0	0.0	0.3	0.3	14.0*	0.0*
Dorosoma cepedianum	gizzard shad	0.0	0.0	2.1*	0.0*	0.3	0.4	0.0	0.0	2.1	0.6	0.3	0.4
Fundulus majalis	striped killifish	6.1	1.2	0.0	0.0	0.0	0.0	6.1*	0.2*	0.0	0.0	0.0	0.0
Leiostomus xanthurus	spot	0.0	0.0	0.0	1.7	1.9	0.0	0.0	0.0	0.0	1.8	1.9	0.0
Lepomis gibbosus	pumpkinseed	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Morone americana	white perch	0.8	1.4	2.1	3.0	16.6*	2.4*	0.8	3.0	2.1	1.2	16.6	6.2
Morone saxatilis	striped bass	3.0*	0.0*	1.8*	0.0*	1.6*	0.2*	3.0*	0.0*	1.8*	0.0*	1.6*	0.0*
Strongylura marina	Atlantic needlefish	1.9	0.0	0.0	0.0	0.5	0.0	1.9	0.0	0.0	0.0	0.5	0.0

Table 18. Interannual mean salinity (parts per thousand) comparisons for each fyke and gill net collection time period (spring, summer, and fall) by sample area. (—) indicates no collections were taken at that location type during that time period. Interannual differences that are significantly different ($p \leq 0.05$) per collection type, are indicated by a different letter.

Gear Type	Sample Area	Date: 4/96	4/10	4/11	4/12	4/13	4/14	4/16
Fyke Net	Poplar Remnants	6.0	---	---	---	---	---	---
Fyke Net	Reference	8.0^{C}	8.0^{C}	7.3^{C}	11.0^{B}	12.5^{A}	10.0^{B}	13.0^{A}
Fyke Net	Cell 1A	---	7.7^{C}	7.3^{C}	12.0^{B}	13.0^{A}	7.7^{C}	13.0^{A}
Fyke Net	Cell 1C	---	---	---	12.0^{B}	12.0^{B}	9.0^{C}	13.0^{A}
Fyke Net	Cell 1B	---	---	---	---	13.0^{A}	9.3^{B}	13.0^{A}
Fyke Net	Cell 3A	---	---	---	---	---		13.0
Gill Net	Reference Creeks	---	7.7^{B}	6.0^{C}	---	---	---	13.0^{A}
Gill Net	Cell 1A Creeks	---	8.0^{B}	7.7^{B}	---	---	---	13.0^{A}
Gill Net	Cell 1C Creeks	---	---	---	---	---	---	---
Gill Net	Cell 1B Creeks	---	---	---	---	---	---	13.0
Gill Net	Cell 3A Creeks	---	---	---	---	---	---	13.0

Gear Type	Sample Area	Date: 7/96	7/10	7/11	7/12	7/13	7/14	7/16
Fyke Net	Poplar Remnants	6.0	---	---	---	---	---	---
Fyke Net	Reference	5.8^{C}	10.5^{B}	10.0^{B}	10.2^{B}	10.0^{B}	10.0^{B}	14.0^{A}
Fyke Net	Cell 1A	---	12.0^{C}	10.0^{D}	13.0^{B}	10.0^{D}	10.0^{D}	14.0^{A}
Fyke Net	Cell 1C	---	---	---	12.0^{B}	7.0^{C}	8.0^{C}	14.0^{A}
Fyke Net	Cell 1B	---	---	---	---	10.3^{B}	10.0^{B}	14.0^{A}
Fyke Net	Cell 3A	---	---	---	---	---	---	14.0
Gill Net	Reference Creeks	---	11.0^{B}	10.0^{C}	---	---	---	14.0^{A}
Gill Net	Cell 1A Creeks	---	11.0^{B}	10.0^{C}	---	---	---	14.0^{A}
Gill Net	Cell 1C Creeks	---	---	---	---	---	---	14.0
Gill Net	Cell 1B Creeks	---	---	---	---	---	---	14.0
Gill Net	Cell 3A Creeks	---	---	---	---	---	---	14.0

Gear Type	Sample Area	Date: 9/95	10/10	10/11	10/12	11/13	10/14	10/16
Fyke Net	Poplar Remnants	17.5	---	---	---	---	---	---
Fyke Net	Reference	16.5^{AB}	14.4^{C}	7.5^{D}	16.0^{B}	14.7^{C}	15.0^{C}	17.0^{A}
Fyke Net	Cell 1A	---	12.7^{C}	6.0^{D}	16.0^{B}	15.3^{B}	14.0^{C}	18.0^{A}
Fyke Net	Cell 1C	---	---	---	16.0^{B}	16.0^{B}	15.3^{B}	18.0^{A}
Fyke Net	Cell 1B	---	---	---	---	15.3^{C}	16.0^{B}	18.0^{A}
Fyke Net	Cell 3A	---	---	---	---	---	---	17.0
Gill Net	Reference Creeks	---	13.7^{B}	6.7^{C}	---	---	---	17.0^{A}
Gill Net	Cell 1A Creeks	---	14.0^{B}	5.7^{C}	---	---	---	18.0^{A}
Gill Net	Cell 1C Creeks	---	---	---	---	---	---	17.7
Gill Net	Cell 1B Creeks	---	---	---	---	---	---	18.0
Gill Net	Cell 3A Creeks	---	---	---	---	---	---	16.7

Table 19. Interannual mean water temperature (°C) comparisons of each fyke and gill net collection time period (spring, summer, and fall) by sample area. (—) indicates no collections were taken at that location type during that time period. Interannual differences that are significantly different ($p \leq 0.05$) per collection type, are indicated by a different letter.

		Date						
Gear Type	Sample Area	4/96	4/10	4/11	4/12	4/13	4/14	4/16
Fyke Net	Poplar Remnants	12.0	---	---	---	---	---	---
Fyke Net	Reference	17.8	14.7	15.0	16.8	15.8	13.9	17.2
Fyke Net	Cell 1A	---	10.1^{E}	11.5^{D}	19.0^{A}	10.8^{DE}	14.9^{B}	13.5^{C}
Fyke Net	Cell 1C	---	---	---	16.2^{B}	16.3^{B}	7.5^{C}	17.0^{A}
Fyke Net	Cell 1B	---	---	---	---	14.4^{B}	16.2^{A}	13.9^{B}
Fyke Net	Cell 3A	---	---	---	---	---	---	15.6
Gill Net	Reference Creeks	---	19.1^{B}	24.1^{A}	---	---	---	19.8^{B}
Gill Net	Cell 1A Creeks	---	20.4	20.0	---	---	---	21.6
Gill Net	Cell 1C Creeks	---	---	---	---	---	---	---
Gill Net	Cell 1B Creeks	---	---	---	---	---	---	21.5
Gill Net	Cell 3A Creeks	---	---	---	---	---	---	16.9
		Date						
		7/96	7/10	7/11	7/12	7/13	7/14	7/16
Fyke Net	Poplar Remnants	26.0	---	---	---	---	---	---
Fyke Net	Reference	25.0	26.7	28.8	26.6	26.4	27.7	28.6
Fyke Net	Cell 1A	---	25.9^{BC}	28.3^{A}	24.3^{C}	25.8^{BC}	26.6^{AB}	26.0^{BC}
Fyke Net	Cell 1C	---	---	---	24.1^{B}	24.1^{B}	25.0^{AB}	25.8^{A}
Fyke Net	Cell 1B	---	---	---	---	27.0	27.1	27.0
Fyke Net	Cell 3A	---	---	---	---	---	---	26.7
Gill Net	Reference Creeks	---	29.6^{B}	32.6^{A}	---	---	---	33.6^{A}
Gill Net	Cell 1A Creeks	---	31.5^{B}	31.2^{B}	---	---	---	34.2^{A}
Gill Net	Cell 1C Creeks	---	---	---	---	---	---	33.4
Gill Net	Cell 1B Creeks	---	---	---	---	---	---	33.2
Gill Net	Cell 3A Creeks	---	---	---	---	---	---	30.8
		Date						
		9/95	10/10	10/11	10/12	11/13	10/14	10/16
Fyke Net	Poplar Remnants	21.5	---	---	---	---	---	---
Fyke Net	Reference	20.0^{A}	16.8^{ABC}	16.6^{ABC}	19.6^{AB}	10.6^{C}	14.4^{BC}	18.2^{AB}
Fyke Net	Cell 1A	---	18.1^{C}	20.7^{A}	20.9^{A}	9.0^{E}	15.1^{D}	18.6^{B}
Fyke Net	Cell 1C	---	---	---	20.9^{A}	13.6^{C}	11.3^{D}	16.5^{B}
Fyke Net	Cell 1B	---	---	---	---	11.9^{C}	14.7^{B}	19.7^{A}
Fyke Net	Cell 3A	---	---	---	---	---	---	15.9
Gill Net	Reference Creeks	---	18.6^{C}	20.2^{B}	---	---	---	23.9^{A}
Gill Net	Cell 1A Creeks	---	20.8^{B}	22.6^{A}	---	---	---	20.2^{C}
Gill Net	Cell 1C Creeks	---	---	---	---	---	---	19.8
Gill Net	Cell 1B Creeks	---	---	---	---	---	---	21.7
Gill Net	Cell 3A Creeks	---	---	---	---	---	---	18.4

DISCUSSION

A primary objective of the Poplar Island restoration project was to restore marsh habitat to a condition, for marsh nekton, superior to that of the eroding Poplar Island remnant marsh islands that comprised the archipelago during the 1995-1996 baseline nekton surveys. Based on previous (Meyer 2004, 2005, 2006a, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014) and current nekton surveys of Poplar Island, it is apparent that beneficial localized changes have occurred related to the Poplar Island wetland restoration efforts.

After seven years of marsh maturation within Cell 1A, five years within Cell 1C, four years within Cell 1B, and one year within Cell 3A, little change from Poplar Island baseline conditions related to the number of nekton species utilizing restored Poplar Island marshes was evident. During 2016, indications of significant increase in nekton species accumulation were observed during the spring where more species were observed within Cells 1A, 1C, 1B, and 3A compared to the baseline remnant marshes. Previously significant increases were only observed within Cells 1A and 1B versus initial baseline collections during spring 2012 and 2014, respectively. However, the number of nekton species observed within Cell 1B during spring, Cells 1A, 1C, 1B, and 3A during summer, and Cells 1B and 3A during fall 2016 were significantly lower than within the reference marshes. These observations indicate that nekton species accumulation within the restored marshes was limited. While the restored Poplar Island marshes are relatively large, their structural habitat and hydrologic complexities are simple, as is the case with most restored habitats (Minello and Zimmerman 1992). Differences in marsh habitat maturation, including sediment development, and population establishment by distribution-limited species (Levin et al. 1996), might contribute to the observation of significantly fewer nekton species within the restored marshes of Poplar Island compared to the reference marshes. Over time frames longer than the one to seven year maturation time period involved with these Poplar Island marsh surveys, such differences between restored and reference marshes for nekton species accumulation might equalize as restored marshes mature and marsh habitat complexity (Minello and Zimmerman 1992) and potential for colonization by dispersal limited species increases. However, reduced complexity of habitat, including salinity regime within the restored marshes compared to reference marshes might impair restored marshes from ultimately mimicking reference marshes.

The restored marshes within Poplar Island have restricted freshwater input from uplands and are virtually reliant on rainwater from the wetland cells for freshwater input. The lack of substantial drainage areas that allow for seepage of freshwater through the restored marshes into the adjacent creeks associated with the Poplar Island wetlands differs from reference marshes, which have significant drainage areas. The end result in freshwater input differences between Poplar Island and reference marshes effectively alters the marsh physical characteristics. The habitat complexity of the reference marshes is increased by periodic freshwater input from surrounding uplands causing them to be hydrologically positive estuarine habitat, capable of producing lower salinity profiles than the adjacent bay water. The lack of significant freshwater seepage into the restored Poplar Island marshes create hydrologically neutral estuarine habitats with less complexity, causing their salinity profiles to be little different than the adjacent Chesapeake Bay water (Meyer 2011). Many of the rare species that occur within the reference marshes are common to brackish and oligohaline waters [*Fundulus luciae* (spotfin killifish), banded killifish, rainwater killifish, etc.] (Rohde et al. 2009). Accumulation of rare species, typically associated with lower salinity marsh habitats, might yet occur within the restored Poplar Island marshes should freshwater input from future planned upland cells create more predictably complex salinity regimes within the restored wetlands.

The island-mainland effect based upon the theory of island biogeography indicates that habitat size, and degree of isolation, can significantly influence the accumulation of species, particularly rare species and their abundance. Based upon the island biogeography concept, "large," well-connected habitats with high complexity would be expected to have a higher occurrence of rare species than "small," less complex, and/or isolated island type habitats (MacArthur and Wilson 1967, With and Crist 1995). The homogeneous nature of the restored wetland habitats produced within Poplar Island compared to heterogenous variability in habitat and environmental components that occur within the reference habitats (i.e., salinity, sediment, vegetation) appears to be reducing the potential for more diverse nekton assemblage development within the restored marshes of Poplar Island. Poplar Island marshes, even after seven years of maturation, have yet to proximately mimic the functional attributes and the more complex nature of the reference marshes. Further, because Poplar Island marshes are hydrologically limited island habitats, they might ultimately assume different functions from mainland marsh habitats (Meyer 2006b).

No significant differences were apparent among the reference and Cell 1A, 1C, 1B, and 3A marshes for mean abundances of total, transient, and resident nekton groups during 2016. The abundance of resident marsh species was stable over time within reference marshes and during the three annual measurements within Cell 1B marsh, however resident marsh species abundance was more variable within Cells 1A and 1C, though in more recent collections they appeared to be stabilizing. Transient species population size varied considerably within both reference and Poplar Island restored marshes, as is indicative of populations subject to abiotic environmental fluctuations. Interannual differences in total fish abundance within the reference and Cell 1B marshes were primarily influenced by variability in transient fish abundance, while differences within the restored marshes of Cells 1A and 1C were significantly influenced by both transient and resident marsh nekton variability. The ability of a habitat to maintain stable resident populations is representative of habitat maturity. It is evident that the reference marshes represent mature, stable salt-marsh habitat. Past data for Cell 1A resident marsh nekton populations indicated high fluctuation in abundance, however recent data for Cell 1A and that for Cell 1B suggest more stable populations have developed. Cell 1C marsh is still in an early stage of development relative to resident marsh nekton population stability, and the low marsh vegetative die-off within Cell 1C during 2013 was likely a factor contributing to increased abundance variability with resident marsh species populations.

During 2016, Cell 1A, 1C, 1B, and 3A marshes generally provided habitat for nekton species commonly associated with marshes in the geographical area of Poplar Island (Lippson and Lippson 1984, McIvor and Odum 1988, Meyer et al. 2001). After seven years of maturation, Cell 1A had significantly higher abundances of all four target forage marsh nekton species (sheepshead minnow, mummichog, striped killifish, and grass shrimp) compared to the remnant marshes during the 1995-96 pre-construction baseline. Further, after two years of maturation, since 2011, Cell 1A marsh abundances for mummichog and grass shrimp were equivalent to or significantly exceeded those of the mainland reference marshes. During 2016, after five years of maturation, Cell 1C marsh had significantly higher abundances of sheepshead minnow, mummichog, and grass shrimp, compared to the remnant marshes during the 1995-96 pre-construction baseline. Cell 1C marsh followed a similar pattern as Cell 1A marsh and after two years of maturation, abundances of mummichog, and after three years of maturation, abundances of grass shrimp were statistically equivalent to, or significantly greater than those in nearby reference marshes. Since 2014 (after two years of maturation), Cell 1B marsh has had significantly higher abundances for sheepshead minnow, striped killifish, mummichog, and grass shrimp compared to the remnant marshes during the 1995-96 pre-construction baseline. Since 2013 (one year of maturation), Cell 1B marsh mummichog and grass shrimp abundances were statistically equivalent to, or significantly greater than abundances in nearby reference marshes. During 2016 (after one year of marsh maturation), Cell 3A marsh had significantly higher abundances of sheepshead minnow, mummichog, and grass shrimp compared to the remnant marshes, while mummichog and grass shrimp abundances were statistically equivalent to, or significantly greater than reference marshes. The abundance patterns for striped killifish were similar to past annual patterns, with significantly lower abundances in Poplar Island compared to reference marshes, and suggests that the conditions for the establishment of a stable population for this species within Poplar Island wetland cells has yet to be produced. The abundances of sheepshead minnow within Poplar Island marshes continued to be significantly lower than within reference marshes during 2016. However, contrary to past nekton surveys, significant increases in the sheepshead minnow populations within the marshes of Cells 1A, 1C, and 1B have occurred, and successful population establishment may have succeeded within these wetland cells. Data from future surveys will help confirm this conclusion.

Colonization by resident marsh nekton occurs during the late fall through late winter, with mummichog and sheepshead minnow capable of moving over 800 m through open water to colonize new marshes and establish breeding populations (Meyer 2006b; Meyer and Posey 2014b). While Poplar Island is over 1.5 miles from the mainland, initial immigration by mummichog to the restored marshes of Cells 1A, 1C, 1B, and 3A, and by striped killifish to Cells 1A, 1C, and 1B, did not appear to be encumbered by dispersal difficulties (Lotrich 1975, Teo and Able 2003, Chitty and Able 2004), nor did grass shrimp colonization of Cell 1A, 1C, 1B, and 3A marshes. Striped killifish have, to a limited degree, occurred within Cell 1A, 1C, and 1B marshes, though their occurrence and abundance within Poplar Island wetland cells have been inconsistent to date. Shallow-water estuarine shoals and beach areas containing high sand sediment content have typically been considered to be preferred habitat for striped killifish (Abraham 1985), sediment conditions which are atypical of Poplar Island wetlands. Cell 1A, 1C, 1B, and 3A wetland sediments are predominantly composed of silt and clay, reducing the viability of these wetland cells as an optimal habitat for striped killifish. The restored Poplar Island wetland habitats appear to be facultatively used by striped killifish and act as marginally suitable habitat for this species. Although prevalent within the reference marshes from 2010 through 2016, there was little evidence of sheepshead minnow occurrence within Cell 1A, 1C, and 1B marshes until 2016. The establishment of sheepshead minnow populations within Cells 1A, 1C, and 1B is an important milestone related to these marsh's support of the four target forage marsh nekton species, for which sheepshead minnow was the most recent to show indications of successful colonization and population establishment.

Comparative size class data from summer 2016 fyke net collections demonstrate mummichog Y1+ size classes contributed a larger portion to populations within the reference compared to Cell 1A, 1C, and 3A marshes, while sheepshead minnow and striped killifish Y1+ size classes contributed larger proportions to the populations of reference compared to Cell 1A, 1B, and 1C marshes. However, the relative abundance of mummichog Y1+ size classes within Cell 1B was similar to reference marshes, while Cell 1A marsh contained a substantial proportion of Y1+ individuals, as also noted during summer 2014. Similarly, during summer 2016, the mean size of mummichog and striped killifish were also significantly larger within the reference compared to Poplar Island wetland cell populations, while the mean size of sheepshead minnow populations were significantly larger within the Poplar Island wetland cells than the reference marshes. The cohort occurrence patterns observed during summer 2016 for mummichog between the reference and Poplar Island Cell 1A and 1C marshes, and for striped killifish between the reference and Poplar

Island Cell 1B and 1C marshes, were consistent with those observed during summer 2014, while evidence of a substantial increase in Y1+ mummichog individuals within Cell 1B marsh during summer 2016 versus 2014 collections was evident (see Meyer 2014). The consistency of a substantial proportion of the Cell 1A mummichog population being comprised of Y1+ individuals based on summer 2014 and 2016 data suggests that the Cell 1A marsh might have developed a sufficient forage base to support a larger proportion of mummichog size classes (Raichel et al. 2003). While Cell 1B marsh is of younger age than Cell 1A, the support of Y1+ mummichog size classes might be influenced by the intra-cell connection with Cell 1A, which allows for free exchange of intra-cell water for active dispersal of resident marsh fishes, including mummichog, sheepshead minnow, and striped killifish, and planktonic and active dispersal of the resident marsh fish forage base. The potential for free movement among sub-cells through intra-cell channels is particularly pertinent for the dispersion of larger Y1+ individuals which are known to move over larger spacial scales than smaller size classes (Kneib and Wagner 1994; Hunter et al. 2009). The occurrence of substantial populations of sheepshead minnow within Cell 1A and 1B marshes further suggests marsh maturation to accommodate this marsh resident and the importance of the intra-cell connections for dispersion. The highest summer abundance for sheepshead minnow, among the cells discussed here, was within Cell 1A - the oldest of the restored cells sampled in 2016 - followed by Cell 1B, which is located immediately adjacent to Cell 1A and connected through an intra-cell channel. While Cell 1C is connected to Cell 1B, it is more distant from Cell 1A, and any radiating dispersal from Cell 1A through Cell 1B would require a longer time frame for population establishment within Cell 1C. The general lack of sheepshead minnow within Cell 3A during 2016 further suggests that the origin of the sheepshead minnow dispersal was from an established population originating near Cell 1A. Cell 3D, which was restored in 2005 and was measured to have a sheepshead minnow population of 441.3 individuals/ 5 linear meters of marsh during summer 2016 (D. Meyer, unpublished data), provides the most likely candidate for the colonization source due to its proximity to Cell 1A. Data from 2017 will help to confirm the observed patterns of population size structure for mummichog and resilience of the sheepshead minnow populations within Poplar Island wetland cells. Similarly in the size-class structures and mean lengths for sheepshead minnow among Poplar Island cells, particularly between Cell 1C versus Cells 1A and 1B, suggests analogous biotic and abiotic conditions within these cells related to growth and population persistence, and potential interactions among cell populations. Summer 2016 striped killifish population size structure and mean lengths also demonstrated a degree of similarity among Cells 1A, 1B, and 1C (particularly between Cells 1B and 1C). Such similarities among populations further suggests common biotic and abiotic conditions among Cells 1A, 1B, and 1C, and population mixing among the cells. However, results related to striped killifish might also have been enhanced by the low replication of individuals included in the comparison tests, reducing potential to observe significant effects. Striped killifish is a wide ranging marsh transient (Abraham 1985) and it is probable that the summer striped killifish population at Poplar Island ranges throughout the Poplar Island wetlands and is not range limited during the summer as is mummichog (Lotrich 1975, Meyer and Posey 2009, 2014b). The consistent low relative contribution of the Y1+ cohorts in the mummichog within Cells 1A, 1C, and 3A, and sheepshead minnow and striped killifish populations within Cells 1A, 1B, and 1C, related to population size class patterns versus the reference marshes, suggest that differences in YOY recruitment and mortality rates between Poplar Island restored and reference marshes significantly reduced potential for YOY to contribute to the Y1+ size cohorts and subsequently influenced population structure.

Significant reduction in overwinter survival is known to occur in fish cohorts that are unable to accumulate sufficient energy stores (Hurst and Conover 2001) and such might be the case for resident marsh fishes during the early development stage of the restored Poplar Island marshes. Cell 1C marsh experienced a significant low marsh vegetation die-back during 2013 that negatively affected the marsh nekton community (see Meyer 2013), slowed the maturation process of the marsh time-line, and likely the ability of Cell 1C marsh to support similar increases in Y1+ mummichog cohort as Cells 1A and 1B during summer 2016. Likely factors that can explain observed differences between restored and reference marsh Y1+ cohort contribution include: differences in prey forage base to support the existing resident fish population density (Raichel et al. 2003) related to marsh maturity (Levin et al. 1996), hydroperiod related reductions in marsh surface forage time (Rozas 1995), resident fish (particularly YOY) densities exceeding optimum carrying capacity, unequal YOY production among reference and restored marshes, differences in predation induced mortality rates, or a combination of factors that could synergistically be responsible for population structure differences. Causality related to nekton usage and population structure pattern differences observed between reference and restored Poplar Island marshes might be difficult to determine. The time frame for assessment of the maturation process for Poplar Island restored marshes related to nekton community might require a time frame longer than the seven year period used within the Cell 1A marsh; a decadal time frame should be considered a more realistic criterion for restored marshes to produce ecological functions related to their ultimate climax stage (Craft and Sacco 2003).

Gill net collections from reference and Poplar Island marsh creeks during 2016 indicated that the fish species observed were similar to those observed by Markle (1976) and Smith et al. (1984) for comparable habitats within the Chesapeake Bay region. Declines in nektonivorous, non-nektonivorous, and total fish abundances within Cell 1A marsh creeks after 2010 indicate that the marsh creek fish populations have trended to a lower, more stable equilibrium level, which during 2011, were significantly lower than within the reference marsh creeks. However, no significant difference between Poplar Island Cell 1A, 1B, 1C, and 3A versus reference marsh creeks for nektonivorous, non-nektonivorous, and total fish abundances were observed during 2016. The subsequent reduction from initial higher marsh creek fish abundances within Cell 1A was also apparent within Cell 3D (Meyer 2011), and similar declines after an initial faunal colonization pulse was noted by Fonseca et al. (1996) associated with newly restored estuarine habitats, after which an eventually stable equilibrium occurred as habitats matured.

Significant differences in the abundance for individual fish species were evident between the reference and Poplar Island cell marsh creeks, and of particular interest were consistent significantly lower abundances of nektonivorous fishes: striped bass within all Poplar Island cells versus reference marsh creeks, and white perch within Cell 1A, 1B, and 1C compared to reference marsh creeks. These along with the consistent patterns of higher nektonivorous, non-nektonivorous, and total fish abundance within the reference versus the restored Poplar Island marsh creeks suggests that restored wetland marsh creeks are supporting lower levels of bait and predator fish use than the reference marsh creeks.

Just as habitat conditions within the shallow water offshore of the adjacent reference wetlands are key towards defining the functions of reference marshes and marsh creeks, so too are habitat conditions within Poplar Harbor related to the restored marshes and marsh creeks of Poplar Island. Nekton spillover from adjacent habitats (Tewfik and Bene 2003, Zeller et al. 2003) can partially explain abundance trends observed within reference and restored marsh creek habitats, as well as potential obstructions related to nekton movements. Because of the proximity of Poplar Harbor to deep open-water habitat, influx of open-water and large-bodied species that utilize deeper open-water habitats should be greater within Poplar Harbor and thereby the restored marsh habitats of Poplar Island, than within the reference marsh creek habitat (Meyer 2011). However, there is little evidence of spillover into the Poplar Island wetland complex from the surrounding shallow- and deep-water habitats (Meyer 2011). Increased influx of species that migrate through open-water areas of Chesapeake Bay or utilize deeper open-water habitat should be greater within the shallow-waters of island type habitats compared to shallow-water habitats that border mainlands, due in part to the increased proximity of islands to deep-water habitat. This does not yet appear to have happened within the marsh creeks of Poplar Island.

The trophic transfer potential from the forage nekton to high order predators within Poplar Island restored wetland habitats appears yet to be fully realized. High order predators including striped bass and bluefish, that are known to feed upon marsh residents (Tupper and Able 2000, Nemerson and Able 2003, Buckel and Stoner 2004), have been observed to significantly utilize reference marsh creeks, however, these species have yet to present significant contributions within the restored marsh creeks of Poplar Island. Research conducted within estuarine (Ng et al. 2007) and freshwater creeks (Taylor et al. 2006, Fischer and Paukert 2008) has indicated that creek width and depth has a direct relationship to community complexity and predator occurrence, reflecting that size is important in the determination of a species occurrence and population size (MacArthur and Wilson, 1967, With & Crist 1995). Inlet and marsh creek morphology within Poplar Island needs to be evaluated regarding its effect upon predator utilization. The opportunity for limited finfish use assessment based on inlet structure modification exists related to Cells 4D and 5AB versus previous inlet structure designs, while the opportunity for water body morphology assessment exists with pond use monitoring within Cells 3A, 3C, and 5AB versus previous cells. Monitoring these and other wetland modifications will provide a better understanding of restored wetland habitat functions so that effective habitat modifications or alterations in wetland designs can be initiated to improve functional use of restored habitats and trophic transfer potentials.

CONCLUSIONS

During 2016, indications of significant increase in nekton species accumulation were observed during the spring where more species were observed within Cells 1A, 1C, 1B, and 3A compared to the baseline remnant marshes. Previously significant increases were only observed within Cells 1A and 1B versus initial baseline collections during spring 2012 and 2014, respectively. However, the number of nekton species observed within Cell 1B during spring, Cells 1A, 1C, 1B, and 3A during summer, and Cells 1B and 3A during fall 2016 were significantly lower than observed within the reference marshes. This indicates that nekton species accumulation within the restored marshes was limited. Significantly fewer nekton species within the restored marshes of Poplar Island compared to the reference marshes might be due to differences in marsh habitat maturation, including sediment development, and population establishment by distribution-limited species, all of which might equalize over time. Accumulation of rare species, typically associated with lower salinity marsh habitats, might yet occur within Poplar Island marshes should freshwater input from future planned upland cells create more predictable, complex salinity regimes within the restored wetlands. Poplar Island marshes have yet to mimic the more complex nature of the reference marshes. Based upon the island biogeography concept, Poplar Island marshes might ultimately assume different functions from mainland marsh habitats.

During 2016, after seven years of maturation for Cell 1A, and since 2014, after two years of maturation for Cell 1B, both marshes had significantly higher abundances of all four target forage marsh nekton species (sheepshead minnow, mummichog, striped killifish, and grass shrimp) compared to the remnant marshes during the 1995-96 pre-construction baseline. Further, during 2016, after five years of maturation for Cell 1C, and one year of marsh maturation for Cell 3A, both marshes had significantly higher abundances of sheepshead minnow, mummichog, and grass shrimp, compared to the remnant marshes during the 1995-96 pre-construction baseline. Within the first one to three years of marsh maturation for the Poplar Island cell marshes surveyed during 2016, abundances for mummichog and grass shrimp were equivalent to, or significantly exceeded those of the mainland reference marshes. However, abundances for striped killifish and sheepshead minnow within Poplar Island marshes continued to be significantly lower compared to reference marshes. While this suggests that the conditions for establishment of a stable population for striped killifish within Poplar Island wetland cells have yet to be produced, abundances of sheepshead minnow, contrary to past nekton surveys, demonstrated significant abundance increases within the marshes of Cells 1A, 1C, and 1B during 2016 compared to previous years. Successful population establishment of sheepshead minnow may have succeeded within these wetland cells. Data from future surveys will help confirm this conclusion.

Comparative size class data from summer 2016 fyke net collections demonstrate mummichog Y1+ size classes contributed a larger portion to populations within the reference compared to Cell 1A, 1C, and 3A marshes, while sheepshead minnow and striped killifish Y1+ size classes contributed larger proportions to the populations of reference compared to Cell 1A, 1B, and 1C marshes. However, the relative abundance of mummichog Y1+ size classes within Cell 1B was similar to reference marshes, while Cell 1A marsh contained a substantial proportion of Y1+ individuals, as also noted during summer 2014. The mean size of mummichog, sheepshead minnow, and striped killifish were also significantly larger within the reference compared to Poplar Island wetland cell populations during summer 2016. The consistency of a substantial proportion of the Cell 1A mummichog population being comprised of Y1+ individuals based on summer 2014 and 2016 data suggests that the Cell 1A marsh might have developed a sufficient forage base to support a larger proportion of mummichog size classes (Raichel et al. 2003). While Cell 1B marsh is of younger age than Cell 1A, the support of the Y1+ mummichog size classes might be influenced by the intra-cell connection with Cell 1A which allows free exchange of intra-cell water for active dispersal of resident marsh fishes, including mummichog, sheepshead minnow, and striped killifish, and planktonic and active dispersal of the resident marsh fish forage base. The occurrence of substantial populations of sheepshead minnow within Cell 1A and 1B marshes further suggests marshes have matured to accommodate this marsh resident, and the importance of the intra-cell connections for dispersion. Similarly in the size-class structures and mean lengths for sheepshead minnow among Poplar Island cells, particularly between Cell 1C versus Cells 1A and 1B suggests analogous biotic and abiotic conditions within these cells related to growth and population persistence, and potential interactions among cell populations. The general lack of sheepshead minnow within Cell 3A during 2016 suggests that the origin of the sheepshead minnow dispersal was from an established population originating near Cell 1A. Cell 3D, which was restored in 2005 and was measured to have a sheepshead minnow population of 441.3 individuals/ 5 linear meters of marsh during summer 2016, (D. Meyer, unpublished data) provides the most likely candidate for the colonization source due to its proximity to Cell 1A. Data from 2017 will help to confirm the observed patterns of population size structure for mummichog and resilience of the sheepshead minnow populations within Poplar Island wetland cells. Causality related to nekton usage and population structure pattern differences observed between reference and restored Poplar Island marshes might be difficult to determine. The time frame for assessment of the maturation process for Poplar Island restored marshes related to nekton community might require a time frame longer than the seven year period used within the Cell 1A marsh; a decadal time frame should be considered a more realistic criterion for restored marshes to produce ecological functions related to their ultimate climax stage (Craft and Sacco 2003).

Gill net collections from Cell 1A marsh creeks have shown declines in total fish, non-nektonivorous fish, and nektonivorous fish abundances after 2010 that indicate marsh creek fish populations have trended to a lower, more stable equilibrium levels, which during 2011, were significantly lower than within the reference marsh creeks. The subsequent reduction from initial higher marsh creek fish abundances within Cell 1A was also apparent within Cell 3D (Meyer 2011) after an initial colonization pulse that eventually reached lower stable equilibrium. However, no significant differences for total fish, non-nektonivorous fish, or nektonivorous fish abundances within Poplar Island Cells 1A, 1B, 1C, and 3A versus reference marsh creeks were observed during 2016.

Consistent significantly lower abundances of individual nektonivorous fish species were evident within Poplar Island versus reference marsh creeks during 2016; of particular interest were: striped bass within all Poplar Island cells versus reference marsh creeks, and white perch within Cells 1A, 1B, and 1C compared to reference marsh creeks. These along with the consistent patterns of higher nektonivorous, non-nektonivorous, and total fish abundance within the reference versus the restored Poplar Island marsh creeks suggests that restored wetland marsh creeks are supporting lower levels of bait and predator fish use than the reference marsh creeks. The trophic transfer potential from the forage nekton to high order predators within Poplar Island restored wetland habitats appears yet to be fully realized. High order predators including striped bass and bluefish, that are known to feed upon marsh residents (Tupper and Able 2000, Nemerson and Able 2003, Buckel and Stoner 2004), have been observed to significantly utilize reference marsh creeks, however, these species have yet to present significant contributions within the restored marsh creeks of Poplar Island. Research conducted within estuarine (Ng et al. 2007) and freshwater creeks (Taylor et al. 2006, Fischer and Paukert 2008) has indicated that creek width and depth has a direct relationship to community complexity and predator occurrence, suggesting that size is important in the determination of a species occurrence and population size (MacArthur and Wilson, 1967, With & Crist 1995). Inlet and water-body morphology within Poplar Island might need to be evaluated regarding its effect upon predator utilization.

Future efforts should involve measures to better understand effectiveness of restored wetland habitat modifications or alterations in wetland designs (i.e., assessment of inlet structure variation, construction of ponds, channel width, etc.) to improve functional use of restored habitats and trophic transfer potentials.

HYPOTHESES CONCLUSIONS

Wetlands use by fish:

Hypothesis G1. There are no differences between decapod or fish abundance, community species composition, or population size class structure among Poplar Island restored marsh habitats compared to those prior to restoration.

Conclusions to date: During 2016, the only indications of significant increase in nekton species accumulation was during the spring where more species were observed within Cells 1A, 1C, 1B, and 3A compared to the baseline remnant marshes. Cell 1A, 1C, 1B, and 3A marshes in general supported higher (often significantly) abundances of nekton species than the baseline remnant marshes. During 2016, after seven years of maturation for Cell 1A, and since 2014, after two years of maturation for Cell 1B, both marshes had significantly higher abundances of all four target forage marsh nekton species (sheepshead minnow, mummichog, striped killifish, and grass shrimp) compared to the remnant marshes during the 1995-96 pre-construction baseline. Further, during 2016, after five years of maturation for Cell 1C, and one year of marsh maturation for Cell 3A, both marshes had significantly higher abundances of sheepshead minnow, mummichog, and grass shrimp, compared to the remnant marshes during the 1995-96 pre-construction baseline. The lack of sufficient populations of nekton species common to both remnant and restored marsh during the seasonal survey time periods precludes size class structure comparisons.

Hypothesis G2. There are no differences between decapod or fish abundance, community species composition, or population size class structure among restored Poplar Island marsh habitat compared to nearby reference marsh habitat.

Conclusions to date: During 2016, the number of nekton species observed within Cell 1B during spring, Cells 1A, 1C, 1B, and 3A during summer, and Cells 1B and 3A during fall 2016 were significantly lower than observed within the reference marshes. This indicates that nekton species accumulation within the restored marshes was limited compared to the reference marshes. Within the first one to three years of marsh maturation for Poplar Island cell marshes surveyed during 2016, abundances for mummichog and grass shrimp were equivalent to, or significantly exceeded those of the mainland reference marshes. However, abundances for striped killifish and sheepshead minnow within Poplar Island marshes continued to be significantly lower compared to reference marshes. While this suggests that the conditions for the establishment of a stable population for striped killifish within Poplar Island wetland cells have yet to be produced, abundances of sheepshead minnow within Poplar Island marshes, contrary to past nekton surveys, demonstrated significant abundance increases within the marshes of Cells 1A, 1C, and 1B during 2016 compared to previous years. Successful population establishment of sheepshead minnow may have succeeded within these wetland cells. Data from future surveys will help confirm this conclusion.

Comparative size class data from summer 2016 fyke net collections demonstrate mummichog Y1+ size classes contributed a larger portion to populations within the reference compared to Cell 1A, 1C, and 3A marshes, while sheepshead minnow and striped killifish Y1+ size classes contributed larger proportions to the populations of reference compared to Cells 1A, 1B, and 1C marshes. However, the relative abundance of mummichog Y1+ size classes within Cell 1B was similar to reference marshes, while Cell 1A marsh contained a substantial proportion of Y1+ individuals, as also noted during summer 2014. The mean size of mummichog, sheepshead minnow, and striped killifish were also significantly larger within the reference compared to Poplar Island wetland cell populations during summer 2016. The occurrence of substantial populations of sheepshead minnow within Cell 1A and 1B marshes suggests marshes have matured to accommodate this marsh resident, and the importance of the intra-cell connections for dispersion. Similarly in the size-class structures and mean lengths for sheepshead minnow among Poplar Island cells, particularly between Cell 1C versus Cells 1A and 1B suggests analogous biotic and abiotic conditions within these cells related to growth and population persistence, and potential interactions among cell populations. Data from 2017 will help to confirm the observed patterns of population size structure for mummichog and resilience of the sheepshead minnow populations within Poplar Island wetland cells. Causality related to nekton usage and population structure pattern differences observed between reference and restored Poplar Island marshes might be difficult to determine.

No significant differences for total fish, non-nektonivorous fish, or nektonivorous fish abundances within Poplar Island Cell 1A, 1B, 1C, and 3A versus reference marsh creeks were observed during 2016. However, consistent significantly lower abundances of individual nektonivorous fish species were evident within Poplar Island versus reference marsh creeks during 2016, of particular interest were: striped bass within all Poplar Island cells versus reference marsh creeks, and white perch within Cell 1A, Cell 1B, and Cell 1C compared to reference marsh creeks. These along with the consistent patterns of higher nektonivorous, non-nektonivorous, and total fish abundance within the reference versus the restored Poplar Island marsh creeks suggests that restored wetland marsh creeks are supporting lower levels of bait and predator fish use than the reference marsh creeks. The trophic transfer potential from the forage nekton to high order predators within

Poplar Island restored wetland habitats appears yet to be fully realized. Inlet and marsh creek morphology within Poplar Island might need to be evaluated regarding its effect upon predator utilization.

Hypothesis G3. There are no differences in decapod or fish abundance, community species composition, or population size class structure associated with age (seral stage) of restored Poplar Island marsh habitats.

Conclusions to date: There has been no significant difference in mean number of nekton species occurrence within the reference marshes from 2010 through 2016. With respect to seral stage, there have been significant increases in the mean number of nekton species within Cell 1A during spring 2016 versus 2010, 2011, and 2014, and within Cell 1C during spring 2016 versus 2012 and 2014. There has been no significant difference in mean number of nekton species occurrence within the Cell 1B marsh from 2013 through 2016. Lack of consistent significant net increases in the number of nekton species utilizing Cell 1A, 1C, and 1B marshes over time indicates that nekton species accumulation with restoration marsh age has been inconsistent and limited during the survey time frame.

Based on fyke net collections, species specific abundance changes have occurred within the reference and Poplar Island marshes between the initial marsh collections and 2016. Within reference marshes, during 2016 compared to 2010, a significant abundance increase was observed for sheepshead minnow during the summer, while abundance declines were apparent for mummichog during the spring, spot during the summer, and fall, and Atlantic silverside during the fall. During 2016, significant increases in abundance within Cell 1A marshes compared to 2010 were observed for sheepshead minnow during spring, summer, and fall, and inland silverside during the fall, while significant abundance declines were apparent for spot during the summer and fall, and mosquito fish during the fall. During 2016, significant abundance increases within Cell 1C marsh compared to 2012 were observed for mummichog and Atlantic silverside during the spring, sheepshead minnow during the summer, and banded killifish during the fall, while the only significant abundance decrease was observed for grass shrimp during fall. During 2016, significant abundance increases within Cell 1B marsh compared to 2013 were observed for sheepshead minnow and striped killifish during the summer, while significant abundance decreases were observed for grass shrimp during the summer and inland silverside during the fall.

Significant differences between summer 2014 and 2016 marsh collections related to population size class structures were evident for Cell 1A, 1C, 1B, and reference marshes for mummichog, within Cell 1C, 1B, and reference marshes for striped killifish, and within the reference marshes for sheepshead minnow. The mean size of mummichog within Cell 1A, Cell 1B, and reference marshes were significantly smaller during summer 2016 compared to summer 2014, as were striped killifish within Cell 1C, and Cell 1B marshes. The opposite was the case for the mean size of sheepshead minnow and striped killifish within the reference marshes, which were significantly larger during summer 2016 compared to 2014. The mean size of mummichog within Cell 1C marsh did not differ significantly between summer 2016 and summer 2014.

During summer 2016, relative abundance of mummichog Y1+ size classes within Cell 1B was greater than during summer 2014, while Cell 1A marsh contained a similar, substantial proportion of Y1+ individuals during summer 2016 as also noted during summer 2014. The consistency of a substantial proportion of the Cell 1A mummichog population being comprised of Y1+ individuals based on summer 2014 and 2016 data suggests that the Cell 1A marsh might have developed a sufficient forage base to support a larger proportion of mummichog size classes. While Cell 1B marsh is of younger age than Cell 1A, the support of the Y1+ mummichog size classes within Cell 1B might be influenced by the intra-cell connection with Cell 1A, which allows free exchange of intra-cell water for active dispersal of resident marsh fishes, including mummichog, sheepshead minnow, and striped killifish, and planktonic and active dispersal of the resident marsh fish forage base. The occurrence of substantial populations of sheepshead minnow within Cell 1A and 1B marshes further suggests marshes have matured to accommodate this marsh resident, and the importance of the intra-cell connections for dispersion. The time frame for assessment of the maturation process for Poplar Island restored marshes related to nekton community might require a time frame longer than the seven year period used within the Cell 1A marsh; a decadal time frame should be considered a more realistic criterion for restored marshes to produce ecological functions related to their ultimate climax stage.

Gill net collections from Cell 1A marsh creeks have shown declines in total fish, non-nektonivorous fish, and nektonivorous fish abundances after 2010 that indicate marsh creek fish populations have trended to a lower, more stable equilibrium level, which during 2011, was significantly lower than that within the reference marsh creeks. The subsequent reduction from initial higher marsh creek fish abundances within Cell 1A was also apparent within Cell 3D after an initial colonization pulse that eventually reached a lower stable equilibrium.

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