Habitat Suitability Models for Diadromous Fish in the Northeast United States

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Technical Report: Habitat Suitability Models for Diadromous Fish in the Northeast United States

Preface

Abstract

Introduction

Diadromous fish species, characterized by their migratory behavior between marine and freshwater environments, play a pivotal role in the ecological and socio-economic fabric of coastal communities. This remarkable migration enables diadromous fish to access essential resources, locate suitable spawning grounds, and maintain population connectivity, contributing to the overall health and resilience of aquatic ecosystems (Limburg & Waldman, 2009). Diadromy can be further categorized into two types: anadromy, where spawning occurs in fresh or brackish inland water, and catadromy, where reproduction takes place at sea (citation needed). These migratory patterns have significant economic and cultural implications, as diadromous fish provide essential food resources, support recreational fisheries, and hold cultural significance for coastal and indigenous communities. The ability to harvest and sustainably manage diadromous fish populations is integral to the livelihoods, traditions, and heritage of these communities, underscoring the importance of understanding and conserving these remarkable migratory species.

In the Northeastern United States, populations of diadromous fish have experienced a historic decline over the past century, primarily due to damming in rivers, overfishing, and pollution (Limburg & Waldman, 2009). This decline has had profound effects on the coastal communities that rely on diadromous fish for their economic and cultural well-being. The decline of diadromous fish threatens not only the availability of a vital food resource but also the economic stability and cultural heritage of these communities.

Understanding the habitat requirements and distribution patterns of diadromous fish species is essential for effective fisheries management and conservation efforts. By studying and monitoring the habitats used by diadromous fish, we can identify key areas for protection and restoration, implement sustainable fishing practices, and mitigate the impact of pollution and habitat alteration. Preserving and restoring these habitats are crucial steps towards ensuring the recovery and resilience of diadromous fish populations, which, in turn, will support the economic viability and cultural identity of the coastal communities that depend on them.

Furthermore, existing habitat suitability index (HSI) models for diadromous fish have played a significant role in understanding their habitat preferences and guiding conservation efforts. However, it is important to note that many of these models are outdated and often group together similar species due to limited available data (citation needed). For instance, some models may combine Atlantic and Shortnose sturgeon or group alewives and blueback herring, overlooking the distinct ecological requirements and behaviors of

these species. These models were developed based on the best available data and observations at the time but fail to capture the complexity of diadromous fish populations accurately.

Since the development of these models, there has been a significant increase in the collection of observations, studies, and data surrounding diadromous fish behavior and movement. This wealth of new information provides valuable insights into the specific habitat requirements, migration patterns, and population dynamics of individual species within the diadromous fish community. With enhanced knowledge about the ecological nuances and habitat preferences of diadromous fish, it is essential to update and refine the existing HSI models to reflect these advancements accurately.

By incorporating the latest data, observations, and studies, the development of updated HSI models holds the potential to improve our understanding of the habitat suitability for diadromous fish species. These updated models can account for the unique ecological characteristics of each species, allowing for more precise assessments of their distribution and the identification of critical areas for reproduction, feeding, and migration. Such refined models can support targeted conservation efforts and help guide management strategies that are tailored to the specific needs of individual diadromous fish species.

The objectives of this paper are twofold. Firstly, we aim to synthesize the latest life cycle observations, studies, and data on diadromous fish species in the Northeastern United States, including Atlantic Salmon, Atlantic Sturgeon, Alewives, American Eels, American Shad, Atlantic Tomcod, Blueback Herring, Rainbow Smelt, Shortnose Sturgeon, and Striped Bass. By consolidating this wealth of information, we seek to enhance our understanding of their migratory behaviors, habitat requirements, and population dynamics, specifically focusing on the spawning and juvenile lifecycle stages. Secondly, we aim to develop updated habitat suitability index (HSI) models specific to each of these ten diadromous fish species, considering the unique habitat preferences and ecological needs during these critical stages. These models will incorporate the most recent data, observations, and studies, enabling more accurate assessments of habitat suitability and the identification of critical areas for each species' survival and reproduction. Through these objectives, we strive to contribute to the broader understanding of diadromous fish ecology, support effective fisheries management, and inform conservation strategies for the benefit of both the species and the coastal communities that depend on them.

Alewives

Alewives (Alosa pseudoharengus) have a slender, elongated body with a silvery coloration and a single, unnotched dorsal fin located towards the posterior part of their body. They possess a deeply forked tail fin and lack the distinctive dark spot behind the gill cover, a characteristic seen in some closely related species (Bigelow & Schroeder, 1953). Alewives also typically measure around 10 to 15 inches (25 to 38 centimeters) in length and weigh approximately 0.25 to 0.5 pounds (113 to 227 grams). However, there can be variations in size among different populations and geographic regions.

Alewives are widely distributed throughout the northeastern United States, inhabiting coastal areas from the Gulf of St. Lawrence in Canada to the mid-Atlantic region of the United States (citation needed). They are particularly abundant in freshwater rivers and estuaries along the Atlantic coast. Figure x shows the range of alewife habitat throughout the Northeast. Alewife populations can be found in various states, including Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, and Delaware, among others. They have historically undertaken extensive spawning migrations, ascending rivers and streams from their marine habitat to reach their preferred spawning grounds in freshwater systems (citation needed). Alewives also have cultural and historical importance, with their migrations and abundance having influenced the fishing practices and traditions of indigenous communities and coastal regions for centuries. The distribution of alewife populations are influenced by several factors, including the availability of suitable spawning habitats, water quality conditions, and the presence of appropriate food resources (citation needed). While the distribution of alewife populations can vary within this region, their importance as a migratory fish species in supporting ecological processes and serving as a vital resource in coastal communities.

```
# Required packages
#library(ggplot2)
#library(sf)

# Read the alewife habitat data (replace "alewife_habitat.shp" with the actual file name and path)
#alewife_habitat <- st_read("alewife_habitat.shp")

# Plot the map
#ggplot() +
#  geom_sf(data = alewife_habitat, fill = "lightblue", color = "black") +
#  coord_sf() +
#  labs(title = "Alewife Habitat Distribution",
#       subtitle = "Northeastern United States",
#       x = "Longitude", y = "Latitude")
```

Life cycle overview

- describe life cycle

Habitat requirements

- spawning
- juvenile

Habitat suitability models

Spawning

Depth

Salinity

Temperature

Flow Velocity

Sediment Composition

Juvenile

Depth

Salinity

Temperature

Flow Velocity

Sediment Composition

American Eels

- description of species
- map of geographic range
- description of northeast distribution

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- juvenile

Habitat suitability models

spawning

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Salinity

Temperature

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Sediment Composition

juvenile

Depth

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Temperature

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Sediment Composition

American Shad

- description of species
- map of geographic range
- description of northeast distribution

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Spawning

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Temperature

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Sediment Composition

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Atlantic Salmon

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Atlantic Sturgeon

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Atlantic Tomcod

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- map of geographic range
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Salinity

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Blueback Herring

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- map of geographic range
- description of northeast distribution

Life cycle overview

Habitat requirements

- spawning
- juvenile

Habitat suitability models

Spawning

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Sediment Composition

Juvenile

Depth

Salinity

Temperature

Flow Velocity

Sediment Composition

Rainbow Smelt

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- map of geographic range
- description of northeast distribution

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- spawning
- juvenile

Habitat suitability models

Spawning

Depth

Salinity

Temperature

Flow Velocity

Sediment Composition

Juvenile

Depth

Salinity

Temperature

Flow Velocity

Sediment Composition

Shortnose Sturgeon

- description of species
- map of geographic range
- description of northeast distribution

Life cycle overview

Habitat requirements

- spawning
- juvenile

Habitat suitability models

Spawning

Depth

Salinity

Temperature

Flow Velocity

Sediment Composition

Juvenile

Depth

Salinity

Temperature

Flow Velocity

Sediment Composition

Striped Bass

- description of species
- map of geographic range
- description of northeast distribution

Life cycle overview

Habitat requirements

- spawning
- juvenile

Habitat suitability models

Spawning

Depth

Salinity

Temperature

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Sediment Composition

Juvenile

Depth

Salinity

Temperature

Flow Velocity

Sediment Composition

Synthesis and Discussion

- Comparison of habitat suitability models across species
- Implications for fisheries management and conservation
- Future directions and potential improvements for habitat suitability models

Conclusion

- Summary of key findings
- Importance of habitat suitability models for diadromous fish management
- Final remarks and call to action