**Shad & River Herring Technical Committee**
**Meeting Summary**

October 27, 2022

**Technical Committee Members:** Brian Neilan (Chair, NJ), Wes Eakin (Vice-Chair, NY), Jacque Benway (CT), Kevin Job (CT), Bill Post (SC), Brad Chase (MA), Ingrid Braun (PRFC), Jeremy McCargo (NC), Ken Sprankle (USFWS), Mike Brown (ME), Patrick McGee (RI), Ruth Haas-Castro (NOAA), Matthew Jargowsky (MD), Patrick McGrath (VA), Kevin Sullivan (NH), Jim Page (GA)
**ASMFC Staff:** James Boyle, Katie Drew, and Caitlin Starks

The TC met via conference call on October 27, 2022 to review updates to the Massachusetts Shad Habitat Plan and the Massachusetts and Maine River Herring Sustainable Fishery Management Plans (SFMPs).

The next SFMPs to be reviewed are from Connecticut (Shad) and the Potomac River Fisheries Commission (Shad).

1. **Massachusetts Taunton River Shad Habitat Plan Addition**

Brad Chase presented the American Shad Habitat Plan for the Taunton River that was developed to begin a stocking project of juvenile shad. A previous assessment from the 1960s determined there were 45rkm of potential spawning habitat in the river, and Massachusetts seeks to assess the amount of suitable habitat that currently exists and use stocking to restore the population. In 2022, 5 million shad larvae were stocked with the goal of stocking 2-4 million each year at 4-5 locations in the river over the next 6-8 years for a cumulative total of 20 million fish stocked. **The TC recommended the plan for approval by consensus.**

2. **Massachusetts River Herring SFMP (Nemasket River Update and Herring River Addition)**

Brad Chase presented the updated MA SFMP for River Herring, which included updated information for the Nemasket River and added a section for the Herring River.

*Nemasket River*

The update proposes the following sustainability metrics:

**Sustainability Measures.** The ongoing spawning run count with calculated run size will serve as the primary measure to monitor the Nemasket River run status.
**Sustainability Target.** One fishery-independent sustainability target will be used. Harvest will be capped at 10% of the time series mean (TSM). This value will be recalculated each year.
**Primary Action Threshold.** The 25$^{th}$ percentile of the Nemasket River run count time series will serve as the primary action threshold to trigger a management response to declining run size.

**Management Actions.** With two consecutive years where the Nemasket River run count is below the 25th percentile, the sustainability target will be reduced to 5% of the TSM for the following year. Three consecutive years with the run count below the 25th percentile of the time series will trigger a minimum 3-year closure the following year. In order to reopen the harvest, an opening threshold of three consecutive years above the TSM would have to occur.
**Secondary Threshold.** An annual exploitation rate of 10% of the run size will serve as a secondary threshold or warning limit. Following a single, annual exceedance of this threshold, the Massachusetts Department of Marine Fisheries (DMF) will meet with the Herring Commission to review harvest records and management practices and document the review and cause of increase in exploitation rate in a joint memorandum.

Additionally, the update proposes to limit harvest establishing a harvest period of five weeks, with three harvest days per week, and by establishing a weekly catch limit to 20 fish per permit.

*Herring River*

The new section concerning the portion of the Herring River in the town of Harwich proposes the following sustainability metrics:

**Sustainability Measures.** The ongoing spawning run count will serve as the primary measure to monitor the Herring River run status.
**Sustainability Target.** One fishery-independent sustainability target will be used that limits harvest at 10% of the time series mean (TSM) with adjusted count data for 2009-2022. This value will be recalculated every three years.
**Primary Action Threshold.** The 25th percentile of the Herring River run count time series distribution will serve as the primary action threshold to trigger a management response to declining run size.
**Secondary Threshold.** An annual exploitation rate of 10% of the run size will serve as a secondary threshold or warning limit. Following a single, annual exceedance of this threshold, DMF will meet with the Harwich Department of Natural Resources to review harvest records and management practices and document the review and cause of the increase in exploitation rate in a joint memorandum.
**Management Actions.** In any given year, a run count falling below the 25th percentile will result in DMF reporting this to ASMFC in their annual compliance report for Shad and River Herring, and DMF having a pre-season discussion with Harwich Department of Natural Resources on potential concerns. If the run count drops below the 25th percentile for two consecutive years, the sustainability target will be reduced to 5% of the TSM. If the run count drops below the 25th percentile three consecutive years a minimum 3-year closure will be imposed on harvest for the following year. In order to reopen the harvest, a threshold of three consecutive years above the 25th percentile would have to occur.

Additionally, harvest will be limited by distributing a maximum of 600 permits, establishing a harvest period of five weeks, with three harvest days per week, and by establishing a weekly

catch limit to 20 fish per permit. **The TC recommended the updated plan for approval by consensus.**

The TC also discussed the difficulty of using mortality estimates as sustainability metrics due to the sensitivity of the estimate to variations in age classes. The Stock Assessment Subcommittee for the 2023 River Herring Benchmark Assessment will review alternative methods for estimating mortality that are less sensitive to these variations.

3. **Progress Update on Maine River Herring SFMP Addendum**

In 2019, the Board approved an addendum to the Maine River Herring SFMP to allow for three provisional fisheries through 2024, with a required update in 2022, in an effort to incentivize the continuation of local restoration efforts. Mike Brown presented the report on the status of the fishery relative to the established metrics with the request that the fishery be allowed to continue for the remainder of its permitted term. Of the three locations that were capable of harvest under the addendum, only one chose to permit harvest. At that location, while mortality is higher than desired (1.79), it is still under the target of 2.0. Repeat spawning was the only metric not met, and the addendum establishes a management action of reducing harvest by 5% of TSM. Notably, one location that did not yet allow harvest met the criteria for inclusion in the state SFMP. **The TC recommended the fishery be allowed to continue under the current guidelines of the addendum for the remainder of the permitted period.**

# American Shad Habitat Plan for the Taunton River, Massachusetts

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June 2022

## Introduction

American shad (*Alosa sapidissima*) habitat plans are required by the Atlantic States Marine Fisheries Commission (ASMFC) through Amendment 3 of the Interstate Fishery Management Plan for Shad and River Herring. The first Massachusetts shad habitat plan was prepared in 2014 (MA DMF 2014) with an update submitted to ASMFC in 2021 (Chase et al. 2021). This American shad habitat plan for the Taunton River will be included in the next Massachusetts update for ASMFC and follows ASMFC formatting for shad habitat plans. However, the primary purpose at this time is to support the development of a cooperative shad stocking effort in the Taunton River between the Massachusetts Division of Marine Fisheries (DMF), Massachusetts Division of Fish and Wildlife (*MassWildlife*), and the United States Fish and Wildlife Service (USFWS).

American shad spawning runs in Massachusetts occur in two large rivers bordering several states and six small coastal watersheds. The Connecticut River and Merrimack River have relatively large runs of American shad that support recreational fisheries and are managed by multi-jurisdiction management plans (CRASC 1992; and MRTC 1997). The American shad habitat plans for the Connecticut River (CRASC 2014) and Merrimack River (MRTC 2010) were reported independently from the Massachusetts shad habitat plan. The other coastal rivers with known spawning runs present are: Palmer River, Jones River, the Indian Head and South rivers in the North River watershed, Neponset River, and Charles River. The Taunton River historically had a robust shad run and fishery that experienced sharp declines in the early 20$^{th}$ century, with limited recent evidence of a remnant run.

The principal threat identified for most shad runs in Massachusetts in the 2021 ASMFC shad habitat plan was **Barriers to Migration**. However, significant questions exist on the status of potential threats such as water withdrawals and water quality impairment that require further investigation.

**Life History.** American shad in Massachusetts undergo a late-spring spawning run to natal rivers. Spawning occurs from late April and can extend into July. Shad in New England are iteroparous (individuals can spawn over multiple years) unlike the semelparous (spawn only once) runs in southern states. A synopsis of investigations on American shad spawning habitat requirements (Greene et al. 2009) revealed that although consensus is lacking, shad generally spawn well upstream of the tidal interface at mid-river runs in relatively shallow depths (< 4 m) with more apparent selection to water velocity (0.3 to 0.9 m/s) than to a specific substrate type. Spawning shad release semi-buoyant eggs in the water column that gradually sink to the bottom where hatching occurs in 6-15 days when water temperatures range from 12-17 °C.

Juvenile shad spend their first summer primarily in the lower freshwater reaches of natal watersheds. Emigration of juveniles to tidal waters typically occurs in the fall for northern populations, with southern populations migrating later in the year. Numerous factors influence the growth of juvenile shad in freshwater habitats and the maturity of adult shad in marine waters (Greene et al. 2009). In Massachusetts shad spawning runs, the average age of maturation for shad is typically 5-6 years old, with fish maturing as early as age-3 and returning as old as age-8.

## Taunton River

**Watershed Information.** The Taunton River is the largest river in southeastern Massachusetts and has no barriers that impede American shad passage along the 62 kilometer (km) main stem. The Taunton River includes a large drainage area (approximately 1,456 $km^2$) that is supported by numerous significant tributaries. The Taunton River, which is formed by the confluence of the Matfield and Town rivers in Bridgewater, passes the borders of more than 10 towns before reaching the tidal Mount Hope Bay, which connects to Narragansett Bay (Figure 1). The watershed has a legacy of industrial pollution, yet is unique in Massachusetts among coastal rivers with no dams along its entire main stem.

**Fish Ladder Specifications:** No fishways in main stem Taunton River.

**Regulatory Authority:** The principal regulatory authority related to American shad is found with the state regulations of the DMF (coastal) and *MassWildlife* (inland). Wetlands habitat and water quality protections are provided by M.G.L. Chapter 131 §40 and CMR 10.00 and administered by the Massachusetts Department of Environmental Protection (*Mass*DEP).

**Water Withdrawal Permissions:** Three facilities have MA Water Management Act permits with authorized surface and groundwater withdrawals totaling 3.27 million gallons per day (MGD). Of these three facilities, the largest withdrawal at 3.03 MGD is for a municipal public water source.

**Water Discharge Data:** The main stem Taunton River has a United States Geological Survey stream flow gauge in Bridgewater (No. 01108000, 676 $km^2$ drainage area). The average monthly discharge at the Bridgewater gauge station is 900 cubic feet per second (cfs) for April and 554 cfs for May from the time series record of 1929-2020.

**Water Quality Monitoring:** *Mass*DEP assesses waterbodies by comparing water quality to Surface Water Quality Standards (SWQS), identifying threats to habitats, and recommending remedial actions (*Mass*DEP 2005 and 2018). The Taunton River watershed was last assessed in 2004 (Rojko et al. 2005); with most of the potential main stem shad habitat listed as *Suitable* to support aquatic life or "Not Assessed.

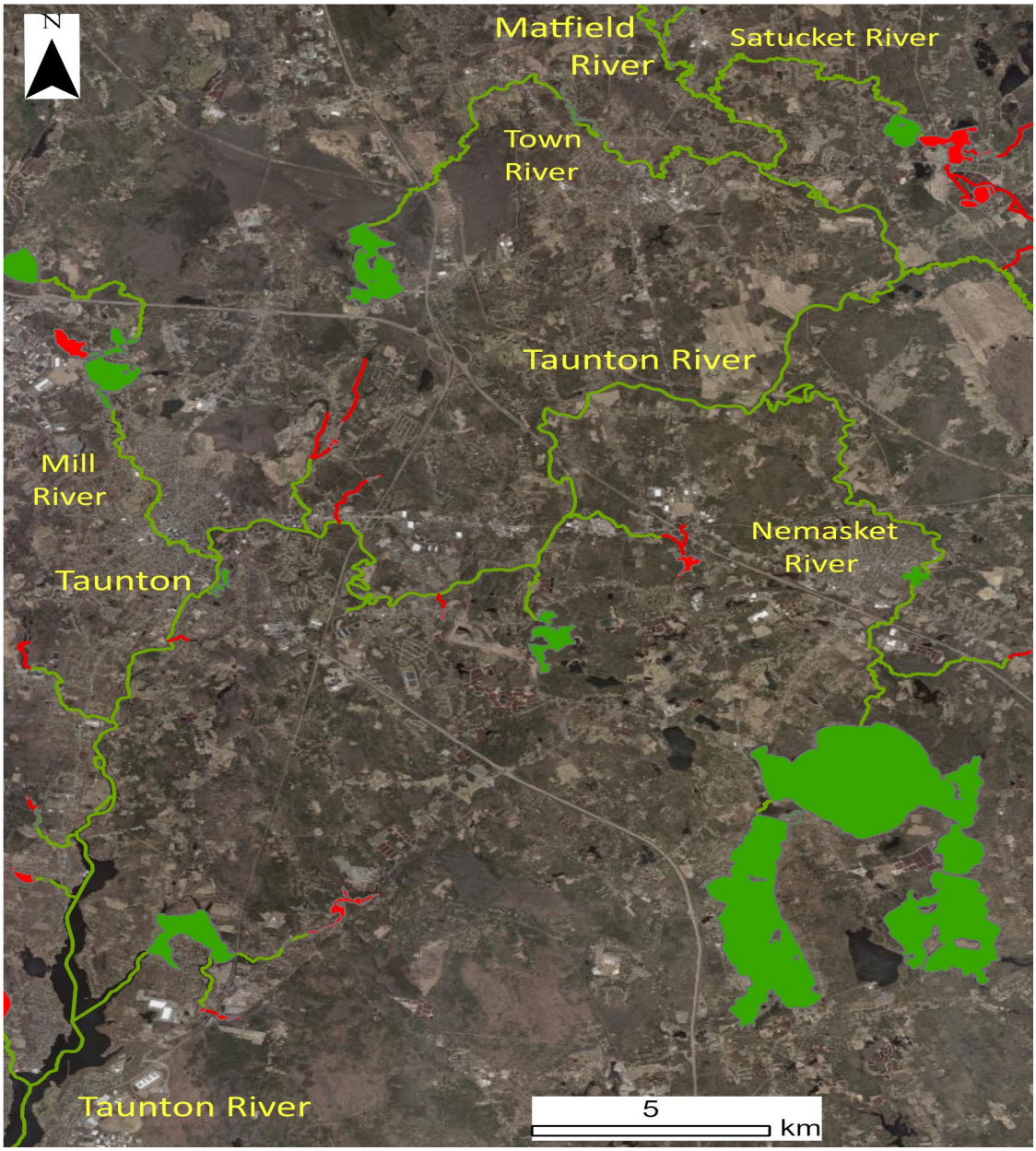
The Taunton River Watershed Alliance (TRWA) has been monitoring water quality throughout the Taunton River watershed for over two decades, measuring levels of nitrate, total phosphorus, and bacteria, along with abiotic metrics. High levels of total nitrogen and total phosphorus have been the greatest impairment to water quality in the Taunton River in recent decades, followed by bacteria levels. Recent improvements in water management, most notably improvements in sewer system integrity and treatment plants and pump station capacity have resulted in declining nutrient and bacteria levels in the Taunton River (TRWA 2019).

## American Shad Status

**Historical.** Belding's (1921) anadromous fish survey of the early 20th century recognized a sharp decline in the historical shad run in the Taunton River. A quote from Belding (1921) suggests the significance of industrial pollution in the watershed and its impact on the shad population, "if not for vast amounts of pollution, the Taunton River with its many branches and ponds would support extensive alewife and shad fisheries. The shad, once present in numbers, is now commercially extinct". The next anadromous fish survey in the 1960s (Reback and DiCarlo 1972) also cited pollution as the primary driver of low shad numbers in the Taunton system as opposed to dams. During this survey, additional work was done to identify shad habitat in the Taunton River. DMF surveyed the stream substrate from the Berkley Bridge in Dighton (between the Segregansett River and Three Mile River tributaries) to the Jenkins Leatherboard Company dam (Town River) in Bridgewater (Figure 2). The Berkley Bridge was the lower limit of salt water intrusion. They documented 45 river kilometers (rkm) of potential spawning habitat in this stretch and highlighted the promising outlook for shad restoration. They also named the Segreganset River and

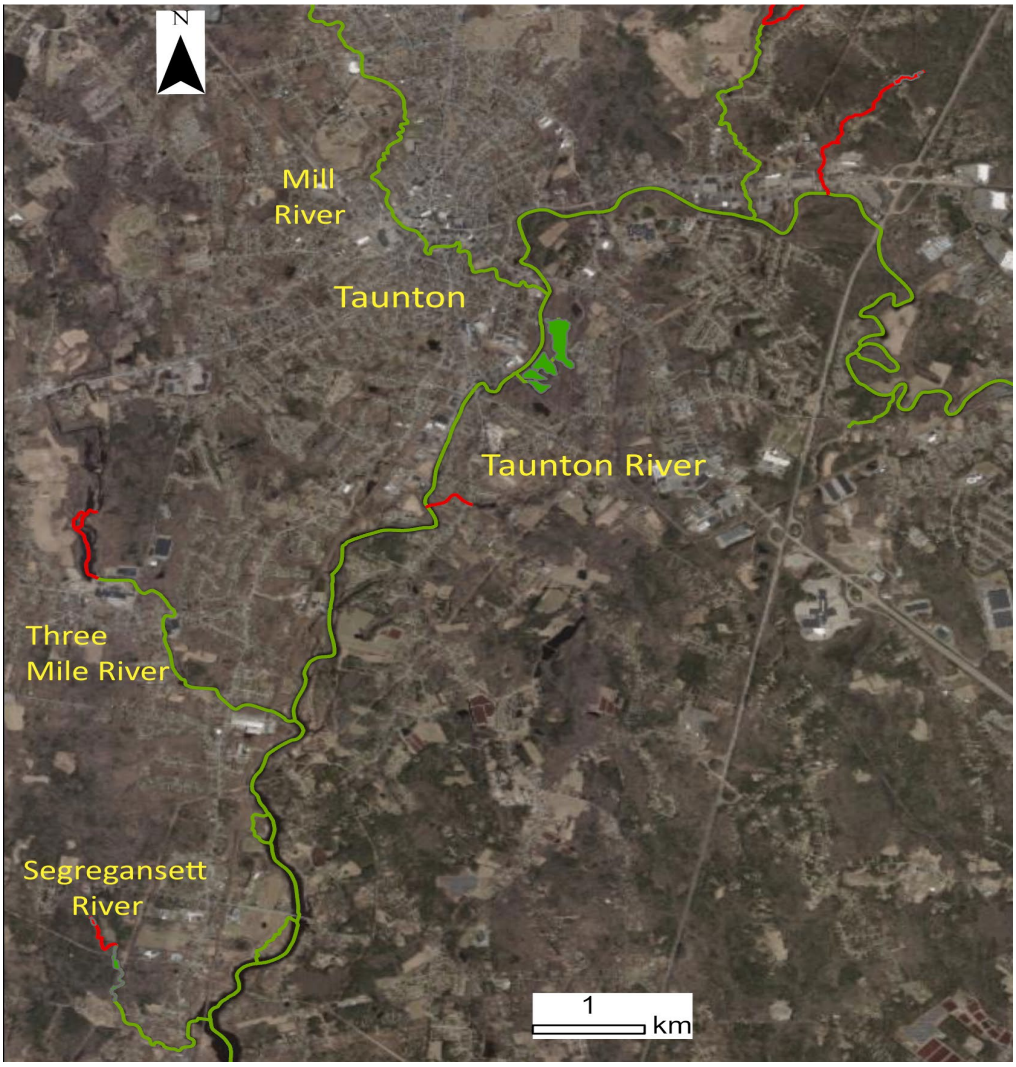
Nemasket River as Taunton River tributaries with shad present. Reback and DiCarlo (1972) noted a shad stocking project in 1969 that transferred shad eggs from Connecticut River adults to the Nemasket River. During the much of the 1970s and into the 1980s DMF stocked adult American shad in the Taunton River from the Connecticut River with attempts also made to stock fertilized shad eggs (MA DMF, unpublished report). Unfortunately, no monitoring was conducted to assess the response to these stocking efforts.

**Figure 1.** Taunton River watershed and major tributaries. Waterways in green are passable to diadromous fish and those in red have barriers to passage. Source: DMF Diadromous Fish Restoration Priority List.




**Recent Conditions.** The most recent DMF anadromous fish survey (Reback et al. 2004) echoes the potential for shad restoration in the Taunton River but recognized that shad stocking in the 1960s and 1970s with eggs and adults from the Connecticut River produced little evidence of success. In recent decades, the status of shad in the Taunton River watershed was largely unknown with a few anecdotal reports of angler catches and observations of individual adult shad.

**Figure 2.** American shad survey locations in the Taunton River reported by Reback and DiCarlo (1970).




While some American shad populations in other Atlantic drainage rivers have rebounded to varying degrees naturally, others have required external efforts from both habitat restoration and stocking (Hendricks et al. 2002). Proximate, strong runs are likely a significant factor where runs naturally rebound (Pess et al. 2014). Recent American shad stocking efforts in the Charles River, conducted by DMF in collaboration with the USFWS Northeast Region hatcheries, has resulted in documented returns of spawning adult shad. Further, passage improvements concurrent with stocking efforts in the Pawcatuck and Pawtuxet Rivers in Rhode Island have resulted in a returning shad run.

Over the last three decades, water quality and fish passage have improved significantly enough to potentially support a returning shad population in the Taunton River. Water quality improvements are largely the result of increased passage and enforcement of the Clean Water and Wetlands Protection acts, along with the closing of riverside mills. Dam removals and the construction of fish ladders have substantially improved access to upstream habitats to tributaries that were inaccessible for centuries. With these apparently improved habitat conditions, DMF began literature reviews of past records of shad in the Taunton River in 2016 and field investigations on the status of shad in the Taunton River in 2017.

## Pre-Stocking Monitoring

The status of American shad in the Taunton River in recent decades is poorly documented. The abundance has substantially declined from historic levels, but little is known on the causes and present level of population abundance and condition of spawning and nursery habitat. Uncommon and intermittent catches of shad by anglers confirm their presence in the Taunton River, but not much else is known. DMF stocked American shad in the Taunton River from 1969 through 1987 with little documented success. Recent successful shad stocking in the Charles River using advanced hatchery methods has led to discussions on other watersheds that might be viable for shad restoration, including the Taunton River. Prior to initiating stocking, more information was needed on the status of a remnant population. Concurrently, DMF has identified the Taunton River as an important coastal river where improved information is needed on diadromous fish population demographics, habitat status, and restoration potential. These data needs have resulted in the development of a monitoring project for American shad in the Taunton River, with pilot work conducted in 2017 and continued through 2021.

In 2017, a beach seining survey was conducted from June – September to target potential juvenile shad nursery habitat. Sampling was conducted throughout the main stem Taunton River, with few suitable sampling locations found above the Weir Village in Taunton. This effort identified six shoreline stations with suitable physical conditions for seine sampling. These fixed stations were sampled during 2018-2021 with sampling targets of 1-2 seine hauls each month. All catches were identified to species where possible, enumerated, and measured, with length measurements taken for all diadromous fish and a subsample of 20 fish for each other species captured. At each station, a YSI 6920 water quality sonde was used to record water chemistry following Quality Assurance Program Plan protocols similar to the DMF's river herring habitat assessments (Chase et al. 2020).

The 2017 seine survey did not catch any juvenile American shad. In 2018, six individual juvenile American shad were caught during the seine survey. Subsequently, very few additional juvenile shad were caught during 2019-2021 and similarly low numbers of adult shad were caught while conducting exploratory boat electrofishing between the Segregansett River and Mill River confluences with *MassWildlife*. The seining and electrofishing surveys conducted during 2017-2021 are documented in further detail in a separate Taunton River American Shad Monitoring Plan (Mattocks et al. 2022). The preliminary results of the 2017-2021 monitoring suggest that the historic population remains extremely depleted. The lack of strong neighboring runs to provide adequate straying to the Taunton River may be a factor in the lack of population response after recent water quality improvements in the watershed.

## ASMFC Shad Habitat Plan Framework

**1.) Shad Habitat Assessment.** The only assessment of shad spawning and nursery habitat in the Taunton River was conducted by DMF in the 1960s. This survey documented 45 rkm of potential spawning habitat in the Taunton River and highlighted the promising outlook for shad restoration. Recent exploratory work has been done in the Taunton River focusing on the documentation of shad presence.

**2.) Threats Assessment.** No formal threat assessments have been made for shad in the Taunton River watershed. As a river with the uncommon status in Massachusetts of no main stem dams, the threat of **Barrier to Migration is** not a factor. Historical overfishing and industrial pollution were cited in past anadromous fish surveys as impacting shad populations in the Taunton River.

**3.) Habitat Restoration Plan.** DMF is currently working with *MassWildlife* and the USFWS to prepare a scope for stocking shad in the Taunton River.

**Recommended action:**

DMF seeks more information on the presence of shad in the Taunton River, the status of potential shad habitat, and the influence of potential threats such as historical and present pollutant loading, and water quality impairment. We expect that a habitat survey and assessment would be useful for this watershed with methods potentially transferable to other watersheds in Massachusetts, but funding is not presently available. We **recommend** the following actions for the Taunton River: (1) assessment of the amount and suitability of habitat for shad spawning and rearing; and (2) continued monitoring to document the status of a shad spawning run.

**Agency or Agencies with Regulatory Authority:** DMF - coastal waters diadromous fish, *MassWildlife* - inland waters diadromous fish, and *Mass*DEP - wetlands and water quality protection.

**Action actively being addressed by agency:** DMF and *MassWildlife* are presently conducting river bank seining and boat electrofishing to document the presence of shad. Efforts are also underway to develop a cooperative shad stocking project with DMF, *MassWildlife,* and the USFWS.

**Initial Habitat Goal:** No restoration actions are needed to expand habitat access in the Taunton River. Agency efforts will focus on confirming species status and developing a stocking plan in 2022.

**Timeline and Costs for Achieving Goals/Targets.** Juvenile American shad stocking is recommended for six to eight years and would cost approximately $180,000-240,000 with partial reimbursement needed for the regional USFWS hatchery. Monitoring efforts would continue for a minimum of this duration to document changes in adult and juvenile American shad abundances in the river resulting from stocking efforts. Efforts are underway to secure funding sources.

**Possible metrics to evaluate progress:** (1) comparison of water quality parameters to MA SWQS for supporting aquatic life; (2) discharge range that provides suitable water depth and velocity at river habitats; and (3) American shad population metrics based on seine and electrofishing surveys.

**Potential setbacks/areas of concern:** The watershed is part of an active water supply and urbanized area with documented surface water quality and stormwater impairments. The municipal needs for water compete directly with water needs for aquatic life, but the effects are unknown.

**Other organizations:** The USFWS and *MassWildlife* are partners with ongoing shad monitoring and stocking plan development. Additionally, several towns have active river herring wardens that would likely take an interest and perhaps participate in future shad monitoring and restoration efforts as would The Nature Conservancy and the Taunton River Watershed Alliance, active non-profit groups that work to improve the aquatic resources of the Taunton River.

## Taunton River Shad Stocking Proposal

The Taunton River watershed was previously reported to contain approximately 45 rkm and 79.5 acres of potential American shad spawning habitat (MA DMF unpublished report). Based on this estimate, we propose stocking 2-4 million juvenile American shad each year at 4-5 locations in the river over 6-8 years with a cumulative target of 20 million fish stocked. To achieve this goal, approximately 350 broodstock fish would be collected annually from the Connecticut River at the Holyoke Dam fish lift with surviving adults released post-spawning. A cost-sharing or grant funding approach will need to be developed to fund this effort. Additionally, monitoring for juveniles during the summer and fall would continue to document survival; adult monitoring would begin after 3 years of stocking to determine project success (monitoring

methods are still being explored to determine the most effective option). The ultimate goal of this effort would be a self-sustaining population that eventually could be opened for recreational fishing.

The DMF prepared a shad stocking proposal in December 2018 for review by the three participating agencies. DMF and USFWS prepared a Memorandum of Agreement to initiate a 5-year Taunton River shad stocking project (approved June 2022).

The Taunton River shad stocking project will include monitoring that will utilize ASMFC recommendations for shad monitoring and investigate the potential to develop shad population indices of abundance for the Taunton River (Mattocks et al. 2022). Updates of the shad stocking project will be provided in the annual ASMFC Shad and River Herring Compliance Report for Massachusetts.

American shad caught in the Taunton River, May 2015

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# MASSACHUSETTS RIVER HERRNG SUSTAINABLE FISHERY MANAGEMENT PLAN

Submitted by the Massachusetts Division of Marine Fisheries
to the Atlantic States Marine Fisheries Commission



August 29, 2022 – ASMFC Review Draft

Bank Building, 20 Centre Street, Middleborough, Massachusetts 02346

# Nemasket River Sustainable Fishery Management Plan for River Herring

Developed Cooperatively by the Massachusetts Division of Marine Fisheries and Middleborough-Lakeville Herring Fishery Commission

**INTRODUCTION**

The Taunton River watershed contains at least 10 tributaries that support river herring runs of which the Nemasket River is acknowledged as one of the largest runs in Massachusetts. River herring harvest in Massachusetts has been prohibited since 2006 due to concerns over declining stocks. The objective of this Sustainable Fishery Management Plan (SFMP) is to allow a reopening of the recreational river herring fishery in the Nemasket River, located within the towns of Middleborough and Lakeville, Massachusetts (Figure 1). This 2022 SFMP is an update of the original SFMP prepared cooperatively by Massachusetts Division of Marine Fisheries (DMF) and the Middleborough-Lakeville Herring Fishery Commission (Herring Commission) and approved by the Atlantic States Marine Fisheries Commission (ASMFC) in 2016.

River herring were an important food source for Native American tribes living along Massachusetts coastal rivers. The Wampanoag tribe established villages along the Nemasket River (which means "place of fish") and caught herring during the annual spring migration. The Wampanoag taught the early European settlers to catch herring for sustenance and for fertilizer. Soon after Middleborough was incorporated as a town, laws were established for commercial and sustenance river herring harvest. The early Middleborough rules provided allowances for citizens to catch herring, with shares given to widows, orphans, and the poor. Mill owners along the river were required to allow the passage of herring during the annual migration. Also, around this time, a long-standing practice began to elect or appoint herring wardens to oversee the herring catch and enforce the fishery regulations. The Town of Lakeville split from Middleborough in 1853 and established itself as a separate town. The incorporating legislation specifically states that Lakeville and Middleborough jointly manage the Nemasket River herring fishery and jointly share profits (Appendix 1).

Two species of river herring occur in the Nemasket River. A large majority are alewives (*Alosa pseudoharengus*) that typically arrive in mid-March; although in warm winters, they can arrive in late-February. Blueback herring (*Alosa aestivalis*) follow two to three weeks later. River herring are present throughout April and into May. Traditionally the upstream migration peaks in April and fades during the second or third week of May, although in times of abundance the run can continue into June.

**WATERSHED**

The Taunton River starts at the confluence of the Matfield River and Town River and flows into Mount Hope Bay near the City of Fall River. The Taunton River is unique among large coastal rivers in Massachusetts in having no main stem dams. The entire watershed is 562 $mi^2$ and covers a wide range of rural, suburban, and urban areas in 43 towns and cities. One stream flow gauge station is present on the main stem river in Bridgewater (USGS #01108000; drainage area = 261 $mi^2$). The mean April discharge for the time series to present is 896 cfs. The river was used extensively for commerce and waterpower during colonial and industrial times. Presently, the mills have long since been closed, water quality has improved, and the Taunton River is now designated as a Wild and Scenic River by the U.S Congress.

The eleven-mile long Nemasket River starts at the Assawompsett Pond dam and flows north, entering the Taunton River near the Bridgewater/Middleborough line. The Nemasket River has low gradient and water velocity throughout the entire length and has only one small section with swifter flow, a short distance below Wareham Street in Middleborough. The river is crossed by ten roads (including a multi-lane highway) and two railroad tracks. The low grade and changes in water supply withdrawals may have contributed to recent increases in invasive aquatic vegetation and siltation. The upper one third of the river forms the boundary between Middleborough and Lakeville. For approximately the lower two thirds of its length, the Nemasket River flows entirely within Middleborough.

Overall, river herring migrate approximately 23 miles and must pass three obstructions in the Nemasket River on the way from Mount Hope Bay to the spawning grounds in the Assawompsett Pond complex. A partially restored colonial mill complex is located at Oliver Mill Park, an attractive and popular public park that includes a large and functional pool and weir fish ladder constructed by the DMF Fishway Crew in the 1980s (Figure 2). The second obstruction is a remnant industrial mill dam and a movable bascule gate from a former power plant at Wareham Street. A concrete pool and weir fish ladder is located here; originally built in 1874 and most recently by the DMF Fishway Crew in 1996 (Reback et al. 2004). The third obstruction is the Assawompsett Pond dam that includes a 1968 Denil fish ladder: the first Denil built in Massachusetts (Reback and DiCarlo 1972). Recently, water level operations have allowed passage directly through the gates of the dam, negating the need for the fish to use the ladder.

**SPAWNING HABITAT**

The Assawompsett Pond complex consists of Assawompsett Pond, Pocksha Pond, Great Quittacus Pond, Little Quittacus Pond, and Long Pond providing over 5,000 acres of river herring spawning and nursery habitat. The first four are directly connected, forming the largest natural pond complex in Massachusetts. This amount of habitat is certainly a contributing reason why the Nemasket River hosts one of the largest herring run in Massachusetts. Much of the surrounding watershed land, except for Long Pond, is owned by cities, the state, or conservation trusts. Long Pond has experienced more traditional lakeside development, with many seasonal cottages now trending towards year-round neighborhoods.

All ponds in the Assawompsett Pond complex except Long Pond are protected water supply reservoirs for the cities of Taunton and New Bedford. As such, the cities vigorously protect the watershed, and did not even allow fishing from the shore for almost a hundred years. Given the protections and goals of the water supply, the lakes have maintained suitable water quality. The lakes are shallow and prone to temperature changes, although except for years of very low water, there has been no observed limitation of spawning or nursery habitat quality. Spawning adult herring can access the entire pond complex, except for Little Quittacus Pond which is gated off to ensure herring do not enter the intake pump at the New Bedford water treatment plant. Juvenile herring remain in the pond complex for several months, until exiting during a seaward migration occurring primarily in the fall.

**HERRING FISHERY COMMISSION**

The towns of Middleborough and Lakeville have a long-standing commitment to manage and protect the Nemasket River herring run. This tradition has been supported by monetary incentives and interest to sustain a natural resource used widely by the public. Over the years, individuals and commercial enterprises were allowed allotments of herring and commercial licenses were issued through annual bids. For many years, Middleborough and Lakeville residents were allowed one bushel of herring annually. Commercial herring fishing on the Nemasket River ended in 1965. For many decades, herring wardens were appointed by the Selectmen, but no formal program was in place. In 1996, the current Herring Commission was established, and new harvest rules were promulgated. Any Middleborough or Lakeville residents could buy a permit allowing up to four dozen (48) herring being taken per week, with four days open for harvest. Three hundred permits were reserved for residents of other communities. The harvest was overseen by the wardens and several volunteer observers. The season ran from the last Wednesday in March to June 15, although catching usually ended in May as the herring run faded. This system remained in place until DMF instituted the ban on recreational herring harvest in 2006.

The current Herring Commission consists of seven volunteer fish wardens, appointed jointly by the Boards of Selectmen in Middleborough and Lakeville. Wardens are the voting members of the Commission and are assisted by several volunteers. The Commission is broadly charged with administering and enforcing herring harvest regulations, maintaining and enhancing herring habitat, and public education on the herring run. It was agreed that since the spawning grounds and river boundaries were in both Middleborough and Lakeville, and the law gave control of the herring fishery to both towns, then both towns should work jointly to protect the herring. Operating as a Chapter 44, Section 53E and ½ revolving fund agency, Commission funds came solely from the sale of herring permits. With the ban on herring catching, no permits have been sold and no operating funds have been generated since 2005. Through frugal management practices the Commission presently maintains an annual operating budget.

**POPULATION AND HARVEST ESTIMATES**

Early in the 20th century Belding (1921) reported the Nemasket River herring run was underperforming mainly due to blockages and pollution related to mill works on the river. The herring harvest in 1912 was reported as 200 barrels (estimated as about 193,000 fish at 965 fish/barrel) with an estimated potential of 2,000 barrels (about 1,930,000 fish) (Belding 1921). A review of more recent river herring surveys by DMF (Reback and DiCarlo 1972; Reback et al. 2004) and Herring Commission files reveals a pattern of improvement in the herring run during the 20th century that may reflect rebounding habitat quality as mills closed, reconstructed fishways, and the stewardship of the Herring Commission.

Volunteer herring counts were established in 1996 and utilize a ten-minute count at the exit of the Wareham Street fish ladder, along with recording air temperature, water temperature, weather at the time of the count, and barometric pressure. The volunteer count data were provided to DMF, who then calculate annual estimates of herring passage based on extrapolating the ten-minute counts.

The Nemasket River herring count data was revisited in 2012 to generate run size estimates using a random stratified sampling design recommended by DMF (Nelson 2006). The updated analysis partitions 10-minute counts into three periods of each day. This approach avoids bias that can occur when counts are concentrated at a time of day of run peaks and these data influence the extrapolated results for other times of the day. The updated analysis results in lower run size estimates than the earlier method (Table 1, Figure 3). The run size time series shows a low period of 2004-2005 of less than 250,000 herring each year, followed by a moderate increasing trend since the harvest ban in 2006. The series high estimate was over 1.3 million fish in 2002 followed by about 840,000 fish in 2013. These catch numbers relative to

other herring counts in Massachusetts support the commonly held assertion of the Nemasket River being one of the largest herring run in the state, and the largest run in many years.

For decades prior to 1996, the residents of Middleborough and Lakeville were allowed one bushel of herring per year, although recreational harvest enforcement was not consistent and was poorly reported. The illegal harvest of herring mainly for lobster and striped bass bait became a growing problem that no records can accurately describe. In 1996, local control was formally established, and the Herring Commission has since endeavored to record recreational herring catch numbers. Issued permits were formatted to allow Herring Wardens at the catching station to record the number of fish taken on each catching day. Harvest permitting ceased with the state-wide ban in 2006.

**Stocking Source.** The Nemasket River has been a source of river herring for stocking to augment or create runs at other rivers for many decades. For the last ten years, the Herring Commission participated in formal multi-year stocking programs in cooperation with DMF. Typically, the Commission provided 2,000 herring per year to restock other runs on a five-year program. The five-year period allowed for one or two years of continued stocking after the first returns of spawning fish should have occurred. Stocking efforts have been recently conducted for the Town River, Three Mile River, and Ten Mile River, and in cooperation with the Rhode Island Department of Environmental Management, University of Massachusetts, and DMF for stock enhancement and research purposes.

**SUSTAINABLE HARVEST PLAN**

**ASMFC.** The Atlantic States Marine Fisheries Commission's Amendment 2 to the Interstate Fishery Management Plan for Shad and River Herring gives states guidance for developing Sustainable Fishery Management Plans (SFMP) for river herring (ASMFC 2009). These plans are to be developed and approved by State jurisdictions then reviewed by the ASMFC Technical Committee (TC) and if suitable forwarded to the ASMFC Shad and River Herring Management Board (Board) for approval. The premise is that SFMPs should allow harvest while not diminishing the potential future reproduction and recruitment of herring stocks. The SFMPs are based on Sustainability Targets that relate management responses to population action and warning levels. SFMPs can be river-specific, regional or state-wide.

> ***ASMFC Sustainability Targets.*** *The recommended sustainability targets in Amendment 2 included: spawning stock biomass, fish passage counts, mortality rates, repeat spawning ratio, and juvenile abundance indices. From these measures, thresholds or targets shall be set to prompt action level (management action such as fishery closure or regulation change) or warning level responses (documentation and management planning).*
>
> *The first ASMFC review of SFMPs occurred during 2011-2012 when state plans from ME, NH, NY, NC and SC were approved. The sustainability targets from these SFMPs were mainly based on exploitation rates, escapement targets related to fishery dependent harvest or independent herring spawning run counts. Additionally, a recruitment failure definition and a juvenile index were applied in one case each as sustainability targets. Several states indicated their intention to investigate the future use of population metrics (mortality, length, CPUE, and repeat spawning ratio) as sustainability targets or warning limits.*

**ASMFC Update.** During the 2017-2018 review of new SFMPs and renewals from 2011-2012, the TC identified several inconsistencies between state SFMPs and the requirements of Amendments 2 and 3. As a result, the Board tasked the TC with developing proposed improvements to Amendments 2 and 3 regarding the five items below. The Board reviewed the TC recommendations in February 2021, and subsequently directed the TC to develop a technical guidance document to ensure that implementation of the Amendment 2 and 3 requirements related to the issues outlined below are consistent with the TC

recommendations. The guidelines were presented to the Board in April 2021 (ASMFC 2021). The Nemasket River SFMP was prepared with consideration for these ASMFC guideline updates.

1.) Management and monitoring of rivers with low abundance and harvest of shad and river herring.
2.) Standardization of SFMP requirements: content, metrics, and management responses to triggers.
3.) Improved integration of stock assessment information into SFMPs.
4.) Clarification of de minimis requirements as they pertain to SFMPs.
5.) Review SFMP renewal schedule and the number of years of data required for a suitable SFMP.

**Herring Commission Objectives.** The Herring Commission sent an inquiry to DMF in December 2013 regarding the potential and process for opening harvest of river herring at the Nemasket River. Consequently, several meetings occurred to discuss the topic and DMF*s* staff evaluated the available biological and count data to develop metrics for a river herring SFMP. The Commission, with their decades of experience managing the Nemasket River run, stated their belief that their previous harvest system of permitting, reporting, and limited harvest days under Commission supervision would allow a sustainable harvest. They support this contention by outlining that the modest harvest of 1999–2005 averaged about 15% of the annual run count with no evidence of impact on future recruitment. Furthermore, these harvest years include two of the lowest run counts in the time series (2004 and 2005) that were followed by nearly 10 years of steady improvements to run counts. Therefore, they expressed an interested in opening harvest to allow similar catches as occurred in 1999–2005, that when removed from the present stock, would constitute an exploitation rate of approximately 10% of the spawning run size.

**State Role.** DMF supported the request and proceeded to develop a SFMP for the Nemasket River herring run that was ultimately approved by the ASMFC in December 2016. The approved SFMP could have been implemented in 2017; however, the Herring Commission elected not to open harvest due in part to concerns over being the only run open to harvest in Massachusetts and a sharp downturn in the 2017 run size. The Commission did not elect to harvest herring during 2017-2022. They wish to update the plan in 2022 to support a future decision to open harvest. DMF supports this approach and has cooperatively updated the SFMP with additional data from 2016-2021.

**Management Unit.** The SFMP has a river-specific management unit of the Nemasket River herring run in the Towns of Middleborough and Lakeville.

**Sustainability Measures.** The ongoing spawning run count with calculated run size will serve as the primary measure to monitor the Nemasket River run status.

**Sustainability Target.** One fishery-independent sustainability target will be used. Harvest will be capped at 10% of the time series mean (TSM). This value will be recalculated each year. This level was selected as a conservative level of harvest that will be lower proportionally than 1999–2005 harvest levels in the Nemasket River and will allow within-year management measures to adjust daily limits and close harvest when the harvest target is reached. Table 1 and Figure 3 provide the run count statistics that formed the basis of the recommended sustainability target.

**Primary Action Threshold.** The 25$^{th}$ percentile of the Nemasket River run count time series will serve as the primary action threshold to trigger a management response to declining run size.

**Management Actions.** With two consecutive years where the Nemasket River run count is below the 25$^{th}$ percentile, the sustainability target will be reduced to 5% of the TSM for the following year. Three consecutive years with the run count below the 25$^{th}$ percentile of the time series will trigger a minimum 3-year closure the following year. In order to reopen the harvest, an opening threshold of three consecutive years above the TSM would have to occur.

**Secondary Threshold.** An annual exploitation rate of 10% of the run size will serve as a secondary threshold or warning limit. An exploitation rate of 10% of annual run size would recently have been similar to a harvest target of 10% TSM; but also would provide an alternative annual signal of how harvest relates to run size. Two exploitation rates in ASMFC-approved SFMPs presently target 18% (SC) and 20% (NH) of average run counts. Annual exploitation rates will be tracked each year with a threshold of 10% assigned as a warning limit. Following a single, annual exceedance of this threshold, DMF will meet with the Herring Commission to review harvest records and management practices and document the review and cause of increase in exploitation rate in a joint memorandum.

**Potential Future Metrics.** With the SFMP implementation, and increasing time series, efforts will be made to develop additional primary and secondary thresholds. DMF has conducted annual biological sampling of alewife and blueback sex, size, and age data at the Nemasket River since 2004 (Table 2, and Figures 4-6). These data allow the calculation of age, length, weight statistics and estimates of sex ratios, mortality, and survival. The target sampling level is 100 river herring per week for the duration of the run to meet suitable levels of power to discern trends (Nelson et al. 2011) for both sexes and species. The targeted run duration is usually six weeks. Aging is conducted using otoliths and following published DMF protocols (Elzey et al. 2015).

The data derived from biological sampling can provide additional information on population status and supporting evidence for management measures. However, as found in Nelson et al. (2011), the length and age metrics for river herring analyzed to date in Massachusetts provide little predictive power when related to population abundance. Mean lengths and mean ages of fish within a run can point to long-term changes in demography, but the current time series appears to be tracking inter-annual fluctuations in year class recruitment into the population and indicates that robust age structure has not been recovered. With these conditions, it is not presently possible to clearly identify thresholds associated with the biological data. This limitation is not unexpected nor prevents the development of future metrics: 18 years of size and age data allows the tracking of about four generations of river herring. DMF recommends that biological data continue to be collected from the Nemasket River herring run with the goal of developing population thresholds based on the following metrics:

**Age Structure.** Evidence of age structure truncation is present now in Massachusetts river herring populations, including the Nemasket River population. Additional cohorts to evaluate age structure or mortality rates may become useful for setting warning limits. Changes in age structure will be examined annually using the $\chi^2$ test as described in Davis and Schultz (2009).

**Repeat Spawners.** A target percentage of repeat spawners in annual spawning run could be used for setting a warning limit. However, with the present focus on otoliths for aging, it would take a renewed effort to collect and process a subsample of scales from older Nemasket River herring to compare to earlier scale samples.

**Escapement Targets.** Alternatively, to annually opening harvest at the start of the run, the Commission could consider not allowing harvest until a suitable escapement target of incoming spawners was met. The escapement target would depend on real-time reporting from an electronic or video counting station at one of the Nemasket River fishways and relate counts to a spawning habitat productivity metric. For example, the Maine Department of Marine Resources uses a calculation based on spawners per surface acre of spawning and nursery habitat (Havey 1961, Havey 1973) to set escapement targets. This would guarantee a certain number of spawners entering the spawning habitat and guard against unexpected low returns.

One potential drawback in some systems could be focusing the harvest on later arrivals that may have a higher proportion of younger fish or blueback herring.

**HARVEST MANAGEMENT**

Opening harvest in a single river creates management and enforcement challenges given that Massachusetts has over 100 rivers and 50 coastal towns that contain river herring runs. Ideally, a regional approach would be established to allow several runs to open at the same time. This would reduce concerns over harvest compliance and enforcement while providing a larger opportunity for Commonwealth citizens who are not town residents to purchase harvest permits. This has been a goal of DMF; however, few herring runs presently have the full complement of favorable stock status, a suitable data series, and the infrastructure and dedication found in the Herring Commission. Since the first SFMP was approved in 2016, three other Towns have requested a harvest opening with only Herring River in Harwich advancing to the present SFMP update.

The prior Nemasket River harvest was managed by the Herring Commission until the 2006 state-wide ban (Appendix A2). They used a proven system of selling an unlimited number of permits to residents and 200–300 permits to non-residents with a weekly maximum catch of 48 fish that could be taken on four open days at only one catching area. Catching was only allowed in the presence of a Herring Commission warden or volunteer observer. The permits were printed with punch-card features on the border that allowed the herring wardens to mark each weekly harvest.

The Herring Commission was interested in opening harvest in 2017 with an approach similar to pre-2006 that allowed a large permit base to have access to 48 fish per week with the acknowledgement that many permit holders won't maximize their allowable catch. After review of three alternative management options, the sustainability target of 10% of the TSM using the following approach was selected for balancing the interest of providing access to a large number of permit holders and preventing overages of the harvest target.

**Harvest Permits.** Typically, 600-700 resident permits were sold per year in the decade prior to the harvest ban and non-resident permits were capped at 200-300 and provided via lottery. The available harvest records do not presently allow a determination of the harvest rate per permit or number of inactive permits. However, the Herring Commission's impression is that a majority of permits did not realize their maximum harvest rate, and many were inactive or marginally used. Therefore, this proposal seeks to limit the potential for overharvesting the sustainability target by reducing the harvest period to five weeks, reducing the harvest days to three per week, and reducing the weekly catch limit per permit to 20 fish. Using the range of permits sold previously, this approach would have a potential maximum harvest that ranged from 80,000 to 100,000 fish (800 to 1000 permits). By allowing unlimited resident permits and 250 non-resident permits via lottery the Commission is expecting about 900 total permits. The maximum harvest under this scenario would be 90,000 fish. An assumed harvest rate of 50% of the maximum potential harvest would result in a harvest of 45,000 fish.

The potential for harvest to exceed the sustainability target exists for this approach if a high proportion of permit holders takes the full weekly harvest each week. This proportion is expected to be low given the Herring Commission's past experience. This outcome is hard to predict but will be easily tracked once harvest is open. The SFMP will diligently monitor harvest performance by permit and week in order to make annual adjustments to relate the harvest target to the numbers of permits issued.

The previous "punch-card" permit system would be augmented with the issuance of daily catch cards to each permit holder that harvests herring. The card would indicate the date, permit number, and number of fish. State regulations will be changed by DMF to require that any possession of river herring in Massachusetts be accompanied by the Nemasket River harvest permit and the daily harvest card. Herring frozen in bags must have the original daily harvest card placed in the bag. The permits and daily catch cards would be professionally printed on waterproof paper.

The usage of harvested river herring trended sharply towards striped bass bait in the decade leading up the state-wide harvest ban. DMF recognizes that a component of the concern that led to the state-wide ban on river herring harvest was excessive harvest and declining conservation ethics related to the harvest for lobster and striped bass bait. Under this SFMP, recreational bait use will be allowed; however, the SFMP seeks to promote and encourage traditional uses of consumption of river herring as grilled, pickled, and smoked fish and fried roe. There will be public outreach associated with the implementation of the SFMP that encourages responsible use of herring for bait and traditional use as food. The Herring Commission will also consider accommodating requests for food as able. For example, requests for only females for roe harvest might be allowed when manageable on-site during the three open days per week. In these cases, the Herring Commission should record the female only harvests and compensate daily as needed by providing males for bait use.

**Native American Harvest.** The Commonwealth of Massachusetts recognizes the aboriginal practice of the Wampanoag tribe to harvest river herring in Massachusetts. In prior years, a Memorandum of Agreement was signed between DMF and the tribe with the agreement that harvest was an aboriginal right for sustenance purposes only and that harvest would be reported by river to DMF. The tribe's harvest is not bound to SFMP measures: however, an accurate accounting of their harvest in the Nemasket River will assist a successful SFMP. DMF will discuss the possibility of issuing free permits to the Wampanoag tribe and to coordinate with the tribe to encourage responsible harvest, record keeping, and the potential to include tribal harvest in annual sustainability targets under the SFMP.

**STATEWIDE REGULATIONS AND ENFORCEMENT**

For this harvest opening to be successful and enforceable, the process will need a tightly managed accounting system for daily harvest, well-planned coordination with the State Environmental Police, and participation from Town law enforcement. A coordination meeting will be held with the Massachusetts Environmental Police, DMF, Town Police, and the Herring Commission each year prior to the season start. DMF will enact changes to the existing state regulations that ban state-wide harvest to allow harvest and possession of Nemasket River herring in accordance with this SFMP. This process will include a review of existing penalties for non-compliance and updating the penalties as needed.

The Massachusetts Environmental Police has recommended that the Herring Commission provide information on permit records and seasonal harvest records to improve the enforcement of harvest regulations. The ideal approach would be to have an online source of permit records and the names and schedules of herring wardens available at the start of each season with weekly updates in harvest by permit. The Herring Commission may not presently have the capacity to provide permit data or weekly harvest records online. However, the Herring Commission recognizes the value in these communications for law enforcement and will endeavor to prepare a spreadsheet of permit holder information and river herring warden names, schedules, and phone numbers for the start of the harvest season.

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**TABLES & FIGURES**

**Figure 1.** Nemasket River Watershed. Source: DMF Diadromous Fish Restoration Priority List. River herring can access green locations and red locations are impassible to river herring.

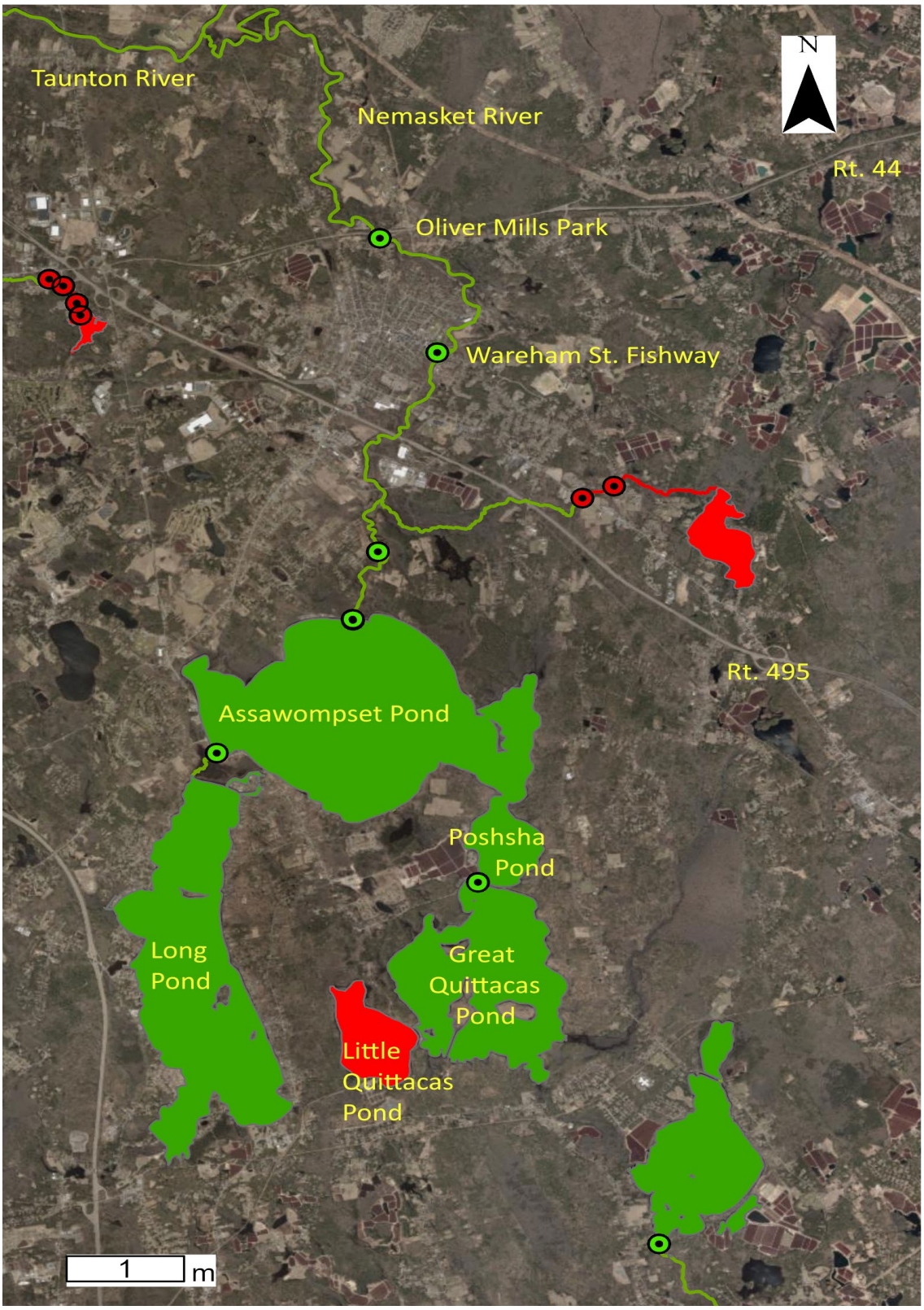


**Figure 2.** Oliver Mill Park, Nemasket River, Middleborough.


**Figure 3.** River herring spawning run count for the Nemasket River, Middleborough/Lakeville, Massachusetts. Graphical presentation of Table 1 data showing the time series mean (TSM), 1st quartile (25th percentile) and sustainability target (10% of TSM) as blue line.

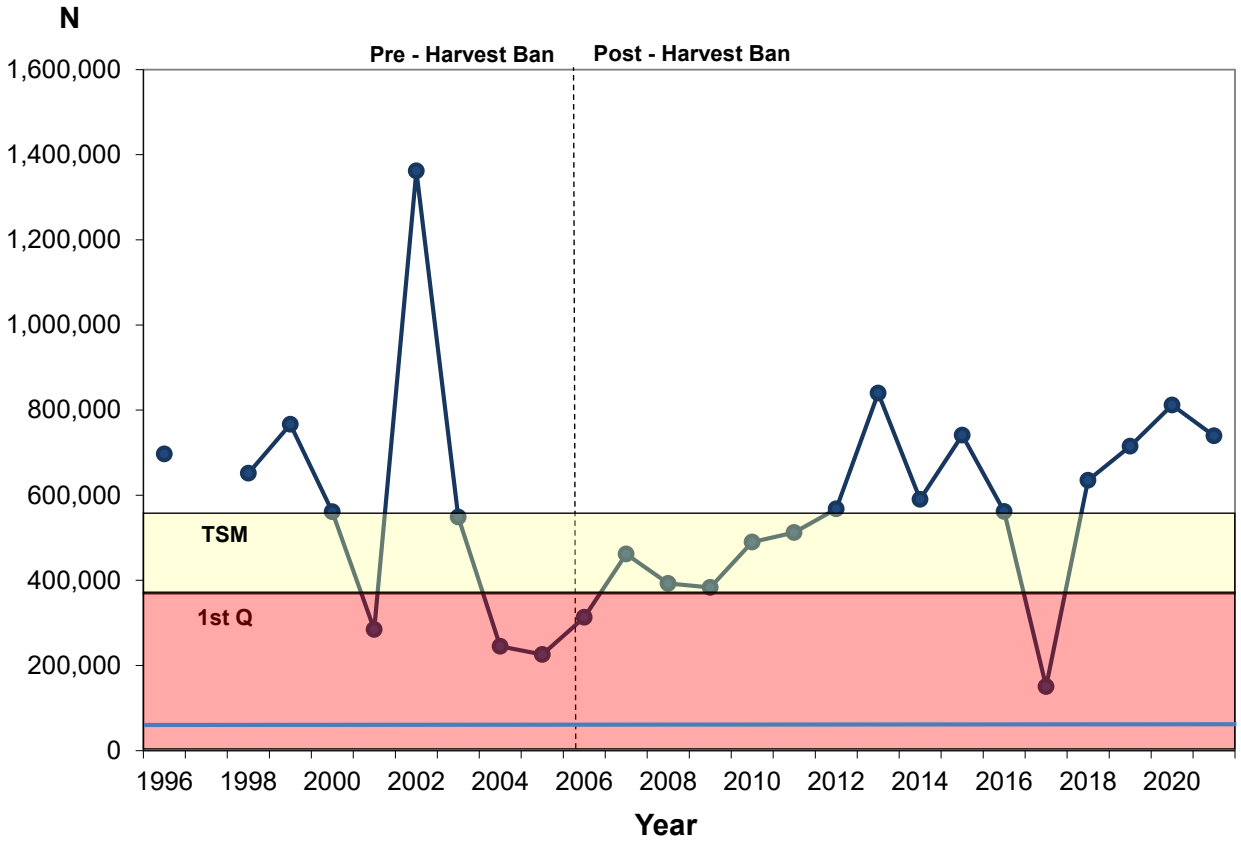


**Table 1.** River herring spawning run counts, prior harvest data, and Sustainable Fishery Management Plan metrics for the Nemasket River at the Wareham Street fishway, Middleborough, during 2004-2021.

| Year | Spawning Run Count (No.) | Permits (No.) | Harvest (No.) | Harvest % of Count (%) | Summary Statistics | |
|---|---|---|---|---|---|---|
| 1996 | 696,666 | | | | | |
| 1997 | | | | | | |
| 1998 | 651,441 | | | | | |
| 1999 | 766,694 | 742 | 104,992 | 0.14 | | |
| 2000 | 560,986 | | 76,426 | 0.14 | | |
| 2001 | 284,498 | 1966 | 59,514 | 0.21 | | |
| 2002 | 1,361,691 | 2698 | 86,301 | 0.06 | | |
| 2003 | 548,835 | 2113 | 61,945 | 0.11 | | |
| 2004 | 244,832 | 2109 | 64,593 | 0.26 | | |
| 2005 | 225,904 | 1931 | 33,964 | 0.15 | **N (years)** | 25 |
| 2006 | 313,242 | | | | **Mean** | 569,869 |
| 2007 | 462,000 | | | | **Median** | 561,538 |
| 2008 | 392,451 | | | | **Minimum** | 150,392 |
| 2009 | 383,338 | | | | **Maximum** | 1,361,691 |
| 2010 | 489,931 | | | | **1st Quartile** | 392,451 |
| 2011 | 512,139 | | | | | |
| 2012 | 567,952 | | | | **10% of TSM** | 56,987 |
| 2013 | 840,033 | | | | | |
| 2014 | 590,105 | | | | | |
| 2015 | 741,048 | | | | | |
| 2016 | 561,538 | | | | | |
| 2017 | 150,392 | | | | | |
| 2018 | 635,234 | | | | | |
| 2019 | 714,951 | | | | | |
| 2020 | 811,568 | | | | | |
| 2021 | 739,266 | | | | | |

**Table 2.** Summary total length statistics for alewife sampled by DMF from the Nemasket River at the Wareham Street fishway during 2004-2021.

| | Year | N | Mean | SD | 2SE | Min | Max |
|---|---|---|---|---|---|---|---|
| **Female** | 2004 | 127 | 291.5 | 14.36 | 1.30 | 255 | 324 |
| | 2005 | 130 | 280.4 | 15.20 | 1.34 | 248 | 318 |
| | 2006 | 127 | 275.3 | 13.66 | 2.37 | 244 | 316 |
| | 2007 | 255 | 278.1 | 12.41 | 1.64 | 197 | 320 |
| | 2008 | 228 | 281.9 | 12.49 | 1.39 | 250 | 320 |
| | 2009 | 191 | 278.3 | 11.33 | 1.87 | 249 | 310 |
| | 2010 | 277 | 281.4 | 11.67 | 1.51 | 256 | 317 |
| | 2011 | 220 | 287.1 | 11.21 | 1.63 | 254 | 315 |
| | 2012 | 154 | 284.3 | 13.44 | 2.11 | 258 | 325 |
| | 2013 | 213 | 279.5 | 9.79 | 1.50 | 258 | 312 |
| | 2014 | 236 | 287.2 | 11.63 | 1.48 | 254 | 327 |
| | 2015 | 248 | 286.6 | 11.92 | 1.49 | 253 | 312 |
| | 2016 | 258 | 296.3 | 14.20 | 1.73 | 253 | 330 |
| | 2017 | 223 | 276.5 | 15.96 | 2.09 | 247 | 327 |
| | 2018 | 167 | 280.6 | 13.45 | 2.04 | 242 | 327 |
| | 2019 | 251 | 285.7 | 9.23 | 1.14 | 256 | 320 |
| | 2020 | 228 | 286.1 | 11.59 | 1.50 | 241 | 310 |
| | 2021 | 239 | 276.3 | 13.39 | 1.70 | 250 | 314 |
| **Male** | 2004 | 141 | 282.6 | 15.15 | 2.51 | 248 | 311 |
| | 2005 | 148 | 273.0 | 16.11 | 2.77 | 233 | 309 |
| | 2006 | 197 | 265.1 | 13.35 | 1.86 | 238 | 315 |
| | 2007 | 395 | 276.6 | 12.84 | 1.03 | 212 | 300 |
| | 2008 | 276 | 269.1 | 12.94 | 1.59 | 225 | 300 |
| | 2009 | 313 | 268.1 | 11.06 | 1.38 | 240 | 308 |
| | 2010 | 276 | 272.1 | 10.67 | 1.26 | 237 | 300 |
| | 2011 | 283 | 275.2 | 11.42 | 1.69 | 237 | 298 |
| | 2012 | 229 | 270.3 | 12.50 | 1.63 | 240 | 303 |
| | 2013 | 284 | 270.5 | 10.14 | 1.43 | 243 | 295 |
| | 2014 | 324 | 277.2 | 11.24 | 1.22 | 249 | 309 |
| | 2015 | 281 | 276.8 | 11.87 | 1.40 | 237 | 310 |
| | 2016 | 321 | 282.1 | 13.30 | 1.46 | 252 | 316 |
| | 2017 | 318 | 263.8 | 17.50 | 1.93 | 195 | 309 |
| | 2018 | 398 | 269.0 | 11.80 | 1.16 | 240 | 300 |
| | 2019 | 306 | 276.5 | 7.76 | 0.87 | 255 | 308 |
| | 2020 | 295 | 276.0 | 10.62 | 1.21 | 248 | 300 |
| | 2021 | 288 | 264.8 | 10.74 | 1.24 | 236 | 300 |

**Figure 4.** Average age of alewife sampled at the Nemasket River, Middleborough, during 2004-2021.

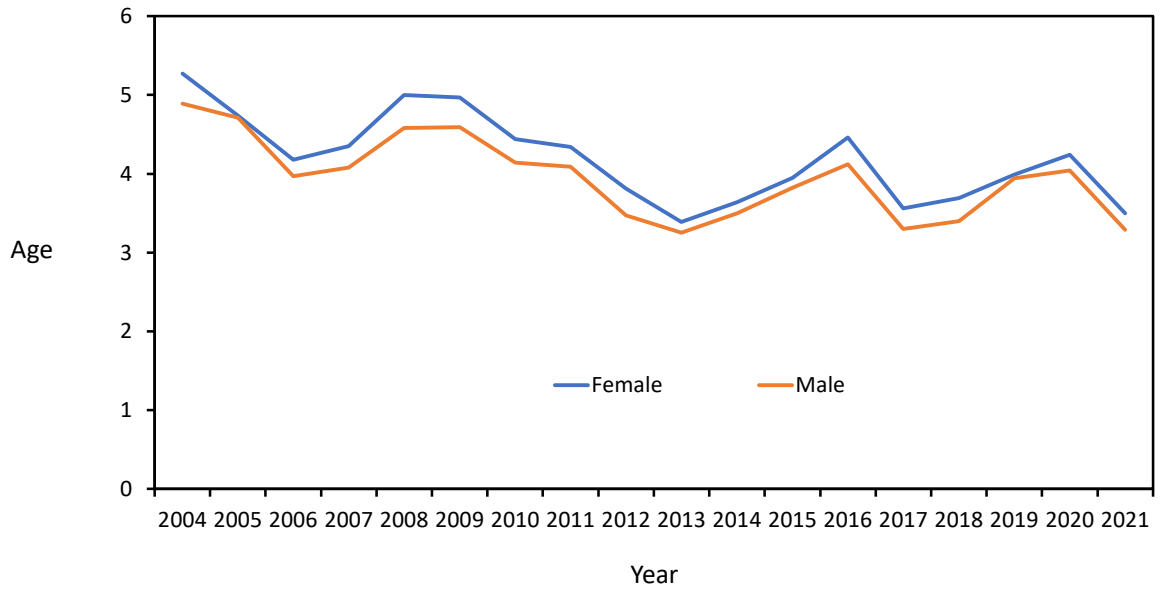



**Figure 5.** Average instantaneous mortality rate (combined sexes, Z ± 2 SE) of alewife sampled at the Nemasket River, Middleborough, during 2004-2021.

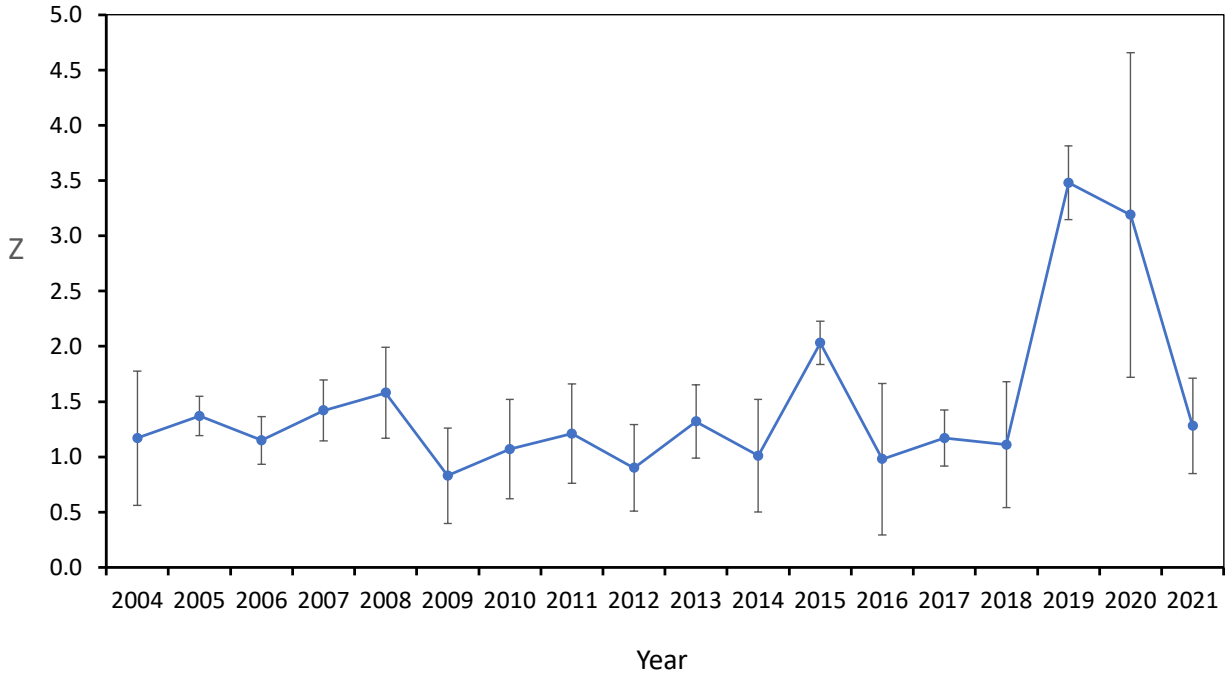
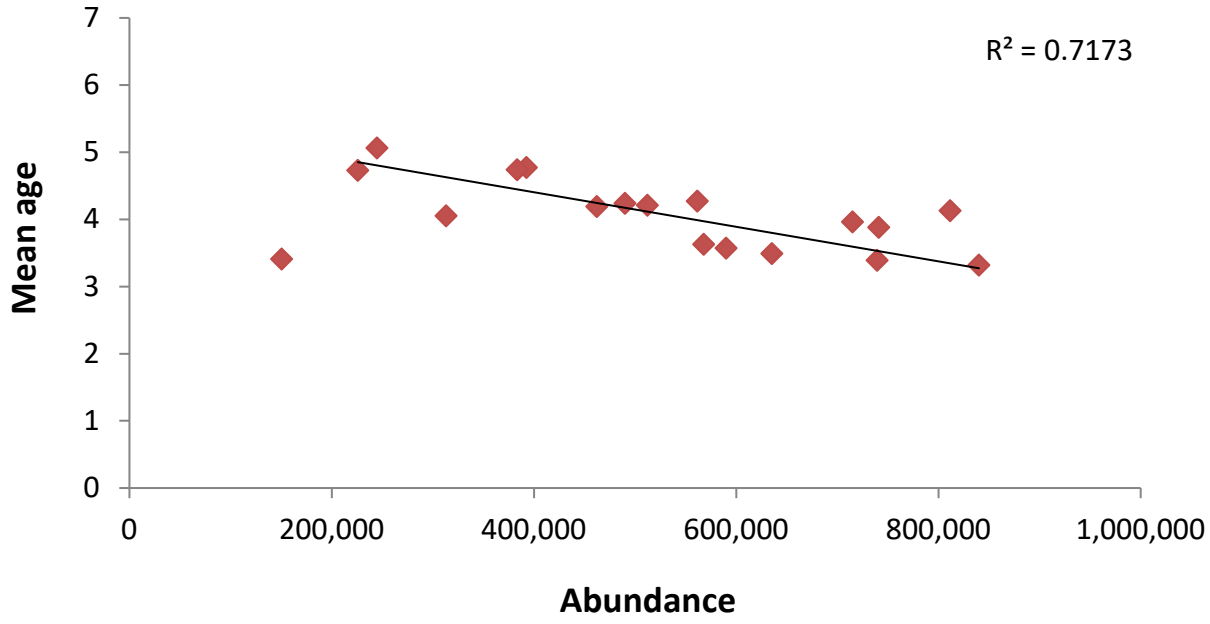


**Figure 6.** Scatterplot with linear trend of the annual mean age (combined sexes) against spawning run abundance for alewife sampled at the Wareham Street fishway, Nemasket River, Middleborough, during 2004-2021. The $R^2$ value improves to 0.770 with the removal of the time series low abundance value (150,392) from 2017.



**APPENDIX**

**A1.** Massachusetts Legislature, Acts of 1853; Chapter 338, Section 5 of the Act incorporating the Town of Lakeville, Massachusetts.

> *"The alewife fisheries of the Nemasket River shall be and remain the property of said towns of Middleborough and Lakeville, and the manner of taking said fish, and the whole management of said fisheries, shall be regulated by the selectmen of said towns; and the proceeds thereof shall be divided between the said towns, in proportion to the number of ratable polls in each respectively, and the respective parts of such protocols shall be disposed of by said towns respectively, in such a manner and for such purposes as each town shall for itself determine and direct."*

**A2.** Middleborough-Lakeville Herring Fishery Commission: Herring Rules and Regulations, December 2004 (the last revisions prior to the state-wide ban in 2006).

MIDDLEBOROUGH · LAKEVILLE HERRING FISHERY COMMISSION

Bank Building, 20 Centre Street, Middleborough, Massachusetts 02346

# HERRING RULES AND REGULATIONS

**A.** No herring may be taken without a valid and signed permit. Herring may only be taken during posted hours with a Warden or Volunteer Observer on duty.

**B.** A **maximum** of 48 fish per week may be taken, in any combination of visits. The Warden or Observer on duty may limit the catch as conditions warrant.

**C.** Herring may **ONLY** be taken by hand-held hoop net **WITH A MESH OF 3/8 INCH OR SMALLER** or by hand. Herring that are "gilled" or otherwise injured must be harvested first.

**D.** Permits are sold at the Middleborough Town Clerk's Office, 20 Center Street, Monday through Friday from 8:45 AM to 5:00 PM. The Commission will determine the number of permits sold and the manner of sale each season.

**E.** Permit Fees: Valid identification will be required.

| | | | |
|---|---|---|---|
| $5.00 | Middleborough/Lakeville Residents | $25.00 | Non-residents |
| $1.00 | Middleborough/Lakeville Senior Citizens | $5.00 | Non-resident Senior Citizen |

Duplicate Permits $2.00 (with proof of identification).

**F.** Catching Days and Times:

| | |
|---|---|
| Wednesday: | 4:00 PM to 8:00 PM |
| Friday: | 6:00 AM to 7:00 PM |
| Saturday: | 5:00 AM to 7:00 PM |
| Sunday: | 6:00 AM to 10:00 AM |

The season opens on the last Wednesday in March and ends June 15, unless closed earlier as dictated by the availability of fish.

Exception: To accommodate sport fishermen and tide considerations; herring may be taken at other times of the day or night, from May 15 to June 15 (depending on the availability of fish). The Middleborough Town Manager must be notified at least 24 hours in advance. **Call (508) 947-0928** during business hours to set an appointment with a Warden or Volunteer Observer.

G. Catching Area:

1. The pool below the falls at the Wareham Street fish ladder in Middleborough is the ONLY legal catching area in Middleborough or Lakeville. **No herring may be taken without the direct permission of the Warden or Volunteer Observer on duty.**

2. No one is permitted to enter the fish ladder, including the concrete mouth of the ladder. No one is permitted to disturb, injure, hinder or obstruct the passage of herring in any fish ladder. Fishing in the pools above or below the fish ladders at Oliver Mill Park and Wareham Street with a rod and reel in a manner which disturbs the herring, or which could snag a herring is prohibited.

3. For safety reasons, to prevent disturbing herring eggs and to prevent hindering the passage of herring; no person is permitted to enter the river at any time.

H. Littering in the general park area or throwing rocks, sticks or other objects into the fish ladders or catching areas is prohibited. Visitors and catchers shall assume all risk and liability.

It is the Commission's intention to provide a safe recreational area. Disorderly conduct or public drunkenness will not be tolerated. Offenders will be ejected from park areas.

MGL Chapter 130 Sect. 95 applies throughout Middleborough and Lakeville:

**Taking Fish From Fisheries Without Permission**

***"Whoever takes, kills or hauls onshore or disturbs, injures, hinders or obstructs the passage of any herring, alewives or other swimming marine food fish ... shall be punished by a fine of not less than five nor more than fifty dollars."***

**The Towns of Middleborough and Lakeville and the Mass. Environmental Police may prosecute violation of these rules. Violators are subject to arrest, fine, seizure of equipment, and loss of permit.**

**All Rules and Regulations are subject to the discretion of the Warden or Volunteer Observer on duty. Regulations may be modified as conditions warrant.**

Revised: December 2004

# Sustainable Fishery Management Plan for River Herring

# Herring River, Harwich, Massachusetts

Developed Cooperatively by the Massachusetts Division of Marine Fisheries and the Harwich Department of Natural Resources

**INTRODUCTION**

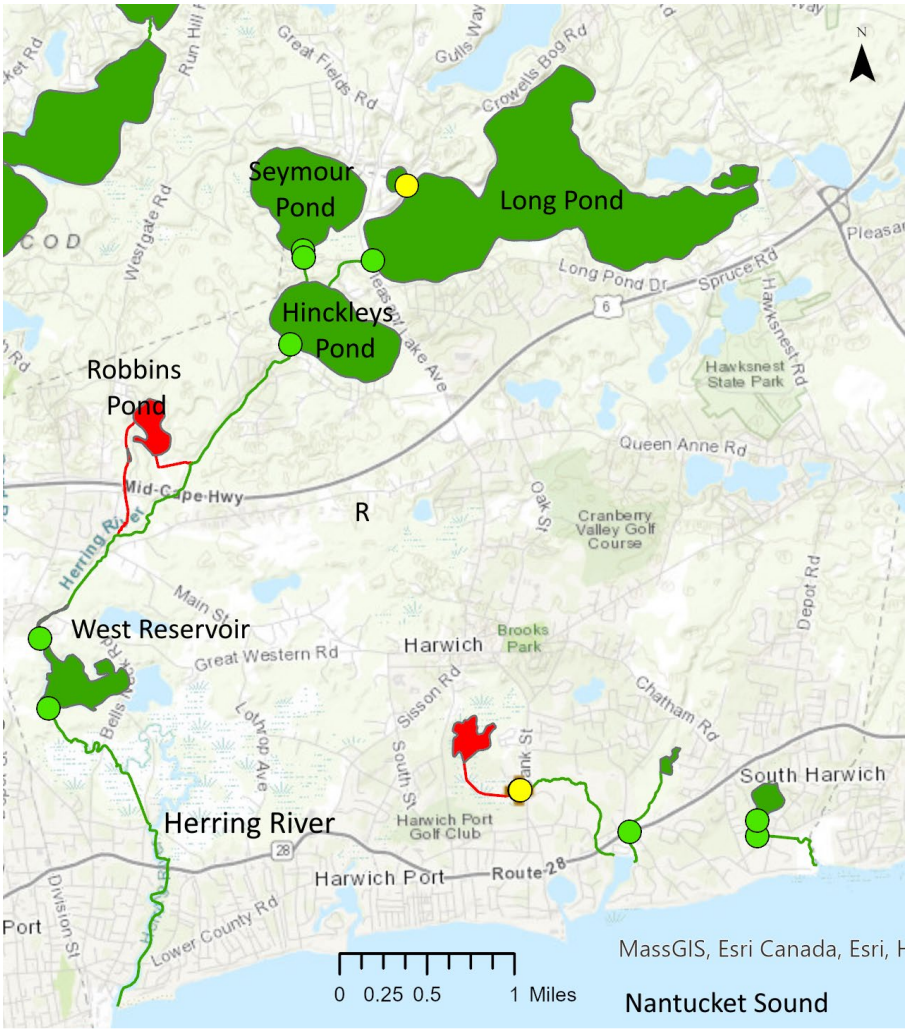
The Herring River, Harwich, has historically been one of the largest river herring runs in Massachusetts. Given the size of this herring run it likely had importance to native tribes for millennia. Reports from the early 20th century indicate that the harvest in the Herring River was among the highest in Massachusetts (Belding 1921). River herring harvest has been prohibited in Massachusetts since 2006 due to concerns over declining stocks. The objective of this sustainable fishery management plan (SFMP) is to allow a reopening of the recreational river herring fishery in the Herring River. River herring in the Herring River consist of two species, alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*). Alewife are most numerous, arriving typically in late-March on spawning runs that can last into early June. Blueback herring arrive later with a shorter duration run that peaks in late May.

**WATERSHED**

The Herring River watershed naturally begins at Hinckleys Pond and flows nearly 7 miles (mi) to Nantucket Sound (Figure 1). In terms of freshwater discharge and wetland acreage, the watershed is one of the largest on Cape Cod. The watershed contains numerous groundwater-fed kettle ponds of glacial origin with porous glacial sands and gravel dominating the river channel and watershed substrata (Godfrey 1974; Tunison 1997). The Herring River estuary has extensive salt marsh wetland with tidal influence extending 3 mi inland to the West Reservoir dam.

The entire watershed is approximately 14.9 $mi^2$ and located within the Towns of Brewster and Harwich. River flows are groundwater driven. A United States Geological Survey (USGS, #01105880; drainage area = 9.4 $mi^2$) flow gauge station is present on the Herring River in North Harwich downstream of Hinckleys Pond. The USGS data series for this station ran from 1966 to 1988, then paused until restarting in 2007 to the present. The mean monthly discharge for both April and May during the entire time series to present is 15.0 cubic feet per second (cfs). A comparison of seasonal averages between the two periods showed an 23% increase in flow from November to April and an 18% decrease from June to September during the 2007-2020 time period.

**Figure 1.** Herring River watershed, Harwich, Massachusetts. Waterways and waterbodies in green are open to river herring passage and those in red have no present passage.




Significant concerns have grown over the rate of development and the manifestation of eutrophication in the Herring River watershed in recent decades (Tunison 1997; MEP 2013). Residential lot development has increased substantially since the 1970s. Sewage treatment for the watershed is provided entirely by individual home septic systems. The Massachusetts Estuaries Project (MEP) has documented water quality impairment in the Herring River due to excessive nitrogen concentrations. The MEP study found that approximately 68% of the nitrogen load in Herring River originates from septic systems. The MEP has developed a total maximum daily load for nitrogen in the river. This TMDL target is presently driving the Town of Harwich planning to implement a sewage treatment system for the watershed.

The watershed has a long history of commercial use with fisheries, salt hay farming, ship building and mills with hydropower developing in the 18th century. Mill construction was active in the 18th century with numerous applications for cotton, wool, grist, wood, and other fabrications. The largest industry near the river may have been cranberry farming which flourished in the 19th century with numerous water control dikes and diversions installed to use Herring River water for irrigation, bog protection and harvesting. Ditches were dug to connect Hinkleys Pond to Seymour Pond and Long Pond in the 19th century to both supply water to cranberry farms and to expand the herring fisheries. The connection from Seymour Pond to Hinckleys Pond was hand dug in 1852-1853 by cranberry bog owner Captain Alvin Cahoon and is

presently called Cahoon Canal. The channel from Hinckleys Pond to Long Pond was dug in the latter half of the 19th century and is presently called Princess Brook. The West Reservoir was created by the construction of a dike for cranberry farm water control in the Belles Neck Bogs possibly in 1880 The dam was most recently reconstructed in 1932 by Vernon Johnson. Belding's coast-wide survey of alewife fisheries (1921) reported there were seven dams on the Herring River used for cranberry bog operations, although some were originally constructed for hydropower. Several water diversions exist presently for cranberry farm supply and two dams remain to regulate outflow at Long Pond and Hinckleys Pond. At least two of the cranberry bog dams washed out in the 1950s and were not rebuilt (Tunison 1997).

**FISHWAYS**

Five fishways are present in the Herring River watershed; four at the outlets of each of the major ponds (Reback and DiCarlo 1972), and a fifth connecting Long Pond to the 9-acre Black Pond. The Black Pond fishway is a 65-ft wood flume of unknown origin placed in a man-made channel connecting the ponds. The fishways at the West Reservoir and Hinckleys Pond were in poor condition at the time of Reback and DiCarlo's survey (late 1960s) and have since been reconstructed.

**West Reservoir Outlet.** The construction of the West Reservoir dike for cranberry farm water control in approximately 1880 likely included a fishway for this valuable herring run. Belding's survey (1921) described an excellent fishway at the concrete dam. The dam was most recently reconstructed in 1932 by Vernon Johnson; with the fishway still called Johnson's Flume by some presently. The fishway was next reconstructed in 1977, designed in cooperation with the Massachusetts Division of Marine Fisheries (DMF) and the U.S. Fish and Wildlife Service (USFWS). This fishway was again reconstructed during 2003-2004 based on a USFWS design funded by DMF. The 2003-2004 construction project involved the National Resource Conservation Service (NRCS), USFWS, and Town of Harwich funding. The present fishway is an 88 ft concrete weir-pool with a width of 4.7 ft and 10 weirs. Some weirs are concrete, and some are wood boards in slots and most have steel side baffles to constrain the width of flow. DMF installed a Smith-Root electronic fish counter at this site in 2016

**Hinckley Pond Outlet.** The DMF Fishway Crew reconstructed the Hinckleys Pond fishway in 1982. No records were found of prior fishways at this location, although anecdotally it is reported that a wood flume was present at the pond outlet for decades. The project was done cooperatively with the Town of Harwich paying for approximately $3,000 in materials and providing heavy machinery. The present fishway is a concrete weir-pool that is 18 ft long, 4 ft wide with 5 weirs, and an auxiliary spillway for flow management. This is the location of a volunteer herring spawning run count from 2009 to 2019.

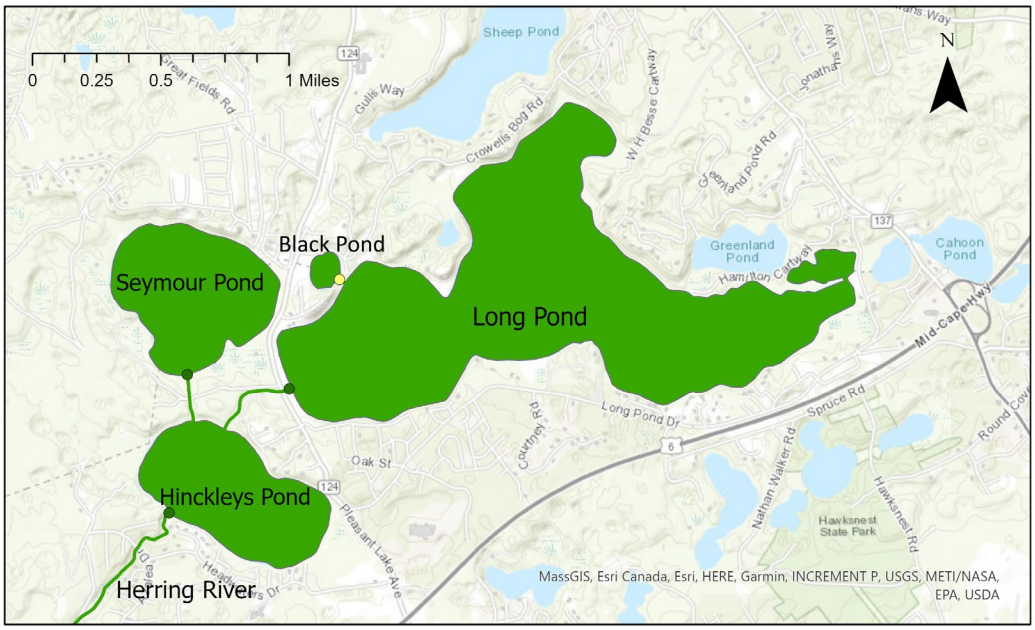
**Seymour Pond Outlet.** The Seymour Pond outlet was hand-dug in the 1850s and likely had a wooden flume to manage outflow. The DMF Fishway Crew replaced a degraded wood flume in 2017 that was reported to have been built in the 1970s (Metcalf and Eddy 1974). The present fishway has two pools and 3 board slots to manage outflow. A Fishway Operations and Maintenance Plan for the Seymour Pond fishway was prepared by DMF for the Town of Harwich in 2018.

**Long Pond Outlet.** Belding's survey (1921) shows a photograph of a wood flume at the outlet of Long Pond. This location has also been called the Princess Brook flume. A concrete weir-pool fishway was constructed by the DMF Fishway Crew at this location in 1948. That fishway was replaced in 1987 by the DMF Fishway Crew under a cooperative project with the Town of Harwich for approximately $4,000. The present fishway is a 100-ft weir-pool, with a concrete section that is 4-ft wide with a single weir that connects to a wood section extending into Long Pond. Sand intrusion from the pond has long been a problem for water depth in the fishway and downstream channel (Metcalf and Eddy 1974). In 2018, DMF fabricated and installed a custom aluminum fishway exit chute to reduce sand entrainment from the pond.

**SPAWNING HABITAT**

The tidal Herring River reaches the outlet of the West Reservoir where the fishway allows access to the 70-acre reservoir. On the north side of the reservoir the backwater of the dam dissipates, and the river continues under the former railway, Great Western Road, and Route 6 to the 171-acre Hinckleys Pond. River herring can pass from Hinckleys Pond to the 168-acre Seymour Pond via Cahoon Canal and to the 717-acre Long Pond via Princess Brook. The three primary spawning ponds provide 1056 acres of habitat (Figure 2). Collectively, the Herring River watershed provides 1,135 acres of spawning and nursery habitat - one of only 4 herring runs in Massachusetts with access to over 1,000 acres.

**Figure 2.** Primary river herring spawning and nursery habitat in the Herring River watershed.




Several locations in the Herring River watershed were developed for leased herring harvest in the 19th century; however, there is no present access to these former spawning habitats. The best documented location is Coy Brook on the eastern side of Herring River which was managed by the Coy's Brook Fishing Company starting in 1842. The brook channel was dug out to allow herring to reach Cornelius Pond (16 acres) and Walker Pond (29 acres) with later efforts to bring herring to Andrews Pond (6 acres) and Flax Pond (15 acres) (Tunison 1997). By the time of Belding's survey (1921) the run was described as "former" with access either not maintained or prevented by cranberry bog operations. Water flow manipulations for cranberry bog operations at the East Reservoir (30 acres) and to Robbins Pond (28 acres) on the western side of the Herring River may have allowed herring passage into those water bodies with managed harvest during the latter half of the 19th century. A drainage culvert presently links the East and West Reservoirs (Tunison 1997), although fish passage is obstructed.

The ponds in the Herring River watershed have had algae blooms that are indications of excessive nutrient loading. Long Pond and Hinckleys Pond have had alum treatments to bind phosphorus that contributes to the algae blooms. The Long Pond treatment occurred over 15 years ago with ongoing improvement of water clarity. The Hinckleys Pond alum treatment was conducted in 2020.

**TOWN MANAGEMENT**

There is a long history of active management of the Herring River run by the Town of Harwich extending back to the 18th century. Belding (1921) reported that a Town managed fishery with a Herring Committee and harvest regulations was established in 1787. As one of the largest herring runs in Massachusetts, cooperative support to maintain the Herring River run was provided by the Massachusetts Department of Fish and Game in the late 19th and early 20th centuries (Belding 1921). Following the designation of river herring as a public resource under state management in the 1930s with allowance for local control (M.G.L. Chapter 130 §94), a Herring River harvest and management plan was developed cooperatively by the Town of Harwich and DMF and approved by the DMF Director

The Town of Harwich managed a herring harvest at the Johnson's Flume fishway off Depot Street in the Belles Neck Bogs Conservation Area for many years with no permit requirement. More recently, leading up to the statewide moratorium in 2006, the run was managed with a daily catch limit and 3-4 no fishing days per week. Harvest permits were first required in 2002. In 2003, permit holders were allowed 6 herring per day for March-May and 12 herring per day after June 1st. Additionally, permit holders could harvest a 5 gallon bucket of herring per family once per week on Tuesday, Thursday or Sunday during March-May. In 2004, harvest was reduced to 12 herring per day per permit on Wednesday, Friday, Saturday, or Sunday from March 1st to June 15th. The permit cost for 2004 was $25 with a limit of 1,000 permits.

Much concern was generated in the 2000s from declining spawning run adults following an extended period of low pond levels and river flow during 2000-2003. The low precipitation during these years approached drought conditions that peaked in 2002 with very low pond levels during all of 2002. The Town responded proactively with discussions of a river herring harvest ban by the Board of Selectmen in 2003- 2004. This action resulted in a Town decision to cease harvest in 2005, one year prior to DMF' state-wide harvest ban approved in 2005 and enacted for the 2006 season.

**POPULATION AND HARVEST ESTIMATES**

Historical information on the Herring River herring run is limited to the Belding (1921) survey and fragments from agency summaries. One account reported 1,200 barrels (estimated 1,158,000 fish at 965 fish/barrel) harvested from Harwich in 1764 (Paine 1937, p. 347). Belding (1921) reported that the herring run in the Herring River generated among the highest annual revenue for Towns in Massachusetts during 1870-1900. In 1912, 1,500 barrels of herring (estimated 1,447,500 fish) were harvested at West Reservoir catching station with Belding (1921) estimating maximum production at 3,000 barrels (estimated 2,895,000 fish), and that an "exceptionally good year" could equate to a total spawning run size of roughly 3.5 million fish. The DMF annual reports from the 1960s provide insight on the size of the Herring River run. From 1963 to 1968 the annual harvest alone was estimated to be approximately 400,000 to 1,000,000 fish (MA DMF, unpublished annual reports).

Interest in the Herring River spawning run prompted a Harwich High School teacher to lead a volunteer visual spawning run count in the 1990s; predating the present DMF river herring counting methods guided by Nelson (2006). These data were not available for the SFMP and may not be comparable to present counting methods. A volunteer visual herring count was established at Hinckleys Pond in 2009 by the Harwich Conservation Trust. Ten-minute counts of adult herring moving through the fishway into Hinckleys Pond are made throughout the day. These counts are applied to a DMF model to extrapolate a population estimate for the spawning run (Nelson 2006). The Hinckleys Pond count averaged 75 thousand fish for 11 years from 2009-2019. The COVID pandemic caused the count to cease for 2020 and 2021. DMF installed a Smith-Root electronic fish counter at the West Reservoir in 2016 which has produced a near-census of the spawning run annually since then, with an average annual count of 620,000 for 2016-2022.

The electronic count series at the West Reservoir provides only 7 years of spawning run count data as of 2022. The volunteer visual count series at Hinckleys Pond has 11 years of data. Decisions on a sustainability metric for this run were supported by a review and comparison of the two counting methods. The present volunteer count targeted at least nine 10-minute counts between 07:00 and 19:00 for the entire spawning run. The electronic fish counter recorded much higher numbers of fish during 2016-2019 than at Hinckleys Pond. The higher number is certainly influenced by the inclusion of night movements and fish that spawn in the West Reservoir and do not advance further upstream to Hinckleys Pond. Table-1 shows the counts for both locations and the ratio of the two sites when both counts occurred. The ratio allows the two options of using adjusted count data from 2009-2022, or solely the electronic count data for 2016-2022.

**SUSTAINABLE HARVEST PLAN**

**ASMFC.** The Atlantic States Marine Fisheries Commission (ASMFC) Amendment 2 to the Interstate Fishery Management Plan for Shad and River Herring gives states guidance for developing Sustainable Fishery Management Plans (SFMP) for river herring (ASMFC 2009). These plans are to be developed and approved by State jurisdictions then reviewed by the ASMFC Technical Committee (TC) and if suitable forwarded to the ASMFC Shad and River Herring Management Board (Board) for approval. The premise is that SFMPs should allow harvest while not diminishing the potential future reproduction and recruitment of herring stocks. The SFMPs are based on Sustainability Targets that relate management responses to population action and warning levels. SFMPs can be river-specific, regional or state-wide.

> ***ASMFC Sustainability Targets.*** *The recommended sustainability targets in Amendment 2 included: spawning stock biomass, fish passage counts, mortality rates, repeat spawning ratio, and juvenile abundance indices. From these measures, thresholds or targets shall be set to prompt action level (mgt. action such as fishery closure or regulation change) or warning level responses (documentation and management planning).*
>
> *The first ASMFC review of SFMPs occurred during 2011-2012 when state plans from ME, NH, NY, NC and SC were approved. The sustainability targets from these SFMPs were mainly based on exploitation rates and escapement targets related to fishery dependent harvest or independent herring spawning run counts. Additionally, a recruitment failure definition and a juvenile index were applied in one case each as sustainability targets. Several states indicated their intention to investigate the future use of population metrics (mortality, length, CPUE, and repeat spawning ratio) as sustainability targets or warning limits.*

**ASMFC Update.** During the 2017-2018 review of new SFMPs and renewals from 2011-2012, the TC identified several inconsistencies between state SFMPs and the requirements of Amendments 2 and 3. As a result, the Board tasked the TC with developing proposed improvements to Amendments 2 and 3 with regard to the five items below. The Board reviewed the TC recommendations in February 2021, and subsequently directed the TC to develop a technical guidance document to ensure that implementation of the Amendment 2 and 3 requirements related to the issues outlined below are consistent with the TC recommendations. The guidelines were presented to the Board in April 2021 (ASMFC 2021). The Herring River SFMP was prepared with consideration for the pertinent guideline updates with provisions adopted where applicable for items #2, 3 and 5:

1.) Management and monitoring of rivers with low abundance and harvest of shad and river herring.
2.) Standardization of SFMP requirements: content, metrics, and management responses to triggers.
3.) Improved integration of stock assessment information into SFMPs.
4.) Clarification of de minimis requirements as they pertain to SFMPs.
5.) Review SFMP renewal schedule and the number of years of data required for a suitable SFMP.

**Standardization of SFMPs.** The 2021 TC guidelines recommend that standardized management responses are provided in SFMPs. For example, if a stock falls below the sustainability target or threshold identified in the SFMP, the state must notify the Board in the next annual compliance report and pursue implementation of the specified management response for the following calendar year. This approach is adopted in the Herring River SFMP and described below under "Management Actions".

**Stock Assessment Information.** The TC supported the inclusion of stock assessment information such as size, age, and mortality data in SFMPs; however, did not recommend new requirements at this time. Each jurisdiction should develop sustainability metrics for their SFMPs and review all available population data with each 5-year plan renewal to see if stock assessment updates or other data can be utilized as metrics in SFMPs. The Herring River SFMP discusses the available biological data collected for this population below under "Potential Future Metrics".

**Time Series Duration.** The guidelines standardized the acceptable time-series duration for data supporting a sustainability metric to be 10 consecutive years for river herring, with allowance of a shorter duration of 7-9 years if the TC accepts additional information related to the proposed exploitation rate, stock size, or other relevant factors. The Herring River SFMP proposes to begin harvest in 2023 based on spawning run count data from 2009 to 2022; using the electronic count data for the most recent seven years and the volunteer count data for the first seven years.

**Town of Harwich Objectives.** The Town of Harwich, Department of Natural Resources (DNR) sent a request to DMF in December 2020 to begin an evaluation of opening harvest for river herring in the Herring River. The Herring River herring harvest was closed by the Town of Harwich in 2005, one year before the coast-wide harvest moratorium in Massachusetts. The Town cites steady improvements in spawning run counts since the closure with high relative counts in recent years as justification to open the traditional recreational harvest.

**State Role.** The DMF supports this request and has proceeded to evaluate the existing biological and count data from the Herring River. From this review, the following framework is presented for a Herring River Sustainable Fishery Management Plan for river herring. The proposed SFMP would commence in 2023. The harvest ban would at that time have been in place for 18 years (2006–2023) and the count time series duration will be 14 years in total; with seven years for the electronic count at the West Reservoir and 11 years for the volunteer visual count at Hinckleys Pond.

**Management Unit.** The SFMP has a river-specific management unit of the Herring River herring run in the Town of Harwich.

**Sustainability Measures.** The ongoing spawning run count will serve as the primary measure to monitor the Herring River run status.

**Sustainability Target.** One fishery-independent sustainability target will be used that limits harvest at 10% of the time series mean (TSM). This value will be recalculated every three years. This target was selected as a conservative harvest level given the short duration of the run count. Table 1 provides the run count statistics that formed the basis of the recommended sustainability target. The target is 10% of the TSM with adjusted count data for 2009-2022. It is recognized that this is a coarse estimate for the years prior to the electronic counter (2009-2015); however, the harvest target is the lower among the two options. This approach will be substituted with a sustainability target derived solely from the electronic counter at the next SFMP update.

**Primary Action Threshold.** The 25th percentile of the Herring River run count time series distribution will serve as the primary action threshold to trigger a management response to declining run size.

**Secondary Threshold.** An annual exploitation rate of 10% of the run size will serve as a secondary threshold or warning limit. Annual exploitation rates will be tracked each year with a threshold of 10% assigned as a warning limit. Following a single, annual exceedance of this threshold, DMF will meet with the Harwich Department of Natural Resources to review harvest records and management practices and document the review and cause of the increase in exploitation rate in a joint memorandum.

**Management Actions.** In any given year, a run count falling below the 25th percentile will result in DMF reporting this to ASMFC in their annual compliance report for Shad and River Herring, and DMF having a pre-season discussion with Harwich Department of Natural Resources on potential concerns. If the run count drops below the 25th percentile for two consecutive years, the sustainability target will be reduced to 5% of the TSM. If the run count drops below the 25th percentile three consecutive years a minimum 3-year closure will be imposed on harvest for the following year. In order to reopen the harvest, a threshold of three consecutive years above the 25th percentile would have to occur.

**Biological Samples.** River herring at the Herring River have been sampled by DMF since 2013 for length, weight, sex and age. Weekly collections of river herring are taken by dip net in the West Reservoir fishway for as many weeks as possible to cover the duration of both the alewife and blueback herring runs. The target sampling level is 100 river herring per week for the duration of the run to meet suitable levels of power to discern trends for both sexes and species (Nelson et al. 2011). These data allow the calculation of age, length, and weight statistics and estimates of sex ratios, mortality, and survival. Aging is conducted using otoliths and following published DMF protocols (Elzey et al. 2015). In most years, the sample size for alewife is sufficient for size and age analyses. In contrast, the blueback run is smaller in size than the alewife and sufficient samples are not always available for robust analysis.

**Biological Sample Summary, 2013-2021.** The Herring River biological data for alewife during 2013-2021 has been summarized in Table 2, and Figures 3-5 display the age and mortality statistics for alewife. Blueback samples have not been sufficient in some years for similar summaries. For example, the age samples from blueback were too low in 2013-2015 and 2018 to estimate mortality. More detailed analyses will be made in subsequent SFMPs to evaluate the contribution of blueback herring to the Herring River run and to consider alternative sustainability targets for both species.

**Potential Future Metrics.** With the SFMP implementation, and increasing time series, efforts will be made to develop additional thresholds based on biological data. The data derived from biological sampling can provide additional information on population status and supporting evidence for management measures. However, as found in Nelson et al. (2011), the length and age metrics for river herring analyzed to date in Massachusetts provide little predictive power when related to population abundance. Mean lengths and mean ages of fish within a run can point to long-term changes in demography, although the current time series appears to be tracking inter-annual fluctuations in year class recruitment to the population and indicates that robust age structure has not been recovered. With these conditions, it is not presently possible to clearly identify thresholds based on the biological data. This limitation is not unexpected nor prevents the development of future metrics: 9 years of size and age data allows the tracking of only two generations of river herring. Biological data will continue to be collected from the Herring River herring run with the goal of considering population thresholds based on the following metrics.

**Age Structure.** Evidence of age structure truncation is present in Massachusetts river herring populations (Nelson et al. 2011). Additional cohorts to evaluate age structure or mortality rates may become useful for setting warning limits. Changes in age structure will be examined annually using the $\chi^2$ test as described in Davis and Schultz (2009).

**Mean Length.** Mean length data provide similar evidence of demographic status as age data with reduced diagnostic capability due to interannual growth changes and the influence of cohort dynamics to shape mean data. However, these data are readily prepared and with a growing duration of the time series, may become a useful index of population change.

**Escapement Targets.** Future SFMPs for the Herring River could alternatively consider to annually open harvest following the meeting of a suitable escapement target of incoming spawners. The escapement target would depend on real-time reporting from the electronic counting station and relate counts to a metric on spawning habitat productivity. For example, the Maine Department of Marine Resources uses a calculation based on spawners per surface acre of spawning and nursery habitat (Havey 1961 and 1973) to set escapement targets. This would guarantee a certain number of spawners entering the spawning habitat and guard against unexpected low returns. One potential drawback in some systems could be focusing the harvest on later arrivals that may have a higher proportion of younger fish or blueback herring.

**Repeat Spawners.** A target percentage of repeat spawners in the annual spawning run could be used to set a warning limit. However, with aging now based on otoliths, it would require an initiative to collect scales from Herring River fish. Given the cost of scale processing and the time needed to collect a useful time series the development of this metric is not presently recommended.

**HARVEST MANAGEMENT**

Opening harvest in a single river creates management and enforcement challenges given that Massachusetts has over 100 rivers in 50 coastal towns that contain river herring runs. Ideally, a regional approach would be established to allow several runs to open at the same time. This would reduce concerns over harvest compliance and enforcement while providing a larger opportunity for Commonwealth citizens who are not town residents to purchase harvest permits. This has been a goal of DMF; however, few herring runs presently have the full complement of favorable stock status, a suitable data series, and the necessary infrastructure and dedication in local run management. Since the inception of the ASMFC SFMP process, four Massachusetts Towns (Wareham, Middleborough/Lakeville, Pembroke, Harwich) have formally requested an opening of river herring harvest at their runs. The Nemasket River SFMP for Middleborough/Lakeville was approved in 2016. The Herring River SFMP for Harwich is the second plan to advance for ASMFC review.

**Proposed Harvest Management.** The numbers of permits, weekly catch limits and harvest days will be managed to avoid exceeding the harvest target of 57,378 (10% of TSM). A ratio of 4:1 for residents to non-residents is recommended for permits; with a maximum permit number of 600. Recommended cost for resident permits is $25 with consideration for different costs for seniors and non-residents.

A cap of 450 resident and 150 non-resident licenses would be enacted with a weekly catch limit of 20 fish allowed over a five-week season with three open days per week. The potential maximum catch under this scenario would be 60,000 fish. Assuming that half the permit holders catch their maximum allowance and the other half only realize half of their maximum harvest, the harvest would be estimated to be 45,000 fish. This assumption is not based on past harvest records but on the expectation that many permit

holders will remain inactive or minimally active each year and will take well below the potential maximum harvest. The harvest management should account for the different runs of alewife and blueback herring in the Herring River. At the onset of the run in late March only alewife are present, and the first month of the run can be nearly all alewife. Bluebacks arrive in late April and early May and can be a majority of the herring in the run from mid-May to early June. An effort should be made to not overharvest either species and to direct some harvest effort to emigrating, post-spawned fish. With these conditions in mind, it is proposed that the harvest season occurs from April 15$^{th}$ to May 15$^{th}$, with the discretion of the Harwich DNR to extend the season to the full 5 weeks depending on harvest and run count statistics.

**Harvest Monitoring.** The potential for harvest to exceed the sustainability target exists under all management options if a high proportion of permit holders takes the full weekly harvest each week. This outcome is hard to predict but can be tracked once harvest is open. The Harwich DNR will diligently monitor harvest performance by permit and week in order to make annual adjustments to relate the harvest target to the number of permits issued.

Harvest will only be allowed at the West Reservoir fishway during three open days per week. Set times for harvest will be posted on the open days and Town Herring Wardens will be present to monitor harvest and issue daily catch cards. The gate to the fishway at the West Reservoir will be closed on all days from March 15$^{th}$ to June 15$^{th}$ from 7 pm to 7 am (with consideration for sundown closures as daylight increases). The Herring Wardens will be authorized to issue citations for harvest violations at the harvest locations and other locations in Harwich. No harvest will be allowed at other herring runs in Harwich.

Harvest will be monitored through the issuance of daily catch cards to each permit holder that harvests herring. The card would indicate the date, permit number, and number of fish and will expire in 30 days. State regulations will be changed by DMF to require that any possession of river herring in Massachusetts be accompanied by the Herring River harvest permit and the daily harvest card. Herring frozen in bags must have the original daily harvest card placed in the bag. The permits and daily catch cards would be professionally printed on waterproof paper.

The usage of harvested river herring trended sharply towards striped bass bait in the decade leading up to the state-wide harvest ban. DMF recognizes that a component of the concern that led to the state-wide ban on river herring harvest was excessive harvest and declining conservation ethics related to the harvest for lobster and striped bass bait. Under this SFMP, recreational bait use will be allowed; however, the SFMP seeks to promote and encourage traditional uses of river herring as food. There will be public outreach associated with the implementation of the SFMP that encourages responsible use of herring for bait and food. The Harwich Department of Natural Resources will also consider accommodating requests for food as able. For example, requests for only females for roe harvest may be allowed when manageable on-site during the three open days per week. In these cases, the Department should record the female only harvests and compensate weekly as needed by providing males for bait use.

**Native American Harvest.** The Commonwealth of Massachusetts recognizes the aboriginal practice of the Wampanoag tribe to harvest river herring in Massachusetts. In prior years, a Memorandum of Agreement was signed between DMF and the tribe with the agreement that harvest was an aboriginal right for sustenance purposes only and that harvest would be reported by river to DMF. The tribe's harvest is not bound to SFMP measures, and the amount is undocumented. Anecdotally, their recent level of effort and catch is unlikely to produce 1,000 fish. DMF will discuss the possibility of issuing free permits to the Wampanoag tribe and to coordinate with the tribe to encourage responsible harvest, record keeping, and the potential to include tribal harvest in annual sustainability targets under the SFMP.

**STATEWIDE REGULATIONS AND ENFORCEMENT**

For this harvest opening to be successful and enforceable, the process will need a tightly managed accounting system for daily harvest, well-planned coordination with the State Environmental Police, and participation from Town law enforcement. A coordination meeting will be held with the Massachusetts Environmental Police, DMF, Town Police, and the Harwich Department of Natural Resources each year prior to the season start. DMF will enact changes to the existing state regulations that ban state-wide harvest to allow harvest and possession of Herring River herring in accordance with this SFMP and the Town of Harwich regulations. This process will include a review of existing penalties for non-compliance and updating the penalties as needed.

The SFMP recommends that the Town of Harwich provides information on permit and seasonal harvest records to the Massachusetts Environmental Police to improve the enforcement of harvest regulations. The recommended approach is to have a record of permits, herring warden contact information, with weekly updates on harvest and the spawning run count provided online by the Town of Harwich. The Town of Harwich will endeavor to create this process during the initial SFMP 5-year period; recognizing that experiences of the first open season will be instructive on how to develop and manage this accounting.

**Table 1.** River herring spawning run count data at Herring River, Harwich. Volunteer visual counts occurred from 2009-2019 at Hinckleys Pond. Electronic counts at the West Reservoir began in 2016, with four years of comparison between the two locations.

| Year | Hinckleys Count No. | Reservoir Count No. | Comparison (Ratio) | Adjusted ( 0.082 ) | Adjusted ( 0.173 ) |
|---|---|---|---|---|---|
| 2009 | 19,336 | | | 235,805 | 111,769 |
| 2010 | 41,254 | | | 503,098 | 238,462 |
| 2011 | 10,466 | | | 127,634 | 60,497 |
| 2012 | 101,624 | | | 1,239,317 | 587,422 |
| 2013 | 91,167 | | | 1,111,793 | 526,977 |
| 2014 | 247,894 | | | 3,023,098 | 1,432,913 |
| 2015 | 127,860 | | | 1,559,268 | 739,075 |
| 2016 | 60,349 | 348,000 | 0.173 | | 348,000 |
| 2017 | 11,980 | 284,936 | 0.042 | | 284,936 |
| 2018 | 47,698 | 864,748 | 0.055 | | 864,748 |
| 2019 | 69,680 | 1,223,263 | 0.057 | | 1,223,263 |
| 2020 | | 887,724 | | | 887,724 |
| 2021 | | 436,090 | | | 436,090 |
| 2022 | | 291,000 | | | 291,000 |
| **Mean** | | 619,394 | 0.082 | | 573,777 |
| **Median** | | 650,419 | | | 481,533 |
| **25th %** | | 319,500 | | | 286,452 |
| **10% of mean** | | 61,939 | | | 57,378 |

**Note:** The average ratio of the two counting stations for 2016-2019 is 0.082. However, there is low confidence that the run in 2014 had over 3 million fish. DMF staff observations and local accounts suggest that 2014 and 2019 were the largest herring runs in the Herring River in over a 20-year period; and were similar in size. Therefore, a conservative approach is taken by using the highest ratio (2016) and applying this to adjust Hinckleys Pond count data for 2009-2015.

**Table 2.** Biological statistics for alewife sampled in the Herring River, Harwich during 2013-2021.

**Alewife** **Total Length (mm)**

| | Year | N | Mean | SD | 2 SE | Min | Max |
|---|---|---|---|---|---|---|---|
| **Female** | 2013 | 96 | 266 | 10.89 | 2.22 | 241 | 290 |
| | 2014 | 165 | 272 | 13.49 | 2.10 | 235 | 310 |
| | 2015 | 226 | 273 | 10.80 | 1.44 | 245 | 304 |
| | 2016 | 233 | 280 | 11.08 | 1.45 | 244 | 308 |
| | 2017 | 257 | 277 | 15.71 | 1.96 | 235 | 321 |
| | 2018 | 160 | 267 | 12.82 | 2.03 | 240 | 303 |
| | 2019 | 267 | 278 | 9.59 | 1.17 | 249 | 324 |
| | 2020 | 214 | 283 | 10.66 | 1.46 | 246 | 312 |
| | 2021 | 326 | 272 | 14.68 | 1.63 | 240 | 308 |
| **Male** | 2013 | 100 | 256 | 9.94 | 1.99 | 232 | 280 |
| | 2014 | 265 | 260 | 12.55 | 1.54 | 233 | 300 |
| | 2015 | 270 | 264 | 9.68 | 1.18 | 241 | 292 |
| | 2016 | 190 | 270 | 11.17 | 1.62 | 237 | 310 |
| | 2017 | 284 | 260 | 14.65 | 1.74 | 215 | 299 |
| | 2018 | 328 | 255 | 11.11 | 1.23 | 224 | 293 |
| | 2019 | 255 | 268 | 10.02 | 1.25 | 230 | 290 |
| | 2020 | 215 | 270 | 11.54 | 1.57 | 228 | 298 |
| | 2021 | 386 | 259 | 13.00 | 1.32 | 226 | 304 |

**Age**

| | | N | Mean | SD | 2 SE | Min | Max |
|---|---|---|---|---|---|---|---|
| **Female** | 2013 | 96 | 3.4 | 0.64 | 0.13 | 3 | 6 |
| | 2014 | 163 | 3.7 | 0.60 | 0.09 | 3 | 6 |
| | 2015 | 220 | 4.0 | 0.38 | 0.05 | 3 | 5 |
| | 2016 | 232 | 4.7 | 0.83 | 0.11 | 3 | 8 |
| | 2017 | 249 | 4.4 | 1.29 | 0.16 | 3 | 8 |
| | 2018 | 157 | 3.5 | 0.84 | 0.13 | 3 | 7 |
| | 2019 | 262 | 3.9 | 0.54 | 0.07 | 3 | 7 |
| | 2020 | 212 | 4.6 | 0.84 | 0.12 | 3 | 8 |
| | 2021 | 324 | 3.9 | 1.08 | 0.12 | 3 | 7 |
| **Male** | 2013 | 100 | 3.2 | 0.52 | 0.10 | 2 | 5 |
| | 2014 | 175 | 3.5 | 0.63 | 0.10 | 3 | 6 |
| | 2015 | 268 | 4.0 | 0.39 | 0.05 | 3 | 5 |
| | 2016 | 187 | 4.4 | 0.83 | 0.12 | 3 | 6 |
| | 2017 | 268 | 3.7 | 1.12 | 0.14 | 2 | 7 |
| | 2018 | 326 | 3.2 | 0.60 | 0.07 | 3 | 7 |
| | 2019 | 244 | 3.8 | 0.43 | 0.05 | 2 | 5 |
| | 2020 | 213 | 4.3 | 0.89 | 0.12 | 2 | 6 |
| | 2021 | 380 | 3.5 | 0.91 | 0.09 | 2 | 6 |

**Note:** N = sample size; SD = standard deviation; SE = standard error

**Figure 3.** Average age of alewife sampled at the Herring River, Harwich, during 2013-2021.

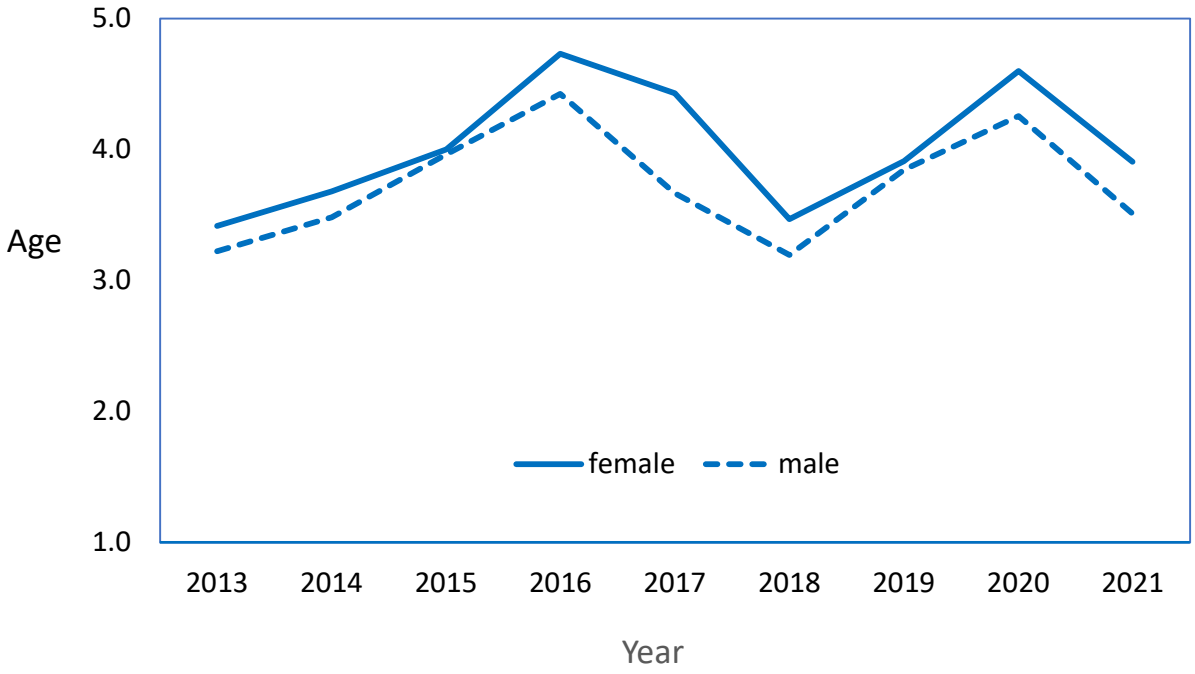



**Figure 4.** Annual age composition of alewife sampled (count = number of adult herring in annual biological sample) at the Herring River, Harwich, during 2013-2021.

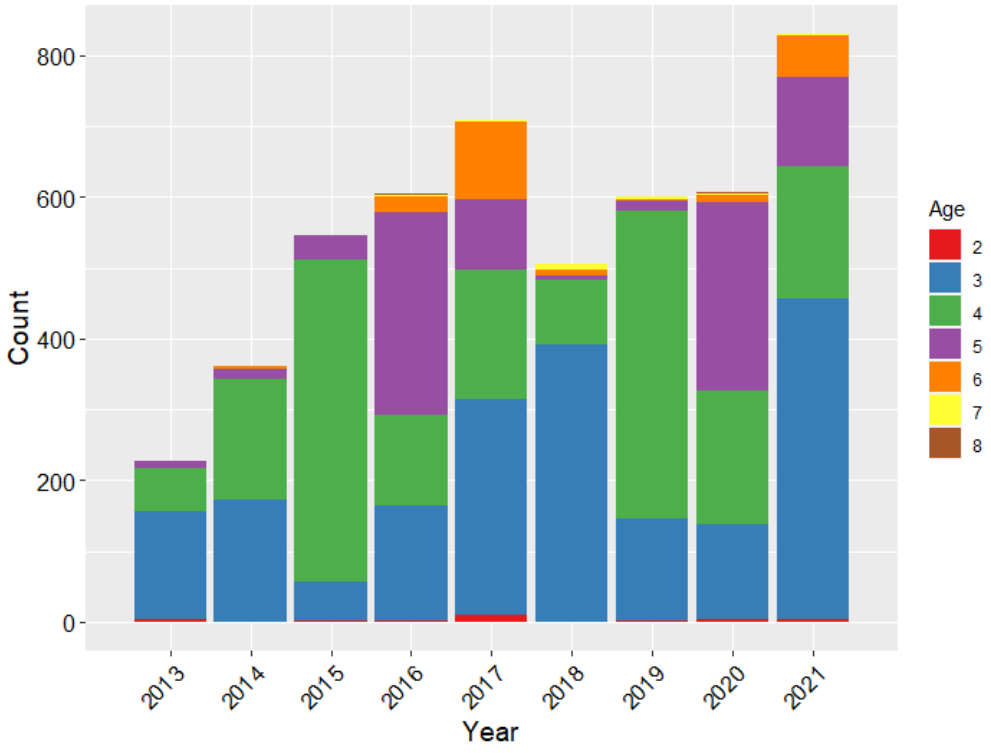
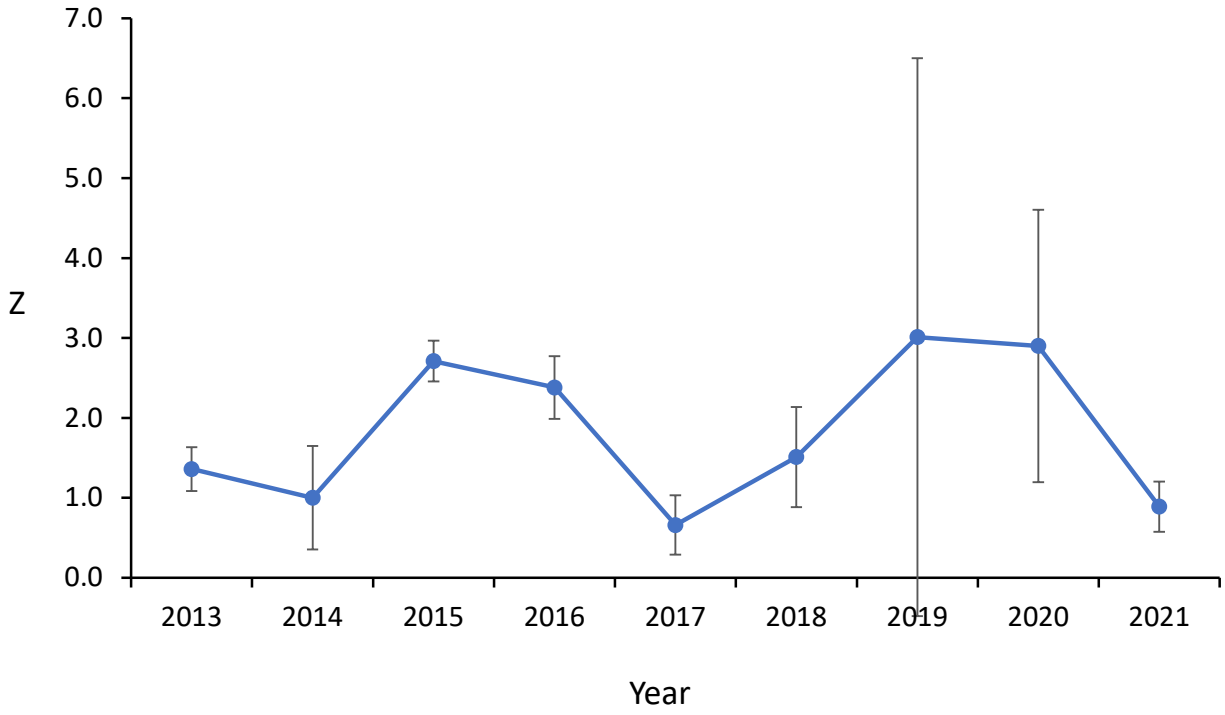


**Figure 5.** Average instantaneous mortality rate (combined sexes, Z ± 2 SE) of alewife sampled at the Herring River, Harwich, during 2013-2021.



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