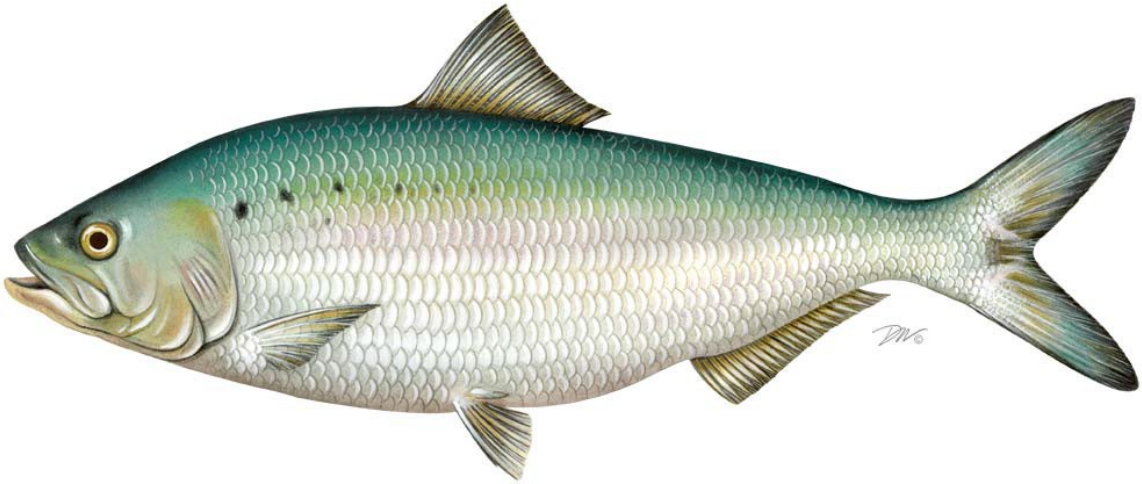
American Shad Habitat Plan for Massachusetts Coastal Rivers



Prepared by:
Bradford C. Chase, John J. Sheppard, Benjamin Gahagan and Sara Turner, Massachusetts Division of Marine Fisheries

Submitted to the Atlantic States Marine Fisheries Commission as a requirement of Amendment 3 to the Interstate Management Plan for Shad and River Herring

Approved May 5, 2021

American Shad Habitat Plan for Massachusetts Coastal Rivers

Submitted to:

Atlantic States Marine Fisheries Commission

Prepared by:

Bradford C. Chase, John J. Sheppard, Benjamin Gahagan and Sara Turner

Massachusetts Division of Marine Fisheries
251 Causeway Street, Suite 400
Boston, MA 02114

January 2021

Approved May 5, 2021

Introduction

American shad (*Alosa sapidissima*) habitat plans are required by the Atlantic States Marine Fisheries Commission through Amendment 3 of the Interstate Fishery Management Plan for Shad and River Herring. This report updates the first Massachusetts shad habitat plan reported in 2014 (MA DMF 2014).

American shad spawning runs in Massachusetts occur in two large rivers bordering multiple jurisdictions and six smaller sized coastal rivers. 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) are reported independently from this 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 had a robust shad run and fishery historically with recent evidence of a remnant run.

The principal threat identified for most shad runs in Massachusetts is **Barriers to Migration**. However, significant questions exist on the status of potential threats and issues such as water withdrawals and water quality impairment and require further investigation. The first MA shad habitat plan (MA DMF 2014) reported on the Palmer River and Charles River because among the six coastal runs they were identified as restoration priorities by the MA Division of Marine Fisheries (DMF). The Taunton River was included in the first shad habitat plan to encourage investigations on the population and habitat status. This update includes additional information on the Jones, North, South and Neponset rivers.

A synopsis of investigations on American shad spawning habitat requirements (Greene et al. 2009) reveals 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.

Table 1. Massachusetts coastal rivers with American shad spawning runs.

River	Watershed	Total Drainage Area (km^2)	Present Migratory Access (rkm)	Present Spawning Habitat (rkm)	Restoration Potential (rkm)	Notes
Palmer River	Narragansett Bay	71	12.4	<5	10.5	with dam removal
Taunton River	Narragansett Bay	1456	62.0	45	0	no main stem barriers
Jones River	South Shore	77	12.0	8.5	0	recent restoration improvements
Indian Head River	South Shore	<100	6.0	2	5	with dam removal/and or passage improvements
South River	South Shore	<100	7.8	1	2	with dam removal/and or passage improvements
Neponset River	Boston Harbor	262	6.8	1	25	from 1970s DMF survey
Charles River	Boston Harbor	805	32.0	32	32	from 1970s DMF survey

Palmer River

Watershed Information. The Palmer River, located in Bristol County, MA, originates in the wetlands of northern Rehoboth (Figure 1) and flows south for approximately 27 river kilometers (rkm) through Swansea to its confluence with the Barrington River and discharges to Narragansett Bay in RI. Two impoundments created by dams are located along the course of the river: Shad Factory Pond and Perryville Pond. The former is a shallow 38-acre pond formed by a dam last rebuilt in 1912. The dam is located at 12.4 rkm with a drainage area of 71.2 km^2. Shad are known to spawn along an unknown proportion of the upper end of the river below the dam. Upstream of the dam, there is 10.5 rkm of potential spawning habitat before reaching the impassible Perryville Dam at 22.9 rkm. The habitat upstream of the Perryville Dam (Perryville Pond; 3.3 acres) has not been assessed but is thought to have low potential for shad. The watershed also supports spring spawning runs of white perch and river herring; and was documented in the 1970s as having spawning rainbow smelt and sea lamprey. The Palmer River presently has the last remaining recreational fishery for American shad in MA south of Cape Cod.

American Shad Status. No current population data are available. Fishery resource surveys were conducted by DMF and the MA Division of Fish and Wildlife (*MassWildilfe*) from 1968 to 1971 and by DMF in 1993. Water quality and creel information were collected in these surveys. Creel survey results are summarized in Table 1. In addition, shad were transplanted by DMF personnel from the Palmer River into the Mattapoisett River in 1968 (N = 78) and in 1969 (N = 80). Anecdotal reports suggest that recreational angling for shad continues in the Palmer River, although at low levels of catch and effort. Population and habitat monitoring were considered when the fish ladder was reconstructed at Shad Factory Pond in 2007; however, this work was not conducted.

Table 1. Summary of Palmer River shad creel surveys conducted between 1968 – 1971 and 1993.

Date	1968	1969	1970	1971	1993
No. Anglers	333	657	413	419	72
Total Catch	148	174	82	120	41
Hours Fished	660	1500	1297	915	108
Catch/Hour	0.22	0.12	0.06	0.13	0.38

Fish Ladder Specifications: A concrete weir and pool fish ladder was installed in 2007 by the Town of Rehoboth, Save the Bay, and several funding partners. The fish ladder was designed by the U.S. Fish and Wildlife Service (USFWS) and the project received technical assistance from the MA Office of Fishing and Boating Access and DMF. The fish ladder is approximately 320 ft. in length with 19 weirs and 16 ft x 3 ft pools. No monitoring of shad passage has been assessed at this location. The Perryville Dam in Rehoboth has no fishway and obstructs passage to unassessed habitat (Reback et al. 2004).

Regulatory Authority: The owner of the dam is responsible for repairing, operating, and maintaining the fish passage facilities as prescribed in M.G.L. Chapter 130 §19. Fish passage at the Shad Factory Pond fish ladder has been historically managed cooperatively by the Town of Rehoboth and the dam owner, the Bristol County Water Authority of Bristol, RI. Wetlands habitat and water quality protections are provided by M.G.L. Chapter 131 §40 and Commonwealth of Massachusetts Regulations (CMR) 10.00 and administered by the Massachusetts Department of Environmental Protection (*Mass*DEP).

Water Withdrawal Permissions: The Bristol County Water Authority maintains a water withdrawal registration (No. 4-26-247.05) issued by *Mass*DEP in the Narragansett Bay and Mt. Hope Bay Shore river

basins to withdraw 2.7 million gallons per day (MGD) from three surface water sources (Swansea Reservoir, Shad Factory Reservoir and Anawan Reservoir) for public water supply. Monthly withdrawal records are required for annual submission to *Mass*DEP.

Water Discharge Data: None currently. The West Branch of the Palmer River had a US Geological Survey gauge station (No. 01109200, drainage area 11.3 km^2) operating during 1962-1974. The monthly mean discharge in May for this period was 9.8 cfs; however, the short duration of the data series and long distance between the West Branch gauge location and Shad Factory Pond limit the data utility.

Water Quality Monitoring: *Mass*DEP assesses waterbodies by comparing water quality to Surface Water Quality Standards (SWQC), indentifying threats to habitats and recommending remedial actions (*Mass*DEP 2007). The Narragansett Bay watershed was last assessed during 2004-2008 (*Mass*DEP 2009); however, the Palmer River segment was listed as "Not Assessed" for its capacity to support aquatic life.

Shad Factory Pond Habitat Assessment. A habitat assessment of river herring spawning and nursery habitat in Shad Factory Pond was conducted by DMF and Save the Bay, a RI non-profit watershed organization, during 2016-2017 (Turner et al. *in Prep*). The assessment investigated water quality conditions in the pond and downstream fish passage conditions. Water quality criteria for dissolved oxygen, Secchi disc depth, pH, total nitrogen, and total phosphorus were exceeded in the lake. The assessment documented significant degradation in the pond due to high growth of the invasive water chestnut. The fishway at Shad Factory Pond had sufficient flow and depth for suitable passage during river herring migration periods. However, the degraded pond conditions would not provide suitable nursery habitat for river herring during summer months and not likely encourage shad passage to upstream riverine habitat.

ASMFC Shad Habitat Plan Framework

1.) Shad Habitat Assessment. No formal assessment of shad spawning and nursery habitat has been conducted in the Palmer River. Previous creel surveys documented a sportfishery for shad in the Palmer River that continues presently, although with low levels of participation, and with no evidence that shad are passing the fishway at Shad Factory Pond to upstream spawning habitat. Upstream of the dam, there is approximately 10.5 km of potential spawning habitat before reaching the impassible Perryville Dam at rkm 22.9. The habitat upstream of the Perryville Dam (Perryville Pond; 3.3 acres) has not been assessed but is thought to have low potential for diadromous species. Consideration was given to conducting shad electrofishing monitoring in the Palmer River during 2016-2017 although funding and staff limits did not allow this action to move forward.

2.) Threats Assessment. No formal threat assessments have been made for shad in the Palmer River watershed. A primary assumed threat to shad for this watershed is the Shad Factory Pond Dam as a **Barrier to Migration**. The fishway at Shad Factory Pond Dam was reconstructed in 2007 and specifically designed to pass shad. However, concerns have grown over water quality and invasive plant infestation in the pond. It is possible that present conditions prevent shad from migrating through the pond to potential upstream riverine habitat. Historically, a large shad commercial fishery occurred in the Palmer River. Belding (1921) reports that the initiation of trap fisheries in the tidal area of the Palmer River in the 1870s and 1880s quickly reduced the shad run to low levels of abundance by the 1910s. Historical overfishing and habitat quality are threats that should be considered along with migration barriers.

3.) Habitat Restoration Plan. Currently, DMF does not have an ongoing project or imminent plans to initiate a shad habitat restoration plan for the Palmer River. The Save the Bay has expressed an interest in investigating the feasibility of removing Shad Factory Pond Dam. If this concept moves forward, DMF would be supportive and potentially a partner in this restoration activity.

Recommended action:

Currently, DMF does not have an ongoing project or imminent plans to initiate an assessment of the Palmer River shad run. DMF did complete a habitat assessment of Shad Factory Pond in 2018 with results that support local interests in dam removal. We **recommend** the following actions for the Palmer River: (1) assessment of the amount and suitability of Palmer River habitat for shad spawning and rearing, (2) census counts of shad and river herring passing upstream into Shad Factory Pond, (3) passage efficiency at the Shad Factory Dam fishway and (4) the feasibility of fish passage improvements at the Perryville Dam.

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

Action actively being addressed by agency: The only action taken to date has been the preparation of an Operations and Maintenance Plan for the Shad Factory Dam fishway. A draft was sent to the dam owner in 2011 requesting comments. The dam owner did not respond to the inquiry.

Initial Habitat Goal: Conduct the shad spawning habitat assessment for the Palmer River upstream and downstream of Shad Factory Pond and assess species presence. If suitable upstream conditions are found, seek funding for passage efficiency studies at Shad Factory Pond and fish passage feasibility studies at Perryville Dam.

Timeline and Costs for Achieving Goals/Targets. None established. Funding is not presently available.

Possible metrics to evaluate progress: (1) comparison of water quality parameters to *Mass*DEP Surface Water Quality Criteria (SWQC) for supporting aquatic life; (2) census counts of shad and river herring into Shad Factory Pond using a locking box trap installed at the fish ladder exit; (3) passage efficiency evaluation using PIT tag study; (4) discharge range that provides suitable water depth and velocity in fishway and water depth and velocity at river habitats.

Potential setbacks/areas of concern: The watershed is part of an active water supply. The municipal needs for water compete directly with water needs for aquatic life, but the effects are unknown.

Other organizations: The Save the Bay was actively involved in the Shad Factory Pond habitat assessment and development of a dam removal project at that site. The Town of Rehoboth has expressed an interest in shad restoration in the Palmer River. The Bristol County Water Authority has an interest and responsibility to allow diadromous fish passage at Shad Factory Pond.

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 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 with no dams along its entire main stem.

American Shad Status: Belding's (1921) anadromous fish survey of the early 20th century recognized historical shad runs in the Taunton River that were rendered commercially extinct due to industrial pollution. 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 to the Jenkins Leatherboard Company dam in Bridgewater. The Berkley Bridge was the lower limit of salt water intrusion. They documented 45 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. 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. Presently, the status of shad in the Taunton River watershed is unknown with some anecdotal reports of finding individual adult shad in the last decade.

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

Regulatory Authority: In the absence of dams and fishways, 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 *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 USGS stream flow gauge in Bridgewater (No. 01108000, 676 km^2 drainage area). The average monthly discharge at the Bridgewater gauge station is 900 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, identifying threats to habitats and recommending remedial actions (*Mass*DEP 2007). The Taunton River watershed was last assessed during 2004 (Rojko et al. 2005); with most of the potential main stem shad habitat listed as *Suitable* to support aquatic life or "Not Assessed.

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 1970s. 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** 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 the *MassWildlife* and the USFWS to prepare a scope for stocking shad in the Taunton River.

Recommended action:

Of the MA coastal rivers in this plan, the least information is known on the status of and threats to American shad in the Taunton River. 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 confirm the presence 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 is 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 2021.

Timeline and Costs for Achieving Goals/Targets. Juvenile American shad stocking is recommended for a 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 at minimum of this duration to document changes in adult and juvenile American shad abundances in the river resulting from stocking efforts. Funding sources have not been identified presently.

Possible metrics to evaluate progress: (1) comparison of water quality parameters to MA SWQC for supporting aquatic life; and (2) discharge range that provides suitable water depth and velocity at river habitats.

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.

Jones River

Watershed Information. The Jones River flows for 12 rkm in a drainage area of 77 km^2 from Silver Lake in Kingston, MA, to Kingston Bay (Figure 2). At 634 acres, Silver Lake is the largest lake in the South Shore Drainage Area. The Jones River is the largest freshwater drainage flowing into Cape Cod Bay. Numerous dams have restricted diadromous fish passage in the Jones River watershed since the 18th century. The lowermost dam at Elm Street was removed in 2019. This dam had a 5-section Alaskan Steeppass fishway that was considered not favorable for shad passage. The next dam upstream at

Wapping Road had no fishway and was removed in 2011. The final dam at Forge Pond is the water control for the City of Brockton's water supply at Silver Lake. This dam had no fish passage until DMF installed a wood weir and pool fishway in 2019. The two dam removals and fishway installation in recent years greatly improved the potential for diadromous fish passage in the upper Jones River watershed.

American Shad Status. Accounts of shad in the Jones River mainly come from anecdotal reports of uncommon sportfishing catches, dead shad observed on the river bank, and schooling adult shad below the Elm Street Dam. Photographs of such accounts have been verified by DMF biologists in recent decades. Ten years of river herring counting at the Elm Street Dam fishway had not recorded observations of shad passing. A rainbow smelt fyke net monitoring series maintained by DMF at the tidal interface in the Jones River has caught two juvenile shad during a 17-year time series (DMF, unpublished information). No known sportfishery specifically targets shad in the Jones River. Collectively, these accounts suggest a remnant run with low numbers of shad presently in the Jones River.

Regulatory Authority. The owners of dams are responsible for repairing, operating, and maintaining the fish passage facilities in MA as prescribed in M.G.L. Chapter 130 §19. The City of Brockton signed a Memorandum of Agreement with DMF to install and operate a fishway at Forge Pond Dam in 2018. In 2019, a DMF Fishway Operation and Maintenance Plan was implemented for Forge Pond Dam. Wetlands habitat and water quality protections are provided by M.G.L. Chapter 131 §40 and CMR 10.00 and administered by the *Mass*DEP.

Water Withdrawal Permissions. The City of Brockton received State Legislation in 1899 to divert water from Silver Lake for their water supply. Their present Water Management Act registration allows the City to withdraw up to 11.1 MGD from Silver Lake and two connected reservoirs to provide nearly all water needs for over 150,000 citizens. This water supply activity routine results in no outflow from Silver Lake from July to October (Gomez and Sullivan 2013). Several cranberry bogs also have water withdrawal permissions in the watershed.

Water Discharge Data. The USGS maintains one stream flow gauge in the Jones River watershed in Kingston at Elm Street (No. 01105870, 4.3 rkm, 51.2 km^2 drainage area). The average monthly discharge at the Elm Street gauge is 56 cfs for April and 42 cfs for May from the time series record of 1966-2020.

Water Quality Monitoring. *Mass*DEP assesses waterbodies by comparing water quality to SWQC, identifying threats to habitats and recommending remedial actions (*Mass*DEP 2007). Recent assessments have listed Silver Lake as impaired due to flow alterations from water supply withdrawals.

Silver Lake Habitat Assessment. A habitat assessment of river herring spawning and nursery habitat in Silver Lake was conducted by DMF and the Jones River Watershed Association during 2008-2009 (Chase et al. 2013). The assessment investigated water quality conditions in the lake and downstream fish passage conditions. Water quality criteria for dissolved oxygen, pH, total nitrogen, and total phosphorus were exceeded in the lake. The most significant impairment documented was the lack of outflow at Forge Pond Dam during summer and early fall each year. No observations of shad were made during the assessment and no fish passage was possible at the two upper impassible dams at that time.

ASMFC Shad Habitat Plan Framework

1.) Shad Habitat Assessment. No formal assessment of shad spawning and nursery habitat has been conducted in the Jones River watershed. The removals of the Wapping Road Dam in 2011 and the Elm Street Dam in 2019 provide a significant opportunity for shad to increase access to upstream riverine habitat. The river gains flow moving downstream from groundwater and tributary contributions. The restored river channel from Elm Street to Wapping Road has riffle-pool conditions that appear suitable

for shad spawning. This reach is approximately 1.5 km. The next reach from Wapping Road to Grove Street has moderate suitability for approximately 5 km. The final reach of approximately 2 km from Grove Street to the Forge Pond Dam has limited suitability due to shallow depths and reduced flow. Freshwater inputs upgradient of Silver Lake are managed for water supply purposes and not likely to provide additional shad habitat for fish that may pass into Silver Lake.

2.) Threats Assessment. No formal threat assessments have been made for shad in the Jones River watershed. The primary assumed threat historically was **Barriers to Migration**. This has been largely mitigated by the removal of the two lower dams that limited access to suitable spawning habitat. A temporary wood fish ladder was installed at Forge Pond Dam, the only remaining dam on the Jones River in 2019. Plans are underway to design and install a permanent fishway at Forge Pond Dam with associated pond dredging, improved attraction flow, and improved design for upstream and downstream passage. However, Silver Lake is not expected to provide additional shad habitat.

The most significant threat to shad may be the large municipal **Water Withdrawal** at Silver Lake that can degrade the upper watershed nursery habitat for shad for most of the season when juvenile shad would occupy this area. In addition to lower flow and channel depth, the chronically reduced flow allows the creation of debris jams and encroachment of wetland shrubs in the river channel. Over time, these obstructions trap sediment, fragment river channel and block fish passage. Sea level rise could be a factor in this watershed as evidence of higher tidal influence at Elm Street observed during over 30 years of DMF monitoring and the recorded pulses of new and full moon tides at the USGS gauge station.

3.) Habitat Restoration Plan. Currently, DMF does not have an ongoing project or imminent plans to initiate an assessment of the Jones River shad run or conduct a habitat restoration plan. Two areas of interest are a shad spawning and nursery habitat assessment in the river reaches made available by the recent dam removals, and population monitoring in response to the dam removals for several species of diadromous fish. The shad run in the Jones River may be the smallest among coastal rivers in MA. Funding is not available presently for new shad investigations.

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

Action actively being addressed by agency. A stream maintenance plan was drafted by DMF in 2019 and approved by the Kingston Conservation Commission. Presently, DMF is working with the Jones River Watershed Association to improve river channel that could benefit shad spawning and nursery habitat. A Fishway Operations and Maintenance Plan for Forge Pond Dam was prepared in 2019 with the first year of application in 2020. The Jones River smelt fyke net monitoring series will be maintained with the potential to document changes in shad catch over time in response to the recent dam removals.

Initial Habitat Goal. Conduct the shad spawning habitat assessment for the Jones River from Elm Street to Grove Street. Match habitat assessments to shad population monitoring

Timeline and Costs for Achieving Goals/Targets. None established. Funding is not presently available.

Other organizations. The Jones River Watershed Association has been actively involved in natural resource stewardship in the Jones River for decades. This association is interested in participating in diadromous fish habitat and population monitoring that could benefit shad.

North River

Watershed Information. The North River watershed is the largest watershed in the South Shore coastal drainage area in Massachusetts with several significant tributaries within six towns (Figure 2). It contains two known tributaries that support shad spawning runs and fisheries: the South River and Indian Head River. The North River is formed at the confluence of the Indian Head River and Herring Brook in Pembroke. The Indian Head River flows for over 3 km from Factory Pond before meeting Herring Brook. There are no dams on the main stem North River. Shad can reach the Elm Street Dam at the Pembroke and Hanover border on the Indian Head River where a 4 ft Denil fish ladder was constructed to allow shad passage. The South River flows for 5.5 km from the Veteran's Park Dam in Marshfield where shad passage is possible but uncertain at a weir and pool fish ladder on the dam.

American Shad Status

South River. The South River presently has a shad spawning run that attracts low levels of sportfishing activity. However, historical records of this fishery are scant. Belding (1921) does not reference shad in his survey and Reback and DiCarlo (1972) simply mention that shad were present in the river in the 1960s. Recent DMF electrofishing for shad has documented the continuance of a well-defined shad run in the South River that aggregate below the Veteran's Park Dam. The Town of Marshfield is leading a cooperative investigation on the potential of removing the dam and installing a nature-like fishway, with feasibility work underway in 2020.

Indian Head River. Belding (1921) made no reference to shad in the Indian Head River, while noting the presence of several active mill industries with impassable dams and ongoing discharges of industrial waste. Reback and DiCarlo (1972) described an excellent sportfishery for shad in the Indian Head River that continues presently to attract large numbers of anglers. They also highlighted deficiencies at the fishway at the Elm Street Dam and recommended reconstruction with an improved design and diversion wall to improve attraction. A 4 ft Denil fishway with a diversion wall was constructed soon after their survey in 1977. No fish passage monitoring occurs at the Elm Street Dam and the passage efficiency of shad at the Elm Street Dam fishway is unknown. DMF initiated a shad electrofishing monitoring study in 2017 in order to better document the shad run and evaluate the development of an index of abundance.

Ongoing Shad Monitoring. An exploratory study was initiated by DMF in 2016 to monitor the presence and abundance of American shad in the South River and Indian Head River. Monitoring and sampling is conducted in both rivers from the head of tide to the first obstruction, using stream electroshocking to collect spawning adult shad. Biological information, including sex, size, age, and genetic samples were collected from individual shad. Scales were collected from shad to provide information on age structure, repeat spawning, mortality, and survival. Anal fin samples were collected from each shad captured and archived for future genetic research. CPUE (catch-per-unit-effort) scores (N_{Shad}/minute) from samples collected at both streams were generated as daily catch rates and used to generate mean CPUE indices. Annual mean CPUE scores were generated as indices of spawning stock abundance. Additionally, stream habitat data was collected in this monitoring effort to characterize and describe riparian and in-water features of the sampling areas in both rivers. Stream maintenance was conducted in both rivers by DMF personnel to remove obstructions to fish passage each year prior to the start of the spawning run.

Sampling trips in the South River are conducted between the last week of April through June along a 1,390 m^2 transect beginning from the South River Elementary School to the base of the Veteran's Memorial Park Dam. Annual geometric mean CPUE scores are shown in Table 2A and Figure 3A, respectively. Results indicate CPUE scores declined from 2016 to 2018 and increased from 2018 to 2020.

Male shad were dominant in samples collected in all years (mean ratio: 2:1, Table 2A). Mean size of males has declined in the five years of monitoring, and the mean size of females increased between 2016 and 2018 but decreased from 2018 to 2020. Age samples of South River shad ranged from 3 – 9 years. Mean age of males has declined in the five years of monitoring, whereas the mean age of females increased from 2016 to 2018, then decreased from 2018 to 2020. Mortality (Z) and survivorship (S) were estimated using (the Chapman-Robson method), and Z ranged between 0.7 and 2.4 (with a corresponding S ranging between 0.1 and 0.5).

Sampling trips in the Indian Head River are conducted between the first week of May through June along a 5,560 m^2 transect beginning downstream from the Elm Street Bridge to the base of the Elm Street Dam. Annual geometric mean CPUE scores are shown in Table 2B and Figure 3B, respectively. Results indicate CPUE scores increased each year throughout the monitoring period. Male shad were dominant in samples collected in all years (mean ratio: 2:1, Table 2B). Mean size of males has declined in the five years of monitoring, whereas the mean size of females was stable throughout the monitoring period despite a decrease in size in 2019. Age samples of Indian Head River shad ranged from 3-9 years. Mean age of males declined from 2016 to 2018 and increased from 2018 to 2020. Mean age of females was stable from 2016 to 2018, decreased in 2019, then increased in 2020. Mortality estimates ranged between 0.5 and 1.4 and survivorship ranged between 0.2 and 0.6.

Table 2. Annual indices of abundance, expressed as arithmetic and geometric mean catch-per-unit-effort (CPUE) scores (N_{Shad}/minute) and population demographic data collected from American shad in the (A) South River; and (B) Indian Head River.

Year	N Male	N Female	Ratio M:F	A. Mean CPUE	G. Mean CPUE	Mean TL (mm)		Mean Age		Chapman-Robson	
						Male	Female	Male	Female	Z	S
2016	44	22	2.0:1.0	0.56	0.48	489	503	6.0	5.6	0.9	0.4
2017	58	21	2.8:1.0	0.42	0.29	482	521	5.6	6.1	1.5	0.2
2018*	38	20	1.9:1.0	0.26	0.24	480	521	5.6	6.1	2.4	0.1
2019	48	32	1.5:1.0	0.45	0.39	465	497	5.3	5.6	0.7	0.5
2020	51	31	1.6:1.0	0.54	0.47	454	492	5.0	5.3	1.0	0.4

* Estimates based on low sample size

B. Indian Head River

Year	N Male	N Female	Ratio M:F	A. Mean CPUE	G. Mean CPUE	Mean TL (mm)		Mean Age		Chapman-Robson	
						Male	Female	Male	Female	Z	S
2016	62	46	1.3:1.0	0.36	0.32	488	512	5.9	6.0	1.4	0.2
2017	88	29	3.0:1.0	0.39	0.36	488	512	5.7	6.0	1.4	0.2
2018	126	55	2.3:1.0	0.48	0.43	465	512	5.2	6.1	0.5	0.6
2019	86	32	2.7:1.0	0.55	0.48	474	499	5.5	5.5	0.6	0.5
2020	77	54	1.4:1.0	0.57	0.50	473	511	5.8	5.8	0.7	0.5

Fish Ladder Specifications. A stone and concrete weir and pool fish ladder is located on the South River at the Town of Marshfield's Veteran's Memorial Park Dam. The fish ladder is approximately 21 ft. in length with 4 weirs, including an entrance weir constructed by DMF in 2017. Visual counting conducted by volunteers of the North and South River Watershed Association have observed shad presence but no passage at his location. The Elm Street Dam, located on the Indian Head River, was last rebuilt in 1920 and subsequently repaired in 1977 by the Towns of Hanover and Pembroke. A concrete Denil fishway (109 ft. length, 4 ft. width, 33 baffles) was installed to allow upstream passage.

Regulatory Authority. The owners of dams are responsible for repairing, operating, and maintaining the fish passage facilities in MA as prescribed in M.G.L. Chapter 130 §19. The Elm Street Dam is owned jointly by the Towns of Pembroke and Hanover. Following repairs by the DMF Fishway Crew at this fishway in October 2020, DMF will prepare an O&M plan to guide improved management for the location. The Veteran's Memorial Park Dam is owned by the Town of Marshfield. This fishway was improved in 2017 with the addition of a concrete entrance box. Following that work an O&M plan was prepared for the Town of Marshfield. Wetlands habitat and water quality protections are provided by M.G.L. Chapter 131 §40 and CMR Regulations 10.00 and administered *Mass*DEP.

Water Withdrawal Permissions*.* The Pembroke Country Club is permitted to withdraw water from the upper Indian Head River from Factory Pond downstream to Ludhams Ford (Elm Street) Dam (Subwatershed Segment MA94-04). Their present Water Management Act registration allows them to withdraw up to 0.13 MGD. The Hanover Water Department is permitted to withdraw up to 1.38 MGD in the lower Indian Head River from Ludhams Ford Dam downstream to the confluence with Herring Brook (Subwatershed Segment MA94-22, *Mass*DEP 2006.

In the South River, the Marshfield Water and Sewer Department is permitted under the Water Management Act to withdraw up to 3.30 MGD (*Mass*DEP 2006). In the North River, the Pembroke Water Department is permitted to withdraw up to 1.26 MGD and the Abington-Rockland Water Treatment Plant is permitted under the Water Management Act to withdraw up to 2.21 MGD (*Mass*DEP 2006).

Water Discharge Data: The USGS maintains one stream flow gauge in the North River watershed in Hanover at the Elm Street Bridge (No. 01105730, 3.2 km, 78.5 km^2 drainage area). The average monthly discharge at the Hanover gauge station is 105 cfs for April and 67 cfs for May from the time series record of 1966-2020.

Water Quality Monitoring: *Mass*DEP assesses waterbodies by comparing water quality to SWQC, identifying threats to habitats, and recommending remedial actions (*Mass*DEP 2007). The North River watershed was last assessed in 2001 (*Mass*DEP 2006). The upper watershed of the Indian Head River (segment MA94-04) was assessed as impaired due to metals, nutrients, and organic enrichment/low DO. The lower Indian Head River watershed (segment MA94-22) did not have sufficient information to make assessments for any designated uses (*Mass*DEP 2003). The South River watershed did not have sufficient information to make assessments for any designated uses (*Mass*DEP 2003).

ASMFC Shad Habitat Plan Framework

1.) Shad Habitat Assessment. No formal assessment of shad spawning and nursery habitat has been conducted in the North River watershed. An active restoration project is underway to consider removing the Veteran's Memorial Park Dam in Marshfield and replace it with a nature-like fishway. Fish passage improvements for shad at this location could provide access to approximately 1 km of suitable shad spawning habitat before reaching Chandlers Pond. It is uncertain if shad would pass through Chandlers Pond and continue through the small tributary feeding into the pond. No project presently is ongoing to evaluate the removal of the Elm Street Dam on the Indian Head River. Such a project would certainly provide benefits to shad passage and access to increased spawning habitat. There is 4-5 km of potentially suitable shad spawning and nursery habitat between the Elm Street Dam and the next dam at Forge Pond in Hanson. This dam is presently impassible with legacy concerns over industrial sediments. Access to Forge Pond dam would also require bridge riprap modifications at Cross Street.

2.) Threats Assessment. No formal threat assessments have been made for shad in the North River. This river system contains the largest remaining shad populations in coastal MA rivers and supports ongoing sportfisheries. Two dams appear to limit upstream access for shad in the Indian Head and South

rivers. Therefore, **Barriers to Migration** are an ongoing threat to shad in this river system. However, these dams have been in place for centuries and anecdotal reports suggest higher shad fishery catch and participation in the 1960s and 1970s. It is likely that other threats are influential to the status of these two small shad runs. Increasing groundwater and surface **Water Withdrawal** as these coastal towns have been further developed in recent decades could be limiting surface flow and habitat quality in the rivers. This threat has not been assessed. The South River has experienced significant encroachment of wetland plants into the river channel between the Veteran's Memorial Park Dam and Chandler Pond in recent decades. This process has led to the deposition of large amounts of fine sediments and reduced channel definition in this river stretch.

3.) Habitat Restoration Plan. Currently, DMF does not have an ongoing project or imminent plans to initiate an assessment of the two North River shad run or conduct a habitat restoration plan. Two areas of interest are a shad spawning and nursery habitat assessment in both the Indian Head and South rivers. DMF will look for cooperative opportunities to pursue shad habitat assessments in this watershed with a priority given to the Indian Head River upstream of the Elm Street Dam. The DMF Diadromous Fish Habitat Restoration Priority List has the Cross Street Bridge location ranked 1st among 82 possible projects in the South Shore Coastal Drainage Area. This project would benefit shad if passage were improved at the Elm Street Dam. DMF staff will prioritize the initiation of an evaluation of this fish passage improvement project as opportunities occur. DMF drafted a South River Stream Maintenance Plan for the Town Marshfield in 2016 and has worked with Town staff and volunteers on numerous trips to remove debris jams and shrub overgrowth upstream of Veteran's Memorial Park Dam. This work revealed significant alteration of potential shad spawning pool and riffle habitat as wetland shrub plants choked the river channel and led to high sediment accumulation and channel braiding.

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

Action actively being addressed by agency. Fishway repairs were conducted by DMF at the Elm Street Dam on the Indian Head River in 2020, and stream maintenance is ongoing in the South River. DMF intends to continue with the shad electrofishing project in both rivers and look for opportunities to evaluate the potential shad habitat upstream of the Elm Street Dam in the Indian Head River.

Timeline and Costs for Achieving Goals/Targets. None established. Funding is not presently available.

Other organizations. The North and South River Watershed Association has been actively involved in natural resource stewardship in this watershed for decades. This association is interested in participating in diadromous fish habitat and population monitoring that could benefit shad. The Towns of Pembroke, Hanover and Marshfield have demonstrated similar interests and stewardship.

Neponset River

Watershed Information. The Neponset River originates at the Neponset Reservoir in Foxboro and flows for 45 km to Dorchester Bay (Figure 4). Fish passage is obstructed at the Lower Mills Dam (also called the Baker Chocolate Factory Dam) located at head-of-tide (6.8 rkm) on the Dorchester and Milton border. The Lower Mills Dam has a 7 ft spillway height and 79 ft spillway width that is connected to former mill buildings on both sides. The next dam upstream is the Tilestone and Hollingsworth Paper Company Dam at 11 rkm. This dam has a 9.5 ft spillway height, 151 ft spillway length with no fish passage facilities. DMF conducted a survey upstream of the two dams in 1995 and documented 25.3 km of suitable riverine habitat for shad and river herring spawning.

American Shad Status. Reback and DiCarlo (1972) recognized a substantial former shad fishery in the Neponset River that was eliminated by two dams in the lower watershed and launched efforts to restore passage in the 1990s. In anticipation of fish passage improvements at the two dams, DMF stocked 1,047 gravid adult shad from 1995 to 2001. Extensive multi-agency efforts have investigated dam removal and fishway options at the dams since 1994. Unfortunately, costly remediation of industrial contaminants has slowed momentum on the process: stalling what might be the shad restoration concept with the highest potential benefits among coastal MA rivers. Actual records on the recent presence of shad are limited. DMF monitoring for smelt spawning below the spillway of the Lower Mills Dam observed a few adult shad during late spring on several dates in the 1980s and 1990s.

Regulatory Authority. The owners of dams are responsible for repairing, operating, and maintaining the fish passage facilities in MA as prescribed in M.G.L. Chapter 130 §19. Both dams are owned by the MA Department of Conservation and Recreation (DCR). Wetlands habitat and water quality protections are provided by M.G.L. Chapter 131 §40 and CMR 10.00 and administered by *Mass*DEP.

Water Withdrawal Permissions. Several minor water withdrawals occur in the Neponset River watershed. However, municipal water supply for towns in the watershed is primarily provided by the Massachusetts Water Resource Authority, independent of the Neponset River.

Water Discharge Data. The USGS maintains a stream flow gauge in the Neponset River watershed in Milton at the Baker Dam (No. 011055566, 6.8 rkm, 262 km^2 drainage area). Flow data at this station is adjusted to account for tidal influence. The average monthly discharge at the Baker Dam gauge station is 580 cfs for April and 337 cfs for May from the time series record of 1996-2020.

Water Quality Monitoring. *Mass*DEP assesses waterbodies by comparing water quality to Surface Water Quality Standards (SWQC), identifying threats to habitats, and recommending remedial actions (*Mass*DEP 2007). The Neponset River watershed was last assessed during 2004; with a large percentage of the potential shad habitat listed as *Impaired* due to several stressors including low dissolved oxygen, very high levels of polychlorinated biphenyls (PCBs), and high nutrients.

ASMFC Shad Habitat Plan Framework

1.) Shad Habitat Assessment. A shad habitat assessment was conducted in the Neponset River during 1995 by DMF. This assessment found suitable habitat for shad and prompted restoration efforts in the watershed that have stalled due to concerns over project costs and contaminated sediments. The DMF Diadromous Fish Habitat Restoration Priority List has the Lower Mills location ranked 3rd (tied) among 111 possible projects in the Boston Harbor and North Shore region. Shad restoration potential is an important factor that contributes to this high rank as a restoration priority.

2.) Threats Assessment. No formal threat assessments have been made for shad in the Neponset River watershed. The primary threat is clearly **Barriers to Migration** given the two impassible dams in the lower watershed. Water flow does not appear to be a major threat given the stream flow gauge records of relatively high flow for the entire shad spawning and nursery habitat period. Sea level rise could be a factor in this watershed as evidence of higher tidal influence at Lower Mills has been observed during more than 30 years of DMF monitoring. The rising sea level could be a significant negative influence on rainbow smelt spawning habitat and other head-of-tide spawning fish. This impact likely does not influence shad; however, the impact to other species adds to the rational for providing fish passage at Lower Mills.

3.) Habitat Restoration Plan. Currently, DMF does not have an ongoing project or imminent plans to initiate an assessment of the Neponset River shad run or conduct a habitat restoration plan. The results of the prior survey are likely still relevant, although updated information may benefit restoration goals. No funding is presently available for shad restoration planning or population monitoring.

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

Action actively being addressed by agency. None at the present time. In 2018 the dam owners, DCR, signaled some willingness to re-examine providing passage at the Baker Chocolate and Tilestone Dams. DMF intends to revisit the concept of fish passage improvements at the two dams at the next opportunity with DCR.

Timeline and Costs for Achieving Goals/Targets. None established. Funding is not presently available.

Other organizations. The Neponset River Watershed Association has been actively involved in natural resource stewardship in the Neponset River for decades. This association is interested in participating in diadromous fish habitat and population monitoring that could benefit shad. The DCR as dam owners, will be an essential partner in any restoration planning.

Charles River

Watershed Information: The Charles River is a relatively large coastal river in Massachusetts that provides habitat for diadromous fish for nearly 130 km as it flows to Boston Harbor (Figure 4) and borders the lands of 24 towns and cities. The drainage area of the primarily urbanized watershed is approximately 805 km^2. There are eight dams that fragment diadromous fish habitat in the Charles River. The upper two dams have no passageways and the lower six have passageways with most designed to pass shad but with unknown efficiency.

American Shad Status: Belding (1921) refers to the Charles River as one of the first rivers in Massachusetts to lose its shad and alewife fisheries due to pollution and dams. Reback and DiCarlo (1972) state that shad were not present in the Charles River at the time of their 1960s survey of anadromous fish; however, they note the high restoration potential and interest of DMF to pursue shad restoration. A river assessment was conducted by DMF in the late 1960s to determine the available potential spawning habitat. The survey covered a total of 98 rkm from the Charles River locks to Medway and documented approximately 64 rkm with suitable shad spawning habitat. This survey led to an effort to stock fertilized shad eggs in 1971. Intensive stocking of shad eggs occurred through much of the 1970s and sporadic stocking of mature adult shad continued from 1978 to 1992. The results of the stocking effort were not evaluated, although returning adult shad were captured in low numbers while collecting river herring for stocking below the Watertown Dam during the 1990s and 2000s (Reback et al. 2005). Shad stocking efforts were renewed in 2006 to apply improved culture techniques and oxytetracycline (OTC) marking to evaluate restoration responses.

Ongoing Shad Monitoring

Starting in 2006, a cooperative effort between DMF and the USFWS has made several concerted efforts to restore American shad to the Charles River. Restoration efforts have included stocking larvae into

potential nursery habitat upstream of barriers, video monitoring of fishway passage, telemetry studies, and age validation work.

From 2006 – 2017, USFWS stocked an average of 2.2 million OTC-marked larvae in potential nursery habitat upstream of the Moody Street Dam (4th barrier). Gravid American shad were collected from the Merrimack River and cultured to fry stage at the USFWS Nashua or North Attleboro hatcheries. Starting in 2012, the two agencies conducted electrofishing downstream of the Watertown Dam (2nd barrier) in document the status of the shad run and restoration contributions. During 2012, weekly, spawning run electrofishing trips yielded a total of 30 adult shad. The otoliths of each adult were removed and examined for an OTC mark and were aged along with scales from each fish. Of the 30 adults retained, 25 were an age (3-6) that could have originated from the restoration efforts. Of those 25 fish, 15 possessed an OTC mark. It is unknown whether non-marked fish are the result of straying, hatchery product that lost or failed to incorporate an OTC mark, or remnant of a natural population. Since the resumption of stocking in 2006 an effort was made to identify if a remnant spawning run existed, using the Denil fishway at the Watertown Dam as a fish trap.

When the trap was operated, adult shad were prevented from passing through the upstream exit by way of tightly spaced vertical bars. The trapping approach had limitations, although did document the presence of low numbers of adult shad. In 2013 and 2014, DMF replaced this trap methodology with a video monitoring system. Video data documented over 350,000 river herring and 44 adult shad passing through the fishway in 2013 and over 310,000 river herring and 41 shad in 2014. In 2013 and 2014 only 58 (2013: 22, 2014: 36) adult American shad were captured while electrofishing, meaning the number of shad successfully utilizing the fishway exceeded the number sampled below and supports the possibility of natural reproduction occurring in the watershed. However, most shad on video appeared smaller and were likely males. The entrance of the Watertown Dam fishway is on the opposite side of the river from the thalweg, creating an attraction problem for shad. Shad would need to leave the thalweg well downstream of the fishway and follow flow on the river right bank or cross from the thalweg below the dam apron to river right over a large, shallow and turbulent area.

From 2008 to 2016 larval American shad reared in the USFWS North Attleboro National Fish Hatchery and stocked to the Charles River received oxytetracycline (OTC) marks. The initial years of marking were to help differentiate between natural and stocked American shad. This program was modified to incorporate an age validation that began in 2013. Limited age validation work has occurred for this species and additional studies in different watersheds will benefit coastwide management. Examination of larvae sacrificed to evaluate marking procedures indicated that OTC marks were present in most individuals but that larvae appeared to incorporate OTC better, leading to stronger marks, at older ages. Beginning in 2013, larvae received double or triple marks with varying days between marks. Variation of mark procedures between years allows marked fish to be assigned to a specific hatch year, thereby allowing for direct age validation. Recaptures of multiple marked fish began in 2017 but catches of marked shad were low until 2019 (2017 N = 17, 2018 N = 24, 2019 N = 32). Given the small sample sizes and the fact that counting daily growth rings can be difficult, there was some uncertainty in year class identification in samples from 2017 and 2018. The larger sample size and the increased abundance of triple marked samples in 2019 has increased our confidence that we can correctly identify year classes and validate our ages. Due to COVID related field work restrictions no sampling occurred in 2020.

In the springs of 2015 and 2016, DMF collaborated with USFWS Central New England Fisheries Conservation Office biologists to conduct an acoustic telemetry study on spawning adult shad. The goals of the study were to examine impediments to passage and restoration by understanding distribution of adult shad in the Charles River (Gahagan and Bailey 2020). A total of 98 adult American shad were

tagged and acoustic arrays were maintained during 2015-2017. The study successfully used surgical implantation methods to track American shad over multiple years and achieved other study goals.

Fish Ladder Specifications: Detailed specifications on the Charles River fishways are provided in Reback et al. (2005). The first barrier in Boston Harbor is the Charles River Locks, built for navigation and flood control. A locking protocol is used to pass migrating fish at this location with specific timing provisions for the shad migration. The 2nd, 5th and 6th dams have large-width (4-6 ft) Denil fishways designed by the USFWS to pass river herring and shad. The 3rd barrier has been partially breached to allow fish passage. The 4th barrier at the Moody Street Dam is a hybrid ladder with a lower section of 4' Denil baffles leading to a large weir pool section with a 180° turn between the 2nd and 3rd weirs. The uppermost dams, the Metropolitan Circular Dam at 32.2 rkm and the Silk Mill Dam at 32.5 rkm have no fishways. Shad presently have access to approximately 32 rkm of potentially suitable habitat.

Regulatory Authority: The owner of the dam is responsible for repairing, operating, and maintaining the fish passage facilities as prescribed in M.G.L. Chapter 130 §19. Seven of the eight dams on the Charles River are owned by the Massachusetts Department of Conservation and Recreation. The Silk Mill Dam is privately owned. Wetlands habitat and water quality protections are provided by M.G.L. Chapter 131 §40 and CMR 10.00 and administered by the *Mass*DEP.

Water Withdrawal Permissions: With a large urban watershed that connects many towns, the Charles River is subject to complex water management. Communities in the metropolitan Boston area (inside Route 128) receive water from the Massachusetts Water Resources Authority's Quabbin Reservoir. Communities outside of Route 128 are allowed under 14 MA Water Management Act permits to withdraw water from groundwater wells and reservoirs.

Water Discharge Data: The importance of the Charles River for water resource management is reflected by the presence of 18 USGS stream flow gauges in the watershed. The Waltham stream flow gauge station (No. 01104500, 19.6 rkm, 650 km^2 drainage area) is on the main stem Charles River and is most proximate to the fishways. The average monthly discharge at the Waltham gauge station is 616 cfs for April and 366 cfs for May from the time series record of 1931-2020.

Water Quality Monitoring: *Mass*DEP assesses waterbodies by comparing water quality to Surface Water Quality Standards, indentifying threats to habitats and recommending remedial actions (*Mass*DEP 2007). The Charles River watershed was last assessed during 2002-2006 (*Mass*DEP 2008); with a large percentage of the potential shad habitat listed as *Impaired* due to several stressors including low dissolved oxygen, high nutrients, and invasive plant growth.

ASMFC Shad Habitat Plan Framework

1.) Shad Habitat Assessment. No formal assessment of shad spawning and nursery habitat has been conducted in the Charles River watershed since the late 1960s. The interest of maintaining shad passage in the Charles River has a long history that includes the installation of four large Denil fishways at dams that were designed for shad passage. Shad presently have access to approximately 32 rkm of potentially suitable habitat. There are no present plans to update Charles River shad habitat assessment plans. Should opportunities arise to consider updates on shad habitat information in the Charles River the river upstream of the impassible Metropolitan Circular and Silk Mill dams should be evaluated.

2.) Threats Assessment. No formal threat assessments have been made for shad in the Charles River. Historical **Barriers to Migration** and degraded water quality were identified in past DMF surveys as impacting shad in the Charles River. Much work was conducted to provide fish passage at 6 of the 8 dams during the 1970s and 1980s. The implementation of the Clean Water Act in the 1970s slowly

reduced industrial pollution loads in the river. Presently, Barriers to Migration remains a significant threat due to inefficiencies at some of the fish passage facilities and the two remaining impassible dams. To this point, the results of the recent telemetry study showed that the New Boston Dam at the head of tide and the Watertown Dam, the first obstruction within the freshwater segment of the river, both lead to migratory delays and likely cause additive mortality (Gahagan and Bailey 2020). New Boston Dam delayed pre- and post-spawn shad, with several post-spawn shad dying at the dam and lock structures. The Watertown Dam blocked most pre-spawn shad from ascending the river and fish that did pass experienced delays of multiple days.

The watershed is heavily urbanized with documented surface water quality and stormwater impairments. Stormwater is a concern as rain events quickly degraded water quality in the watershed. Invasive plant species are also a threat of concern; particularly water chestnut.

3.) Habitat Restoration Plan. Currently, DMF does not have an ongoing project to initiate a shad restoration plan in the Charles River watershed. We **recommend** the following actions for the Charles River as opportunities allow: (1) assessment of the amount and suitability of Charles River habitat for shad spawning and rearing; (2) further assessment of the passage efficiency at the Watertown Dam fishway and the Moody Street Dam; (3) evaluate the feasibility of providing fish passage at the two upstream impassible dams; (4) In coordination with MA DCR, prepare Fishway Operation and Maintenance Plans for the four upstream fishways at DCR dams with consideration for shad passage requirements; and (5) evaluate the feasibility of fish passage improvements through removal of the Watertown Dam. The Watertown Dam project is the top ranked location among 111 possible projects in the DMF Diadromous Fish Habitat Restoration Priority List for the Boston Harbor and North Shore region (Version-4, 2020). In 2018-2019, DMF participated in a Feasibility Study to examine the removal of the Watertown Dam. The study has not been finalized but the results suggest removal is a feasible option for improving fish passage. The impassible Metropolitan Circular Dam and Silk Mill Dam are tied for 15th on the DMF Diadromous Fish Habitat Restoration Priority List for the Boston Harbor and North Shore region. If passage were provided at these two dams an additional 32 rkm (per survey of 1969-1970) of potential shad spawning habitat could be gained.

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

Action actively being addressed by agency. Present activities included fishway O&M coordination with MA DCR, and an ongoing multi-agency dam removal feasibility study for the Watertown Dam.

Initial Habitat Goal. None established. Funding is not presently available.

Timeline and Costs for Achieving Goals/Targets. None established. Funding is not presently available.

Other organizations: DMF conducts most field work in cooperation with the USFWS and *MassWildlife*. The Charles River Watershed Association is also engaged in a wide range of activities to monitor and improve the aquatic life of the Charles River.

Related Activities

The following three ongoing DMF projects related to diadromous fish could benefit the interest of improving our knowledge of American shad habitat in the future:

1.) A DMF coast-wide anadromous fish passage survey was conducted in the early 2000s (Reback et al. 2005) with a focus on river herring and structural fishways. The datafile of this survey was used to prepare a DMF Diadromous Fish Habitat Restoration Priority List in 2008 with the same focus on river herring and structural fishways. The DMF priority list was updated in 2011, 2016 and 2020 (V-4) with increasing inclusion of information on other diadromous fish species and other habitat types. This datalayer can be improved in the future by adding shad habitat data. Additionally, plans are underway to update the coast-wide anadromous fish passage survey in 2021. This activity can also include more attention to shad spawning, nursery and migratory habitat.

2.) A GIS datalayer of diadromous fish habitat was developed in cooperation with the Massachusetts Department of Transportation in 2013 to provide tools for transportation and diadromous fish restoration planning. The GIS datalayer was focused on river herring migrations and depended on site information and species presence/absence information largely provided by the DMF coast-wide survey (Reback et al. 2005) and DMF Diadromous Fish Habitat Restoration Priority List. The GIS datalayer was updated in 2018 and included an expansion of information on additional diadromous fish species. The datalayer was updated again in 2020 with the objective to increase information on other species and habitat types. This datalayer can be improved in the future by adding shad habitat data.

3.) The DMF conducts habitat assessments for rainbow smelt and river herring to under a Quality Assurance Program Plan (QAPP) that relates habitat and water quality conditions to aquatic life and species life history thresholds (Chase 2010). The QAPP provides guidance that can be transferable to riverine shad habitat assessments and could be updated in the future to include Specific Operation Plans for shad habitat assessments.

Citations

Belding, D.L. 1921. A report upon the alewife fisheries of Massachusetts. Mass. Div. of Fish. and Game, Dept. of Natural Resources, 135 pp.

Chase, B.C. 2010. Quality Assurance Program Plan (QAPP) for Water Quality Measurements Conducted for Diadromous Fish Habitat Monitoring. Version 1.0, 2008-2012. Mass. Div. of Mar. Fish., Tech. Report No. TR-42. http://www.mass.gov/dfwele/dmf/publications/tr42.pdf

Chase, B.C., A. Mansfield, and P. DuBois. 2013. River herring spawning and nursery habitat assessment - Silver Lake, 2008-2009. Mass. Division of Marine Fisheries, Tech. Rep. Series, TR-54.

CRASC. 1992. A management plan for American shad in the Connecticut River Basin. Connecticut River Atlantic Salmon Commission, Sunderland, MA.

CRASC. 2014. American shad Habitat Plan for the Connecticut River. *Prepared for* the Atlantic States Marine Fisheries Commission *by* the Connecticut River Atlantic Salmon Commission, Sunderland, MA.

Gahagan, B.I. and M.B. Bailey. 2020. Surgical implantation of acoustic tags in American shad to resolve riverine and marine restoration challenges. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 12(5): 272-289.

Gomez and Sullivan, 2013. Forge Pond Dam Fish Passage Improvement Feasibility Study and Preliminary Design. Prepared *for* Mass. Division of Marine Fisheries *by* Gomez and Sullivan Engineers, P.C., Henniker, NH.

Greene, K.E., J.L. Zimmerman, R.W. Laney, and J.C. Thomas-Blate. 2009. Atlantic coast diadromous fish habitat: a review of utilization, threats, recommendations for conservation, and research needs. Atlantic States Marine Fisheries Commission Habitat Management Series No. 9, Washington, D.C.

Rojko, A.M., S.D. Tamul, and L.E. Kennedy. 2005. Taunton River Watershed Water Quality Assessment Report. Mass. Dept. of Environ. Protect., Div. of Watershed Mgt ., Worcester, MA, Rep. No. 62-AC-1.

MA DMF. 2014. American Shad Habitat Plan for Massachusetts Coastal River. Submitted to the Atlantic States Marine Fisheries Commission. Approved Feb. 6, 2014.

MassDEP. 2003. *Final Massachusetts Year 2002 Integrated List of Waters.* Massachusetts Department of Environmental Protection, Division of Watershed Management, Worcester, MA. Document CN 125, Final September 2003.

*Mass*DEP. 2006. South Shore Coastal Watersheds 2001 Water Quality Assessment Report. Report No. 94-AC-2. Mass. Dept. of Environ. Protection, Division of Water Management, Worcester, MA.

*Mass*DEP. 2007. Massachusetts Surface Water Quality Standards. Mass. Dept. of Environ. Protection, Division of Water Pollution Control, Technical Services Branch, Westborough, MA (Revision of 314 CMR 4.00, January 2007).

*Mass*DEP. 2008. Charles River 2002-2006 Watershed Water Quality Assessment Report. Mass. Dept. of Environ. Protect., Div. of Watershed Mgt., Worcester, MA Rep., No. 72-AC-4.

*Mass*DEP. 2009. Narragansett and Mount Hope Bay Watersheds 2004-2008 Water Quality Assessment Report. Mass. Dept. of Environ. Protect., Div. of Water. Mgt., Worcester, MA, Rep. No.61/53-AC-2.

MRTC. 1997. Strategic plan and status review: anadromous fish restoration program, Merrimack River. Merrimack River Technical Committee, U.S. Fish and Wildlife Service, Nashua, New Hampshire.

MRTC. 2010. A Plan for the restoration of American shad in the Merrimack River Watershed. Merrimack River Technical Committee, U.S. Fish and Wildlife Service, Nashua, New Hampshire.

Reback, K. E. and J. S. DiCarlo. 1972. Completion report on the anadromous fish project. Mass. Div. Mar. Fish., Publication No. 6496, 113 pp.

Reback. K.E., Brady, P.D., McLaughlin, K.D., and Milliken, C.G. 2004. A survey of anadromous fish passage in coastal Massachusetts: Part 1. Southeastern Massachusetts. Mass. Div. Mar. Fish. Tech. Report No. TR-15.

Reback, K.E., P.D. Brady, K.D. McLauglin, and C.G. Milliken. 2005. A survey of anadromous fish passage in coastal Massachusetts: Part 4. Boston and North Coastal. Mass. Div. of Mar. Fish., Tech. Report No. TR-18.

Turner, S. *in Prep.* River herring spawning and nursery habitat assessment - Shad Factory Pond and the Palmer River. Mass. Div. Mar. Fish. Tech. Report.

Figure 1. Palmer River and Taunton River in the Narragansett Bay Watershed. The green dots are dams that are passable to migratory fish, the red dots are impassible dams, and the yellow dots indicate improvements are recommended.

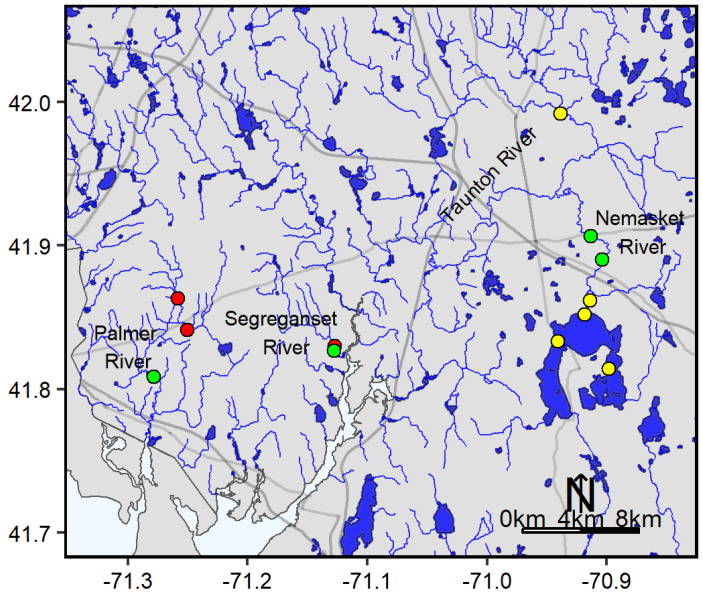


Figure 2. Jones River and North River watersheds in the South Shore Coastal Drainage Area. The green dots are dams that are passable to migratory fish, the red dots are impassible dams, and the yellow dots indicate improvements are recommended. The Indian Head River Dam is located at the green dot west of the North River title.

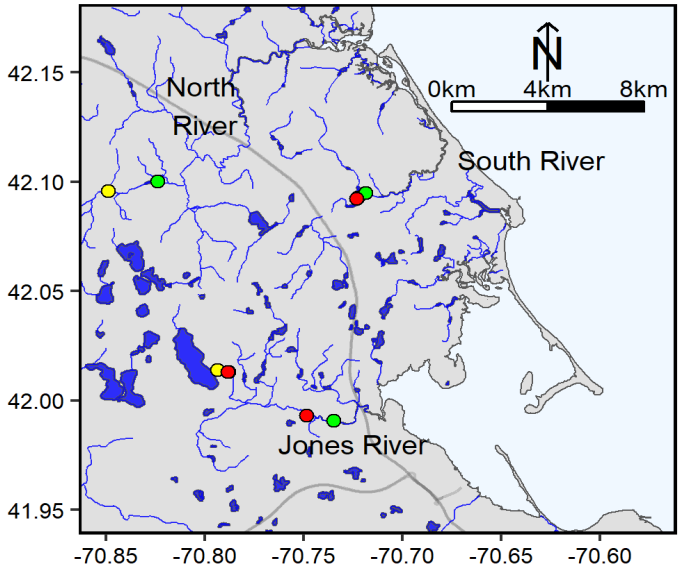
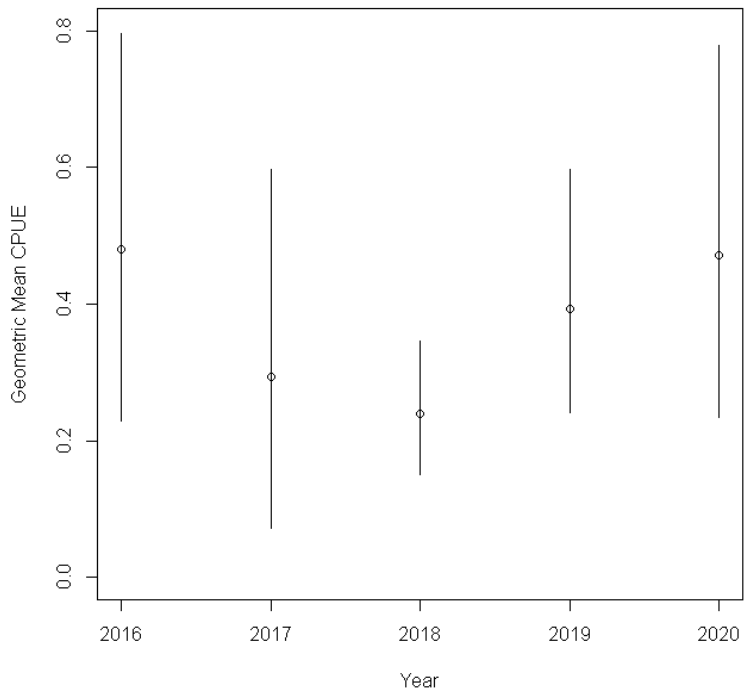


Figure 3. Annual Geometric Mean CPUE scores (+/- 95% C.I.) of American shad (N_{Shad}/minute) derived from electrofishing surveys conducted in the (A) South River; and (B) Indianhead River.

A. South



B. Indian Head

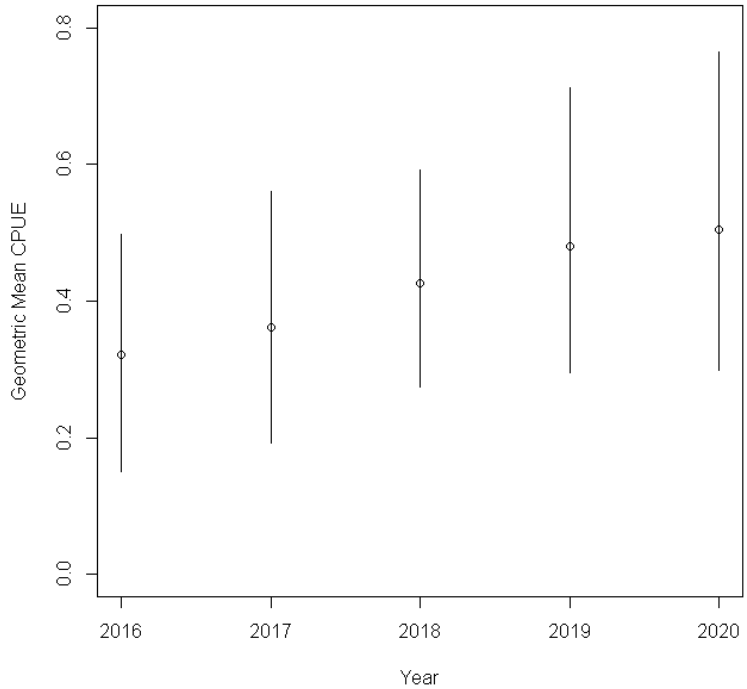


Figure 4. Charles River and Neponset River in the Boston Harbor Watershed. The green dots are dams that are passable to migratory fish, the red dots are impassible dams, and the yellow dots indicate improvements are recommended.