Maine Department of Environmental Protection

17 STATE HOUSE STATION
AUGUSTA ME 04333-0017

Notification/Request for Project Review

TO: Barry Mower, Linda Bacon, Rob Mohlar, Jeanne DiFranco, DEP DEA; John Perry, Jason Seiders, Keel Kemper, DIFW; Craig King, Sean Ledwin MDMR; Whitney McKay, MEMA; Randy Charette, MDACF; Brian Burne, MDOT; Kirk F. Mohney, MHPC

DATE: September 29, 2020

FROM: **Kathy Howatt, Project Manager and Hydropower Coordinator**
Kathy.Howatt@maine.gov , **(207) 446-2642**

This constitutes notification and a request for your agency's review of the project identified below and your submission of comments in accordance with our Memorandum of Agreement on Project Reviews. Questions may be directed to **Kathy Howatt**

This is a Water Quality Certification application.

The deadline for agency comments is: ***October 30, 2020***

DEP Application: #L-19751-33-H-N

Project Name: SHAWMUT HYDROELECTRIC PROJECT

Location: Fairfield-Benton

Applicant Name: Brookfield White Pine Hydro LLC

Contact: Randy Dorman, Licensing Manager:

randy.dorman@brookfieldrenewable.com
Tel #: (207) 755-5605

Application documents are available electronically at:
https://www.maine.gov/dep/ftp/HYDRO/WaterQualityCertifications/Shawmut/

Notes to Reviewers:

The Applicant proposed to operate the 8.65 MW Shawmut Hydroelectric Project under a new FERC license and plans to install and operate upstream and downstream fish passage facilities at the site of the Shawmut dam. The proposed project is located on the Kennebec River in the towns of Fairfield and Benton.

After a thorough review of our agency's standards, programs and responsibilities, the following comments are submitted to the Department of Environmental Protection.

(Comments must be signed and dated in order to be accepted by this Department. If additional space is needed, please attach another sheet).

SIGNATURE Sean Ledwin ***DATE*** ____________

Contents

1. Summary

The State of Maine seeks to restore indigenous diadromous or "sea-run" fish species to historic habitats in sufficient numbers to meet ecological, economic, cultural, and biological objectives. The Kennebec River was once Maine's most productive river system, with vast populations of sea-run fish. For decades, impassible dams and poor fish passage performance have prevented sea-run fish from reaching historic spawning and rearing grounds in sufficient numbers to meet State goals. Since the 1993 Kennebec River Management Plan ("1993 Plan") that called for the removal of the Edwards Dam was adopted, significant progress has been made towards State of Maine goals for these important resources. The removal of Edward Dam, ordered by the Federal Energy Regulatory Commission ("FERC" or "Commission"), fish passage requirements in the *Lower Kennebec River Comprehensive Hydropower Settlement* ("1998 Settlement"**)**, and years of work by the Maine Department of Marine Resources ("MDMR") and others have resulted in full restoration of historic habitats for Endangered Species Act ("ESA") listed Atlantic and shortnose sturgeon, and the largest river herring (alewife and blueback herring) run in North America in the Sebasticook River, topping 5 million fish in some years.

The Kennebec River supports important recreational fisheries for striped bass and American shad, commercial fisheries for river herring and American eel, critical populations of ESA listed Atlantic salmon, and annually exports millions of juvenile and adult sea-run fish to Maine's coastal waters. Statewide, the striped bass fishery supported 3,110 jobs and generated $202-million dollars in revenue in 2016. In 2019, Maine's recreational fishermen landed 92,081 American shad. The lucrative American eel (elver) fishery was worth over $20 million dollars in 2018 and 2019. Statewide, the commercial harvest of river herring is a source of income for the municipalities with fishing rights, and as Atlantic herring stocks have plummeted, river herring have become an increasingly important bait for the lobster industry, valued at $485.4 million in 2019. Atlantic salmon habitat in the Kennebec River above Skowhegan is essential to recover Atlantic salmon statewide and is valued at over $1 billion. Sea-run fish are an important part of the riparian and coastal environment, providing forage for eagles, seals, puffins, whales, cod, pollack, and other freshwater and marine species.

While significant progress has been made to restore mainstem habitats and tributaries in the Kennebec River, the four mainstem dams in the lower Kennebec River (Lockwood, Hydro Kennebec, Shawmut, and Weston) continue to impede the migrations of a number of indigenous sea-run species. The lack of effective passage at these four dams, along with the presence of the impoundments created by the dams, has hindered the development of these fisheries and negatively impacted riverine habitat and the ecological health of the watershed and beyond.

Diadromous fish species require safe, timely, and effective access to high quality habitats at different life stages in order to successfully survive and reproduce. Hydroelectric projects often prevent or delay migrations or cause mortality or injuries that contribute to population level declines. These adverse impacts can be mitigated by properly designed fishways, however many fishways fail to perform as intended, including fishways developed and operated utilizing USFWS Fish Passage Design Criteria (USFWS 2019). When there are a series of fishways within a migration corridor, such as in the lower Kennebec River, the risks increase that one or more underperforming fishways will result in significant cumulative negative impacts to diadromous fish populations. This potential for cumulative impacts creates the need for highly effective fish passage at each of the dams that meet agency performance standards. Dam removal is the most effective fish passage strategy and reduces the cumulative impacts of multiple projects significantly, allowing for reduced performance standards per project. When the need to meet important energy objectives makes dam removal infeasible or undesirable, high standards of passage efficiency at upstream and downstream fishways and proper management of operations to facilitate fish passage are required. Species such as American shad and Atlantic salmon are often impacted significantly by just one improperly working fishway in a given watershed, which is a common circumstance in many of the large rivers in Maine today. American shad migrations and associated production potential are significantly reduced or eliminated due to poor passage at hydroelectric dams on the Kennebec, Androscoggin, Penobscot, and the St. Croix rivers. Fish passage failures at the Lockwood Project provide a cautionary tale as unexpectedly poor performance has left hundreds of returning endangered Atlantic salmon to die or spawn in subpar habitats below the project and likely tens or hundreds of thousands of American shad and other species to be blocked from historic habitats annually.

The State of Maine supports domestic hydropower as an important component of energy in the State and a renewable source of energy critical to meeting climate goals. However, the State also believes that the best approach to meet the management goals for the Kennebec River is to decommission and remove some or all of the dams in the Lower Kennebec. MDMR is writing an amendment to the 1993 Kennebec Management Plan ("Kennebec River Amendment") that will recommend dam decommissioning and removal and will be submitted to FERC as a comprehensive plan. The MDMR, therefore, supports the request made by several fishing and environmental organizations that FERC analyze decommissioning and removal of the Shawmut Project as a preferred option. Any potential lost generation at the lower Kennebec projects through a decommissioning and removal would be offset by strategic hydropower enhancements at projects that are not significant fish passage impediments and/or through new clean energy developments (e.g. grid-scale solar).

The Shawmut Project represents less than 0.1% of the production of electricity in the State of Maine; yet if relicensed with underperforming fishways, would hasten the extinction of an iconic Maine species, Atlantic salmon, and could result in millions of sea-run fish not reaching historic habitats over the term of the license. The Shawmut Project should be considered for decommissioning and removal for the following reasons: the Project has relatively low energy production compared to Statewide renewable energy generation and to other hydroelectric dams owned by Brookfield in the Kennebec River; the Project site is complex and presents significant uncertainty regarding the ability to effectively pass fish at required standards; the Project will need to attain unproven high passage performance to ensure Atlantic salmon recovery and restoration goals for other diadromous species are achieved; and removal of this dam is feasible and reasonably practical, as determined by a Licensee distributed report entitled *Energy Enhancements and Lower Kennebec Fish Passage Improvements Study* (BWPH 2018) (FERC Accession #s 20190701-5155 and 20190701-5154). MDMR believes the Shawmut project is particularly suited for decommissioning and removal.

In the event FERC determines that the Shawmut Project should be relicensed rather than be decommissioned and removed, the Licensee's proposed upstream and downstream fish passage facilities will have to be tested for effectiveness and will need to meet MDMR performance standards. MDMR has included requirements for such testing and performance standards that need to be met for Atlantic salmon, American shad, alewife and sea lamprey in our Terms and Conditions and in the Kennebec River Amendment. Development of and justification for the standards are found in this document in Sections 4.1, 4.2, 4.4, and 4.5 and in in the Kennebec River Amendment. MDMR recommends that DEP incorporate the terms and conditions, performance standards, and testing as part of the water quality certification under 401 of the Clean Water Act as these measures are necessary.

2.Cumulative impacts past, present, and future

In the following section, MDMR considers and analyzes the cumulative impacts the continued operation and maintenance of the Shawmut Project in combination with other hydroelectric projects and other activities in the Kennebec River basin have had and continue to have on migratory fish, including Atlantic salmon, American shad, blueback herring, alewife, American eel, and sea lamprey and on current and potential commercial and recreational fisheries. Herein we consider the geographic scope to include the Kennebec River basin and its tributaries from the Williams Project (FERC No. 2335) to the mouth of the Kennebec River where it enters the Gulf of Maine, including the mainstem Kennebec River dams and impoundments. Activities within this basin that may cumulatively affect these migratory fish species include the construction and operation of dams within the river basin, which have resulted in migratory barriers and loss of spawning habitat. We consider the temporal scope to include the past, present, and reasonably foreseeable future actions for the next 40-50 years and their effects on migratory fish and the fisheries they support. Our analysis focuses on upstream and downstream diadromous fish movement and access to habitat in the Kennebec River and its tributaries, including an evaluation of the Shawmut Project impoundment, along with other impoundments, to act as a barrier to fish movement in the river.

When the Shawmut Project was licensed on January 5, 1981, eight native species of anadromous fish (shortnose sturgeon, Atlantic sturgeon, striped bass, Atlantic salmon, American shad, blueback herring, alewife, and sea lamprey) had been extirpated from significant amounts of historic spawning/nursery habitat in the Kennebec River watershed for more than 140 years due to the presence of 14 hydropower dams without fish passage. The State of Maine and its partners have made significant progress in the restoration of anadromous fish to some parts of the Kennebec River in the intervening years (Table 1; Table2).

Two important events were the passage of the Clean Water Act in 1976 and the removal of Edwards Dam in 1999. Removal of the Edwards Dam allowed shortnose sturgeon, Atlantic sturgeon, and striped bass free access to the remainder of their historic spawning habitat on the mainstem Kennebec River (Wippelhauser et al. 2015; Wippelhauser et al. 2017; Wippelhauser in review) and allowed American shad and blueback herring free access to about 21% of their historic spawning habitat (Table 3).

The catadromous American eel was never completed blocked from reaching freshwater growth habitat above the dams, because of the ability of small juveniles to ascend wetted surfaces (Solomon et al. 2004); however, their abundance was likely reduced. Yoder et al. (2006)

conducted standardized boat electrofishing transects from Chops Point (26.9 miles downstream of former Edwards Dam) to the Wyman Dam (75 miles upstream of Edwards Dam) in 2002 and 2003, and reported that 1) the numerical abundance of American eel (all life stages combined) was highest (200-400 fish/km) between Waterville and Augusta including the segment affected by the Edwards Dam removal, and 2) numerical abundance declined to less than 50-100 eels/km upstream from the Lockwood Dam and young-of-year were absent. In addition, the highest average abundance and biomass of all fish combined occurred in the riverine segment between Waterville and Augusta, followed by the downstream tidal segments, and lastly by impounded river segments.

By 2003, MDMR and its partners had provided upstream fish passage at four non-hydropower dams in the Sebasticook River (Table 1; Guilford Dam, Sebasticook Lake, and Plymouth Pond), which in turn triggered construction of upstream passage at the Benton Falls Project and the Burnham Project. A fish lift at each of the projects became operational in 2006. After the Fort Halifax Dam was removed in 2008, the abundance of alewife and blueback herring in the Sebasticook River increased dramatically (Table 4). This self-sustaining run of river herring is the largest on the east coast (Wippelhauser in review). Interim upstream fish passage (a fish lift terminating in a trap-and-truck facility) became operational at the Lockwood Project in 2006. Upstream and downstream passage for American eel was also provided at each of the projects between 1999 and 2011.

In contrast to these successes, the restoration of Atlantic salmon, American shad, alewife, and blueback herring to a significant amount of spawning habit (Table 2) above the Lockwood Project in the past 14 years has been disappointing. In addition, thousands of native sea lamprey continue to be blocked from upstream habitats. Permanent upstream passage at the Lockwood, Hydro Kennebec, Shawmut and Weston projects, which was to be triggered by passage of specific numbers of American shad, never came to fruition. The presence of popular recreational fishery for American shad below Lockwood dam, suggests that poor passage, not low abundance of shad below the project, is likely the reason triggers were not realized.

3. Status of fish passage at hydropower projects

Lockwood–The upstream fish passage facility at the Lockwood Project became operational in 2006 pursuant to the 1998 Settlement. It is an interim fishlift that terminates in a trap-and-truck facility. Fish and water are collected in the hopper, lifted, and discharged into a 12-foot diameter sorting tank. River herring (alewife and blueback herring) and American shad are dip-netted into two ten-foot diameter tanks, Atlantic salmon are moved into a 250-gallon isolation tank, and the other species are sluiced downstream. The river herring, shad, and salmon are trucked upstream to spawning habitat by MDMR. An upstream passage facility designed specifically for American eels (ramp) is installed in the bypass in the spring and removed in the fall. Downstream passage is provided via spill, a downstream bypass in the power canal that releases 350 cfs, or through the turbines. An angled boom in the power canal serves to guide fish to the bypass.

Pursuant to the 1998 Settlement, permanent (swim-through) upstream passage at the Lockwood Project and the Hydro Kennebec Project was to be operational two years after 8,000 American shad were captured in any single season at the interim facility at Lockwood or a biological assessment trigger was initiated for Atlantic salmon, alewife or blueback herring. The interim upstream passage facility at Lockwood Project was never converted to a permanent facility, because the trigger number was never met – the greatest number of American shad passed at Lockwood in a single year has been 830 fish (Table 4). Ultimately, the listing of Atlantic salmon and the resulting ISPP became the trigger for providing permanent upstream passage at the four mainstem dams. The current license requires the Licensee to provide an upstream fish passage to be operational by May 1, 2022.

Hydro Kennebec–The permanent upstream fish passage facility at the Hydro Kennebec Project, a fish lift, became operational in the fall of 2017. Fish and water are collected in the hopper, lifted, and discharged into an exit flume that extends 470 feet into the headpond. An upstream passage facility designed specifically for American eels (ramp) is located on the west side of the spillway; the entrance and exit are installed in the spring and removed in the fall. Downstream passage is provided via spill (although spill is rare), through a gate located in the powerhouse forebay that discharges into a large plunge pool, or through the turbines. An angled boom in the forebay serves to guide fish to the bypass.

Shawmut–Pursuant to the ISPP and the current license, the Licensee is required to provide an upstream fish passage to be operational by May 1, 2022. Permanent upstream eel passage (ramp) was operational on the east side of the spillway until the installation of a rubber dam on the spillway in 2009 that eliminated attraction to the area. Since 2010, a portable eel passage (6-foot long, 1-foot wide ramp with climbing substrate, a collection bucket and attraction water) has been installed annually between the first section of the hinged flashboards and the unit 1 tailrace. Water released at this location to provide additional downstream passage for Atlantic salmon smolts may interfere with upstream eel passage as evidenced by declines in upstream migrants from 2016 to 2018. In 2019, a second upstream eel passage, similar in design to the other ramp, was installed adjacent to the forebay plunge pool

Downstream passage is provided via a surface weir (sluice), a Tainter gate, hinged flashboards, the turbines or spillway. The 4-feet wide and 22-inch deep sluice is located on the right side of the intake structure next to Unit 6. When all stoplogs are removed, the sluice passes 30-35 cfs over the face of the dam and into a 3-feet deep plunge pool. The 7-foot high by 10-foot wide Tainter gate is located to the right of the sluice and can pass up to 600 cfs. The FLA does not state whether water released from the Tainter gate also passes over the dam and into the 3-foot deep plunge pool. The sluice and Tainter gate are operated from April 1-June 15 to pass Atlantic salmon smolts and kelts and from November 1 to December 31 (depending on ice and flow conditions). Four sections of hinged flashboards immediately adjacent to the canal headworks are opened for the smolt migration season and provide approximately 560 cfs of spill.

Downstream passage for American eel is provided by opening a deep gate (the Tainter gate) to pass approximately 425 cfs and turning off units 7 and 8 for 8 hours for a six-week period between September 15 and November 15. A study conducted by the Licensee in 2008 (Next Era Energy 2009) on the downstream passage of American eel found that passage via the deep gate increased with higher flow through the gate (58.3% at 207 cfs and 83.5% at 425 cfs) when Units 7-8 were turned off, immediate survival (not defined) increased with the higher flow, and immediate survival of eels passing through Units 1-6 was 90% (9 of 10). Survival of eels not entering the forebay was not described. In 2009, the Licensee in consultation with resource agencies designed and constructed a plunge pool below the outlet of the deep gate. MDMR questions whether passing downstream migrating American eels via a flow of 425 cfs into a 3-foot deep plunge pool is safe.

Weston–The Weston Project currently does not provide upstream fish passage. An upstream passage facility designed specifically for American eels (ramp) is located on the west side of the south channel dam. Downstream passage is provided via a surface sluice gate and associated unregulated spill, or through the turbines. The current license requires the Licensee to provide an upstream fish passage to be operational by May 1, 2022.

Abenaki and Anson–These two projects, separated by 0.76 river miles, have the same owner and were licensed together. Both projects currently have upstream and downstream passage facilities for American eel, and both have the same license requirements for upstream and downstream passage for Atlantic salmon. Briefly,[1] interim downstream passage is to be to be operational at each project two years after the Licensee receives written notice from MDMR and the U.S. Fish and Wildlife Service (USFWS) that sustained annual stocking of Atlantic salmon above the projects has begun or will begin within two years. Permanent upstream passage is to be operational at each project within two years after the Licensee receives written certification from the MDMR and USFWS that 226 adult Atlantic salmon originating from the Kennebec River and obtained from the Lockwood fishlift or other lower Kennebec River trap and truck facility have been released into the Kennebec River watershed above the Weston dam in any single season. In no event, however, will permanent upstream and permanent downstream passage for Atlantic salmon be required to be operational prior to May 1, 2020.

4. Fish passage testing and performance standards

Diadromous fish species require safe, timely, and effective access to high quality habitats at different life stages in order to successfully survive and reproduce. Hydroelectric projects often prevent or delay migrations or cause injury or mortality that contribute to population declines. These adverse impacts can be mitigated by properly designed fishways, however many fishways fail to perform as intended, including fishways developed and operated utilizing USFWS Fish Passage Design Criteria (USFWS 2019). When there are a series of fishways within a migration corridor for diadromous species, such as in the lower Kennebec River, the risks increase that one or more underperforming fishways will result in significant cumulative negative impacts to these fish populations. This potential for cumulative impacts creates the need for highly effective fish passage at each of the dams that meet agency design and performance standards.

To ensure that restoration goals for the Kennebec River are met, the new fish passage facility at the Hydro Kennebec Project and the facilities that have been proposed for the Lockwood, Shawmut, and Weston projects (to be operational by May 1, 2022) will need to tested for their effectiveness in passing adult and juveniles stages of Atlantic salmon, American shad, blueback herring, alewife, sea lamprey, and American eel during their upstream and downstream

[1] The licenses contain additional details regarding fish passage for Atlantic salmon.

migrations. In a report that analyzed mitigation (fish passage) at hydropower projects, FERC (2004) acknowledged the impacts of the projects on fish populations and the importance of testing the effectiveness of fish passage facilities and also recognized the use of modeling tools for assessing management actions and fish passage improvements at multiple projects.

Migratory delay comes at energetic costs to further upstream migration and subsequent reproduction, consequently, it is recommended that fish pass performance include not only target numbers or percentage of fish passing, but also metrics for movement rates and time to pass (Castro-Santos et al. 2009; Castro-Santos and Letcher 2010; Castro-Santos and Perry 2012; Castro-Santos et al. 2016). The overall energetic costs to migration and reproduction imposed by migratory delay will increase with the number of dams encountered and should be factored in when setting passage time performance standards.

In response to recent FERC filings, MDMR has developed performance standards in this Amendment for four species, Atlantic salmon, American shad, alewife, and sea lamprey, that are described and justified in sections 3.5, 3.6, and 3.7. In the Environmental Analysis of three recent relicensings (e.g. American Tissue FERC No. 2809-034; Barker Mills FERC No. 2808; Ellsworth FERC No. 2727-092), the FERC did not supported recommendations made by the resource agencies for effectiveness testing of all new fish passage facilities. One reason for the lack of support was the lack of specific performance standards by which the effectiveness testing will be evaluated.

In most cases, dam removal is the most effective fish passage strategy and reduces the cumulative impacts of multiple projects. When the need to meet important energy objectives makes dam removal infeasible or undesirable, high standards of passage efficiency at upstream and downstream fishways and proper management of operations to facilitate fish passage are required. Diadromous species are often impacted significantly by just one improperly working fishway in a given watershed. For example, American shad distribution and abundance in a watershed is significantly reduced or eliminated due to poor passage at hydroelectric dams on the Kennebec, Androscoggin, Penobscot, and the St. Croix rivers in Maine. Poor passage at the Lockwood Project leaves an unknown number of returning endangered Atlantic salmon to die or spawn in subpar habitats below the project and likely tens or hundreds of thousands of American shad and other species to be blocked from historic habitats annually.

5. Current status of diadromous species

5.1 Atlantic Salmon (*Salmo salar*)

The goal for Atlantic salmon is to restore a minimum population of 2,000 adults annually to historic habitats (identified in Table 11) in the Kennebec River. Because restoration of this species as not considered in the 1993 Plan, a more complete description of the species biology, ecology, and fish passage requirements are included here and in the Kennebec River Amendment.

The Atlantic salmon is a medium-sized, highly migratory, anadromous, iteroparous fish that historically ranged from northeastern Labrador to the Housatonic River in Connecticut (Collette and Klein-MacPhee 2002). Hundreds of thousands of adult Atlantic salmon returned annually to spawn in the rivers of New York and New England and represented a culturally significant species for Maine's tribes and later became an important economic resource both recreationally and commercially. Habitat loss and degradation due to dams and industry, overharvest, and other human impacts brought the Atlantic salmon to the brink of extinction within its U.S. range (Fay et al. 2006, NAS 2004). Today, the only remaining population of Atlantic salmon in the United States, the Gulf of Maine Distinct Population Segment (GOM DPS), exists in several watersheds in Maine.

Atlantic salmon are part of a co-evolved diadromous fish community that together shaped Maine's riverine and lacustrine habitats through connectivity with the ocean (Fay et al. 2006, Saunders et al. 2006). As the returns of Atlantic salmon to Maine's rivers declined, it is likely that some of these ecosystem functions also declined or were lost, including reductions to the primary productivity due to the loss of marine derived nutrients from metabolic waste products, eggs, and carcasses that are incorporated into the local food web in the areas where spawning occurs (Moore et al. 2011, Guyette et al. 2014).

Restoration of the species began in 2003 when MDMR initiated a stocking program in the Sandy River using three life stages of GOM DPS Atlantic salmon. In addition to adult Atlantic salmon returns, which are transported from the Lockwood Project fishlift to the Sandy River and allowed to spawn naturally, MDMR has utilized Penobscot-origin, F2 generation fry and eyed-eggs. For five years, eyed-eggs were raised in streamside incubators and released as fry. Since 2004, eyed-eggs have been deposited in man-made redds in the winter, and allowed to develop and emerge naturally (Table 5). MDMR has continued to stock F2 generation eggs; however, much of the habitat in the Kennebec remains underutilized due to poor adults returns and a limited supply of eggs.

In 2009, the Distinct Population Segment (DPS) of the endangered Atlantic salmon was expanded, and critical habitat was delineated for three Salmon Habitat Recovery Units (SHRUs) within the expanded DPS: the Merrymeeting Bay SHRU, Penobscot Bay SHRU, and Downeast SHRU. The Merrymeeting Bay SHRU includes the Kennebec, Androscoggin, Sheepscot, Pemaquid, Medomak, and St. George watersheds. However, nearly all the high-quality spawning/rearing habitat is in the Kennebec River, specifically in the Sandy River (above 4 hydropower dams),the Carrabassett River, and upper Kennebec River above 6 hydropower dams). Access to this critically important, climate resilient habitat is blocked by all of these mainstem dams.

Because the expanded listing included the Kennebec River, Brookfield Renewable (the indirect parent company of the Licensees of the Lockwood, Hydro Kennebec, Shawmut, and Weston projects) developed Interim Species Protection Plans (ISPPs) that created schedules for constructing upstream fish passage and testing the effectiveness of existing downstream fish passage at the four projects; the ISPPs were incorporated into the project licenses by FERC. Prior to the December 31, 2019 expiration of the ISPPs, Brookfield Renewable consulted with state and federal fishery agencies to develop a Species Protection Plan (SPP) to replace the ISPPs. The SPP was submitted to FERC on December 31, 2020, and was rejected by FERC on July 1, 2020 in response to letters from the resource agencies expressing their lack of support for the SPP. At this time, there is no take permit, no Biological Opinion, no proposed performance, and no reasonable and prudent measures to avoid, minimize, and mitigate project impacts on Atlantic salmon.

In 2019, the Recovery Plan for the Gulf of Maine Distinct Population Segment of Atlantic Salmon (*Salmo salar*) Plan (Recovery Plan) was issued (USFWS and NMFS 2019). The Plan includes abundance, productivity, and habitat criteria that must be met in the SHRUs for reclassification (from endangered to threatened) or delisting to occur. The Recovery Plan includes the following abundance criteria for downlisting of the GOM DPS from endangered to threatened and for delisting the species[2]:

> ***Downlisting:*** The DPS has total annual returns of at least 1,500 adults originating from wild origin, or hatchery stocked eggs, fry or parr spawning in the wild, with at least 2 of the 3 SHRUs having a minimum annual escapement of 500 naturally reared adults.
>
> ***Delisting:*** The DPS has a self-sustaining annual escapement of at least 2,000 wild origin adults in each SHRU, for a DPS-wide total of at least 6,000 wild adults.

The current numbers of wild origin Atlantic salmon that return to Maine rivers are orders of magnitude less than those required to meet ESA recovery standards (Table 5). Data provided by MDMR and restoration partners, represented in the U.S. Atlantic Salmon Assessment Committee (USASAC 2019) reports, indicate severe limitations in freshwater production of “naturally reared” fish that would contribute to meeting recovery goals. The recovery of the entire DPS is reliant on the Kennebec River based on the available habitat in this system compared to other rivers statewide. Restoration of Atlantic salmon populations and connectivity to critical habitat in the Kennebec River drainage, therefore, is of utmost importance to the State of Maine. Providing safe, timely, and highly effective passage on the Kennebec River is essential to meeting recovery goals.

To assess the cumulative impacts of multiple dams on Atlantic salmon recovery, the MDMR developed a deterministic model utilizing the best available data, current research and knowledge of the watershed. The model was used to develop survival goals for upstream and downstream passage at each hydropower facility. Major assumption of the model were generally consistent with NOAA Fisheries Dam Impact Models (Neiland et al. 2013; Neiland and Sheehan 2020), utilized in the Penobscot River, and included:

- The number of salmon smolts produced by the Sandy River, Carrabassett River, and mainstem Kennebec downstream of the Williams Project was estimated from the following equations: low number = habitat units*1.0 smolts/unit (P. Christman, Sheepscot River Monitoring, MDMR) and high number = habitat unit*3 smolts/unit (Legault 2005, Orciari et al. 1994). Habitat units were modeled in 74 FR 23900.
- Downstream migrating smolts experienced natural in-river mortality of 0.0033%/km (Stevens et al. 2019) from the release point in each spawning area to the first dam, between dams, and downstream to the Augusta.

[2] The complete list of criteria to accomplish recovery or delisting can be found in the Recovery Plan.

- Estuarine mortality was 0.00368/km for smolts that had passed no dams; 0.0087/km for fish that passed 2 dams; .0.115/km for fish that passed 4 dams; 0.013 for fish that passed five dams, and 0.0145/km for fish that passed 6 dams (Stevens et al. 2019). The estuary extended from the head-of- tide at Augusta to the outlet of Merrymeeting Bay (The Chops).
- The estimates for marine survival used were Low = 0.5% and High = 4.0%. These estimates for marine survival, from smolt to 2-sea winter adult, were chosen based on tagging studies (Baum, 1983) and returns of hatchery smolts to Maine Rivers (Legault 2005). These estimates do not include river or estuary mortality.
- Smolt mortality ranged from 4% to 1% at each dam.
- Upstream passage efficiency of adults ranged from 95% to 99% at each dam.
- The analysis did not included delays at dams during upstream or downstream passage.

According to the analysis, if portions of the Kennebec River were able to achieve production potential and passage survival at each of the six dams were sufficient, it would be possible to reach MDMR recovery goals. Of the scenarios analyzed, the goal of a minimum of 2000 adults returning to their home waters was possible under the “high” marine survival and “high” freshwater survival (Table 6; Figure 1.). Under “high” marine survival and “low” freshwater survival scenarios, it was also possible to reach a minimum of 500 adults returning to their home waters. In order to reach these minimums, smolt mortality needed to be 1% or less at each of the six dams and upstream efficiency needed to be 99% or better. As dams were removed, the upstream and downstream passage efficiency to reach 500 or 2000 adult returns approached efficiencies that have been documented by field studies.

While this analysis indicates that it may be possible to achieve recovery goals, it’s important to acknowledge the issue of passage delays. Smolts that are emigrating downstream need to reach the estuary in a timely manner due to temperature and physiological processes (McCormick et al. 1998). In addition, it is recognized that adult upstream passage delays can have substantial long-term effects. Adult salmon that spend excessive amounts of time in warm mainstem river waters will deplete fat reserves needed for both the upstream spawning migration and for returning to the ocean the following year (Rand and Hinch 1998; Naughton et al. 2005). Passage delays will need to be minimized in order to achieve recovery goals.

Adults salmon return to Maine’s rivers during summer and can be exposed to high temperature events. High temperature both slows and increases the energetic cost of migration at the expense of energy stores necessary for continued upstream movement and reproduction; if thermal stress is severe, it can result in death (Pörtner and Farrell 2008; Jonsson and Jonsson, Elliott and Elliott 2010; Martins et al. 2015). Migratory delays cause by dams can compound the problem, preventing salmon from reaching suitable thermal refuge habitat necessary to withstand high summer temperatures (Hasler et al. 2012; Frechette et al. 2018). In the Kennebec River, suitable cool water habitat for adults exists only upstream of existing dams in headwater tributaries like the Sandy River. Minimizing delays caused by dams is imperative to ensure that salmon reach thermal refuge habitat in order to maximize the survival of fish and available energy stores for reproduction.

Effectiveness studies demonstrate the difficulty of meeting high performance standards for fish passage, although increased flow may improve survival of downstream migrants. Radio telemetry studies conducted at the Weston, Shawmut, Hydro-Kennebec, and Lockwood projects resulted in baseline survival[3] of downstream migrating Atlantic salmon smolts ranging from 89.5–100%, but only 66-94.5% of smolts successfully passed the projects within 24 hours (Table 7). Because the 93.5% baseline survival at the Shawmut Project was less than the 96% proposed in the ISPP, downstream passage flow was increased from 420 to 650 cfs although no additional testing occurred. Radio telemetry studies conducted at four projects in the Penobscot River resulted in adjusted survivals of 84.0-98.0% after spill had been increased between 20% and 50% of river flow at each station from 8 p.m. to 4 a.m. during the peak two weeks of the outmigration period. In the Kennebec River, upstream passage effectiveness has only been tested at the Lockwood Project. In 2016, 20 wild adult Atlantic salmon that were captured in the fish lift were radio tagged and moved downstream. Sixteen of the 18 that returned to the project area were recaptured (89%), and the time from return to the project area to recapture was 0.7-111.2 days (mean=17 days). When the study was repeated in 2017, 13 of 19 (68%) tagged adult Atlantic salmon that returned to the project area were recaptured, and time to recapture was 3.3-123 days (mean=43.5). Due to the poor results, the study was discontinued. As part of a study of energy consumption, adult Atlantic salmon were captured at the Lockwood fish lift, tagged with thermal radio tags and released downstream of the Project. In 2018, 66.7% of the tagged adults (4 of 6) were recaptured, and the time to recapture was 16-33 days (mean=21.8). The following year, 45.0% of tagged adults (9 of 20) were recaptured, and the time to recapture was 9-30 days (mean=18.7).

The NMFS clearly foresaw the need for high performance standards. The Biological Opinion issued for the ISPPs states: "Data to inform downstream passage survival standards for Atlantic salmon smolts and kelts in the Kennebec and Androscoggin Rivers are very limited. However, given the best available information, it is anticipated that downstream survival standards that will be incorporated in the final SPP will likely need to be between 96% and 100% at each Project. These standards will be refined using information from passage studies that will be undertaken as part of the ISPP. It is possible that the proposed studies will indicate that the interim downstream passage facilities currently in place are not enough to meet the standard and that significant structural and/or operational changes may be necessary to achieve such a high level of survival. The interim period will be used to determine how best to operate or modify the Projects to achieve sufficiently high survival rates. In addition, over the term of the interim period we and/or the licensee will develop a model for the Androscoggin and Kennebec Rivers to provide data that will be used to inform the development of upstream and downstream performance standards."

5.2 American Shad (*Alosa sapidissima*)

The American shad is a highly migratory, pelagic, schooling species that ranges along the east coast of North American from Newfoundland to Florida (Colette and Klein-MacPhee 2002; Scott and Crossman 1973). Populations of American shad that spawn north of Cape Hatteras are iteroparous (repeat spawners). American shad return to their natal rivers to spawn, predominately at 5 and 6 years of age New England, and spawning begins at water temperatures

[3] The baseline rate does not consider amount of time to pass the project. The adjusted survival is calculated from fish that passed a project within 24 hours.

ranging from 18 to 25°C. Spawning sites are associated with hydrographic parameters (high current velocity, high dissolved oxygen, and shallow depth), physical habitat features (increasing sediment size and woody debris), and the presence of a forested shoreline (Bilkovec et al. 2004). In the Connecticut, which supports the largest American shad run on the east coast of the United States, year-class strength is determined during the larval emergence stage and is significantly correlated with mean river discharge, water temperature, and total monthly precipitation (Crecco et al 1983; Crecco and Savoy 1984; Crecco and Savoy 1985).

The goal of the 1993 Plan was to restore American shad to their historical range in the Kennebec River and achieve an annual production of 725,000 American shad above Augusta (i.e. above Edwards Dam). American shad historically ascended the Kennebec River to rkm 157, the Sandy River to rkm 75, and the Sebasticook River to rkm 51 (Table 2). Restoration of American shad began in 1987 with the signing of the first KHDG settlement agreement (Table 1), which provided funds for restoration in exchange for delays in upstream fish passage. Between 1987 and 1997, MDMR stocked millions of American shad fry and thousands of fingerlings and adults above the Edwards Dam (Table 8).

This Kennebec River Amendment provides reach by reach (dam to dam) production targets for adult American shad that were not included in the 1993 Plan. Production targets are based on accessible and potentially accessible spawning/nursery habitat area and the most recent determination of adult production per unit of habitat area (CRASC 2017), a method commonly used in other American shad plans and studies in the Connecticut River (CRASC 2017), Susquehanna River (SRAFRC 2010), and Penobscot River (MDMR and MDIFW 2008). The targets were calculated as: number of adult American shad = (habitat surface hectares)*(203 adults/hectare).

The Kennebec River watershed contains approximately 2,508 hectares of American shad riverine spawning/nursery habitat that was historically accessible (Table 2; Table 3). The majority of the habitat (59.6%) is above the Lockwood Dam, while 20.9% lies between the head-of-tide (site of former Edwards Dam) and the Lockwood Dam, and 19.5% is in the Sebasticook River (Table 3). Removal of Edwards Dam was an important step in enhancing the American shad population, but access to habitat above the Lockwood dam is clearly necessary to reach production and distribution goals. MDMR estimates that the habitat above the Lockwood Project could produce at least 303,500 American shad.

Restoration of American shad above the Lockwood Project has not been successful. As described in section 2.3, the trigger for converting the interim upstream passage facility at the Lockwood Project to a permanent one – the capture of 8,000 American shad in any single season – was never met. Since the interim fish lift became operational in 2006, only 1,413 adult American shad have used it (Table 4). Attempts to determine why so few American shad use the Lockwood fish lift have failed. In 2015, the Licensee in consultation with the agencies, conducted a sound study, a 2D hydraulic modeling study, and a radio telemetry study. Interestingly, adult American shad used in the telemetry study were angled by recreational fishermen in the tailrace (Figure 2, Event 1, and Event 2 and 3), but none of the tagged American shad were detected near the fishway entrance.

There are multiple examples of hydropower projects equipped with upstream and downstream fish passage that are not effective for passing American shad. Restoration has stalled due to the small numbers of American shad that annually pass upstream at the lowermost barrier on the Kennebec River (0-830; mean=108) and the Androscoggin River (0-1,096; mean=23). The number of American shad passing the east and west channel dams on the Saco River in 27 years has been marginally better (399-16,435; mean = 2,836), but most are trucked past the next pair of dams (Springs and Bradbury) because the two passage facilities collectively pass < 5% of the arriving American shad. On the Merrimack River, an average of 17% of the American shad that passed the first barrier successfully also passed the second barrier (Sprankle 2004). The mean passage efficiencies for American shad migrating upstream through fishways from the first dam to the spawning grounds were less than 3% on the Susquehanna River, Connecticut River, and Merrimack River (Brown et al. 2013). Survival of adult American shad migrating downstream at four hydropower dams in the Penobscot River ranged from 76.6-94.7% (75% CI of 71.1-97.9%) with 27-80% of migrants passing within 48 hour (BREG 2018; BREG 2019). Migration delays caused by fishways or trapping facilities need to be considered because they can limit spawning success and the number of repeat spawning adults (Castro-Santos & Letcher, 2010).

Computer models have been utilized as an efficient method of assessing the effects of various upstream and downstream passage efficiencies (percent passed and time to pass) on population abundance, persistence, and age structure. Exelon (2012) developed an American shad passage model for the Susquehanna River, but it did not include a time-to-pass metric. Stich et al. (2018) developed a stochastic, life-history based, simulation model for the Penobscot River and found that the probability of achieving management goals (total spawner abundance, distribution to upstream habitat, and percentage of repeat spawners) was greatest with high downstream passage efficiency, minimal migration delays at dams, and high upstream passage efficiency. The Stich et al. (2018) model was modified to develop performance standards for the Connecticut River projects (CRASC 2020) and is currently being used to develop performance standards for American shad in the Kennebec River. The standards developed for the Penobscot, Connecticut, and Susquehanna rivers are surprisingly similar (Table 9): to maintain a population of multi-age spawners requires a minimum downstream passage efficiency of 80 to 98% with fish passing within 24-48 hrs and a minimum upstream passage efficiency of 75-80% with fish passing within 24-48 hrs. Until such time that the Kennebec River can be modeled and a number of scenarios analyzed[4], we will use standards for the Connecticut River.

5.3 Blueback herring (*Alosa aestivalis*)

The blueback herring is an anadromous, highly migratory, pelagic, schooling fish found along the east coast of North America from Cape Breton, Nova Scotia and the Bay of Fundy watershed, New Brunswick, to Florida in the United States (Scott and Crossman 1973; Colette and Klein-MacPhee 2002). Blueback herring are iteroparous, returning to their natal rivers to spawn predominantly between the ages of 4 and 5. Spawning occurs in flowing water over hard substrates and is initiated at water temperatures between 10-15°C.

The 1993 Plan did not include specific goals for blueback herring, because little was known about its distribution and abundance in the Kennebec River at the time. The Kennebec River

[4] Dr. Stich is developing the Kennebec River model, which must be run on a supercomputer due to its complexity.

Amendment provides reach by reach (dam to dam) production targets for adult blueback herring. Production targets are based on accessible and potentially accessible spawning/nursery habitat area and the most recent determination of adult production per unit of habitat area, a method commonly used for American shad and alewife. The unit production was estimated from the number of blueback herring passed at the Benton Falls and the amount of upstream habitat that was available. The targets were calculated as: number of adult blueback herring = (habitat surface hectares)*(1,196 adults/hectare).

The Kennebec River watershed contains approximately 2,508 hectares of blueback herring riverine spawning/nursery habitat that was historically accessible (Table 2; Table 3). The majority of the habitat (59.6%) is above the Lockwood Dam, while 20.9% lies between the head-of-tide (site of former Edwards Dam) and the Lockwood Dam, and 19.5% is in the Sebasticook River (Table 3). Removal of Edwards Dam was an important step in enhancing the blueback herring population, which naturally recolonized the reach between Augusta, the Lockwood Dam, and the Fort Halifax Dam. The population rapidly expanded in the Sebasticook River after the removal of Fort Halifax with over one million adults being passed annually at Benton Falls from 2017-2019 (Table 4. Blueback herring began using the fish lift at the Lockwood Project soon after it became operational in 2006 (Table 4). However, free access to habitat above the Lockwood dam is clearly necessary to reach production and distribution goals. MDMR estimates that the habitat above the Lockwood Project could produce at 2 million blueback herring.

Currently no models have been developed to analyze the effects of upstream and downstream passage efficiency and time-to-pass on blueback herring populations.

5.4 Alewife (*Alosa pseudoharengus*)

The alewife is an anadromous, highly migratory, pelagic, schooling fish found along the east coast of North America from Newfoundland to North Carolina (Scott and Crossman 1973; Colette and Klein-MacPhee 2002). Alewife are iteroparous, returning to their natal waters to spawn, predominantly between the ages of 4 and 5. Alewife typically spawn in lakes and ponds, and spawning is initiated at water temperatures between 10-22° C.

One goal of the 1993 Plan was to achieve an annual production of 6.0 million alewives above Augusta. The 1993 Plan (Table 16; Table 17) identified 20 lakes and ponds above Augusta (totaling 24,606 acres); 15 lakes and ponds below Augusta primarily in the Cobbosseecontee Stream drainage (totaling 13,077 acres), and 8,154 acres of tidal freshwater as historical alewife spawning habitat. The 1993 Plan provided reach by reach (dam to dam) production targets for adult alewife that were based on historically accessible spawning/nursery habitat area and an adult production per unit of habitat area. At the time, MDMR used 235 adults/acre as the unit production, which was the average minimum production of 6 harvested populations for the period 1971-1983 when the fishery was closed one day per week. Recent analysis of data for 7 harvested runs for the period 2005-2017 (with three closed days per week) and reanalysis of the 1971-1983 data has resulted in an average production of 400 adults/acre. The average production in the Kennebec River Amendment were calculated as: number of adult alewife =

(habitat surface acres)* (400 adults/acre) or in metric units number of adult alewife = (habitat surface hectares)*(988.4 adults/hectare).

Restoration of alewife to the Kennebec River began in 1987 with the signing of the first KHDG settlement agreement. With funds from the settlement, MDMR stocked approximately 1.3 million adult alewife into 9 inaccessible lakes and ponds from 1987 through 2006 (Table 4). In 2006, six ponds in the Sebasticook River drainage became accessible due to the removal of Edwards Dam, the installation of upstream fish passage at the Benton Falls, the Burnham project, and three non-hydropower dams, and the removal of one non-hydropower dam (Table 1). After the Fort Halifax Dam was removed, the alewife population migrating up the Sebasticook River expanded significantly (Table 4). Upstream passage into Webber Pond on Seven-Mile Stream has produced an alewife population. Alewives returning to the mainstem of the Kennebec River have increased in number, but the population is maintained by stocking.

The new fish passage facility at the Hydro Kennebec Project and the facilities proposed for the Lockwood, Shawmut, and Weston projects will need to tested for their effectiveness in passing multiple species and life stages, including adult and juvenile alewife. In the Kennebec River Amendment we propose performance standards by which to evaluate the results of the testing. The standards were developed using a newly available alewife population model[5] that was developed to compare theoretical spawner abundance between scenarios with different dam passage rates. This type of model defines inputs using averages applied to groups and is used to explore general trends and compare the results of scenarios when different average values are used as inputs. The basic structure and inputs of the original model have been described in Barber et al. (2018); the same information and the R code is annotated at the web site.

In order to achieve a minimum number of spawners (608,200 adult alewife) to historic habitat in the Kennebec River, upstream and downstream passage of adults and juveniles at each of the four dams would need to be at least 92% effective (Figure 3). If Shawmut Dam was removed upstream and downstream passage of adults and juveniles at each of the three would need to be at least 88% effective (Figure 3). Because adult alewife have limited energy stores, time to pass as each dam should be minimized.

5.5 Sea lamprey (*Petromyzon marinus*)

The goal for sea lamprey is to restore access for the species to historic spawning and nursery habitat. Because restoration of this species as not considered in the 1993 Plan, a more complete description of the species biology, ecology, and fish passage requirements are included here and in the Kennebec River Amendment.

The sea lamprey is an anadromous, semelparous, species that ranges in the wester Atlantic Ocean from the St. Lawrence River in Canada to the State of Florida in the United States (Scott and Crossman; Colette and Klein-MacPhee 2002). Unlike the other diadromous species native to Maine, there is no evidence that sea lamprey home to their natal river system (Kircheis 2004). The species is an important component of the riverine ecosystem in Maine that, like other sea run

[5] The model is available at https://umainezlab.shinyapps.io/alewifepopmodel/

fish species, has been prevented from reaching much of its historic range by barriers to upstream passage. Restoring sea lamprey to their historic range within the state is considered to be beneficial for the restoration and recovery of other sea run fish, particularly endangered salmon (Kircheis 2004). MDMR's goal is to restore sea lamprey to historic habitat above the Lockwood Dam.

In watershed unrestricted by dams, sea lamprey are capable of reaching small, high-gradient, headwater streams (Nislow and Kynard 2009). They spawn in gravel-cobble substrate, and the spawning process results in streambed modification and sediment transport (Nislow and Kynard 2009; Sousa et al. 2012; Hogg et al. 2016). Lamprey spawning activities condition the habitat for other species, including Atlantic salmon, by removing fines and reducing substrate embeddedness (Kircheis 2004). Given the high degree of embeddedness in Maine streams due to past land use practices, the role of lamprey as "ecosystem engineers" is particularly important (Kircheis 2004; Sousa et al. 2012). Detection of a radio-tag from a sea lamprey at Brownsville on the Pleasant River (a tributary of the Penobscot River) in August 2020 indicates that two dam removals, installation of a fish lift that is operated day and night, and installation of a nature-like fishway at a decommissioned hydropower project has positive impacts on lamprey migratory range (MDMR, unpublished data).

Anadromous sea lampreys also serve as a conduit of nutrients between marine and freshwater systems. Semelparous adults contribute marine derived nutrients (MDN) to rivers, whereas filter-feeding ammocetes, (the juvenile life stage that spends up to eight years in stream sediments), break down terrestrially derived nutrients in streams, and eventually export nutrients into the marine environment (Beamish 1980, Kircheis 2004; Nislow and Kynard 2009; Weaver et al. 2018). Atlantic coastal streams are generally considered to be phosphorus-limited, although Sedgeunkedunk Stream in Maine was found to be both nitrogen and phosphorus limited (Weaver et al. 2016). Nislow and Kynard (2009) demonstrated that sea lamprey contributed phosphorus to a Connecticut River tributary at levels as great as 0.26 gm^{-2}. Sea lamprey spawning occurs in late spring and early summer, thus pulses of MDN from post-spawn lamprey carcasses occur after canopy formation reduces light penetration to the stream and concurrent with the emergence of macroinvertebrates and Atlantic salmon fry (Beamish 1980; Nislow and Kynard 2009; Weaver et al. 2015, 2016). Consequently, the influx of nutrients may help support stream food webs during a time when nutrients and energy flow might otherwise be limiting (Weaver et al. 2016). Further, sea lamprey are the sole semelparous species among the complex of sea run species that spawn in Maine's rivers. Gametes and metabolic waste from iteroparous species, such as Atlantic salmon, river herring, and shad do serve as a source of MDN, but carcasses of semelparous species are generally a more important source of nutrients, highlighting the importance of providing lamprey passage into critical habitat areas (Moore et al. 2011; Nislow and Kynard 2009).

Sea lamprey spawning in Maine begins in late May and extends into early summer and peaks at water temperatures of 17-19˚C (Kircheis 2004). During the years 2014-2020, the earliest recorded sea lamprey was counted at the Milford Dam fish lift (Penobscot River) on 7 May (205 and 2016); lamprey have been recorded at Milford as late as 6 July (MDMR unpublished data). Lamprey on the Westfield River have been observed as early as 14 April during the years 2005 to 2019 (Caleb Slater, Massachusetts Division of Fisheries and Wildlife. Pers. Comm.

Westborough, MA). For the years 1978-2018, lamprey were recorded at the Rainbow Dam fishway on the Farmington River, (a tributary of the Connecticut River) as early as 16 April (mean start date of 29 April) and as late as July 11 (mean end date of 24 June; CT DEEP Fisheries Division, unpublished data, Old Lyme, CT). Given the long distances that sea lamprey must travel to reach spawning grounds while temperatures are favorable for spawning, we recommend that a sea lamprey passage season should begin no later than May 1 and extend to July 30. As more information becomes available, this season can be adjusted.

On the Connecticut River, Castro-Santos et al. (2016) reported that 64% of entries into fish passage structures occurred at night (i.e., between sunset and sunrise); in fact, entry rates were as much as 24.4 times greater at night. In a study on the River Mondego, (Portugal), Pereira et al. (2016) found that most detections of sea lamprey in a vertical-slot fish pass occurred at night, i.e., between dusk and dawn (88% in 2014 and 75% in 2015). Data from fish passage facilities in Connecticut indicate that in the early part of the upstream migration period, lamprey enter fish passes exclusively at night. As the run progresses, however, lamprey may enter at any time (Steve Gephard, CTDEEP Fisheries, pers. comm. Old Lyme, CT). At the Westfield River fish passage facility in Massachusetts, nearly all lamprey pass at night (Caleb Slater, Massachusetts Division of Fisheries and Wildlife. Pers. Comm. Westborough, MA). In 2020, lamprey passage occurred primary in the evening hours at the Milford fish lift, with some passage occurring in the early morning (e.g. 1am EST) (MDMR, unpublished data). Given the strong propensity for lamprey to exhibit nocturnal movement patterns, fishways, including fish lifts, should be operated at night to allow for lamprey passage.

On the Connecticut River, the combined passage percentage for sea lamprey at Turner’s Falls was 46.7%, whereas fish pass entry was 64.1% of tagged individuals (Castro-Santos et al. 2016). This is comparable to entry rates for Pacific lamprey at Bonneville (67%) and McNary Dams (61%) on the Columbia River (Johnson et al. 2012; Keefer et al. 2013a; 2013b). At Turner’s Falls, failure to pass was predominantly associated with the fish pass entrance, so concerted improving ability for lamprey to enter fish ladders is likely to be a key aspect of ensuring overall passage success (Castro-Santos et al. 2016). Passage efficiency for a vertical-slot fish pass on the River Mondego, (Portugal), was determined to be 33% via PIT telemetry and 31% via radio-telemetry (Pereira et al. 2016). In 2020, 50 radio tagged sea-lamprey passed the Milford fish lift on the Penobscot River at 81% (MDMR, unpublished data).

Sea lamprey metamorphize as juveniles and swim downstream to feed in the ocean in the late fall and spring (Kircheis 2004). General movement is thought to occur at nighttime and during high flow events (Kircheis 2004). Given their small size at 100 mm to 200 mm (Kircheis 2004), turbine entrainment is possible without appropriately sized exclusion screening or other measures to bypass outmigrating sea lamprey.

5.6 American Eel (*Anguilla rostrata*)

The American eel was not included in the 1993 Plan. Therefore, a more complete description of the species biology, ecology, and fish passage requirements are included in this amendment.

The American eel is a highly migratory, semelparous, facultative catadromous species that spends most of its life in freshwater or estuarine environments then migrates to the Sargasso Sea as an adult to reproduce and die (Collette and Klein-MacPhee 2000; Shepard 2015). Because all adult eels from the entire range of the species come together in one place and reproduce, the American eel population is considered a panmictic (single) spawning population. The larval eels (leptocephali) are transported by ocean current to the west and to the north by the Gulf Stream. The leptocephali metamorphose into glass eels as they migrate toward land. Glass eels become pigmented stage as they move into brackish or freshwater and are called elvers (<6 inches) or yellow eels (>6 inches). Yellow eels inhabit fresh, brackish, and saltwater habitats where they feed primarily on invertebrates and smaller fishes. When they become sexually mature (<8 to 27 years old in Maine), they migrate to the Sargasso Sea to spawn.

The timing of the American eel migrations in Maine' waters is well-known from commercial harvests and MDMR monitoring. Upstream migrations generally begin earlier in the western part of the state and downstream migrations generally begin earlier in the upper reaches of a watershed. The upstream migration of glass eels is considered to occur from March 15- June 15. The upstream migration season for elvers and yellow eels is June 1-September 30. MDMR analyzed historical silver eel harvest data (pounds per day) provided by commercial fishermen for seven sites in the Kennebec River watershed to determine whether the current shut down period is sufficient. The percent by weight of downstream migrating silver eels caught by month were July (0.6%) August (16.5%), September (62.7%) , October (19.1%) and December (1.1%). Approximately 94% of the eels were caught between August 15 and October 31. Migration mostly occurs at night although glass eels may occasionally move during the day.

Like anadromous species, the abundance of American eel has declined, and the decline has been attributed in part to dams, overfishing, and poor water quality. The species has been considered for listing under the ESA twice, but the USFWS determined in both cases that listing was not warranted at the time. The Atlantic States Marine Fisheries Commission (ASMFC) recently completed a stock assessment for American eel (ASMFC 2012), which used trend analyses and Depletion-Based Stock Reduction Analysis, and concluded the stock status is depleted. Two years later Addendum IV reduced the commercial harvest of all life stages of American eel (ASMFC 2014).

6. Term and Conditions Introduction

Eleven diadromous fish species are found in the Kennebec River watershed. These include spawning populations of the endangered shortnose sturgeon, Gulf of Maine Distinct Population Segment (GOM DPS) of Atlantic sturgeon, and GOM DPS of Atlantic salmon. The Kennebec River from its mouth to the Lockwood Project is designated as critical habitat for the GOM DPS of Atlantic sturgeon. The Kennebec River from its mouth to the Anson Project and the Sandy River are designated as critical habitat for the GOM DPS of Atlantic salmon. The Kennebec River supports spawning populations of the recreationally or commercially important American shad, blueback herring, alewife, striped bass, rainbow smelt, Atlantic tomcod, and sea lamprey and provides growth/foraging habitat for the catadromous American eel, which supports a lucrative commercial fishery.

7. Goals and Objectives

MDMR is a cabinet level agency of the State of Maine. MDMR was established to regulate, conserve, and develop marine, estuarine, and diadromous fish resources; to conduct and sponsor scientific research; to promote and develop marine coastal industries; to advise and cooperate with state, local, and federal officials concerning activities in coastal waters; and to implement, administer, and enforce the laws and regulations necessary for these purposes. MDMR is the lead state agency in the restoration and management of diadromous (anadromous and catadromous) species of fishes. MDMR's policy is to restore Maine's native diadromous fish to their historical habitat.

Our recommendations, terms and conditions are guided by the following state, interstate, and federal comprehensive management plans that have been approved by the Commission.

7.1 The Kennebec River Resource Management Plan[6]

Pertinent goals of the 1993 Plan are:

1. To restore and enhance populations of shortnose sturgeon, Atlantic sturgeon, striped bass, and rainbow smelt to historical habitat in the Kennebec River including the segment from Edwards Dam to the Milstar Dam (Lockwood Project) in Waterville by removing Edwards Dam.
2. To restore and enhance American shad populations in the Kennebec River by achieving an annual production of 725,000 shad above Augusta.
3. To restore and enhance alewife populations in the Kennebec River by achieving an annual production of 6.0 million alewives above Augusta.

7.2 Recovery Plan for the GOM DPS of Atlantic Salmon

The *Recovery Plan* identified dams, inadequacy of regulatory mechanisms related to dams, and low marine survival as major threats to the recovery of Atlantic salmon (USFWS and NMFS

---

[6] MDMR is writing an Amendment to the 1993 Plan.

2019). The plan contains the following criteria for reclassification or delisting of the Gulf of Maine Distinct Population Segment (GOM DPS) of Atlantic salmon:

Biological Criteria for Reclassification of the GOM DPS from endangered to threatened will be considered when all of the following biological criteria are met
1. Abundance: The DPS has total annual returns of at least 1,500 adults originating from wild origin, or hatchery stocked eggs, fry or parr spawning in the wild, with at least 2 of the 3 SHRUs[7] having a minimum annual escapement of 500 naturally reared adults.
2. Productivity: Among the SHRUs that have met or exceeded the abundance criterion, the population has a positive mean growth rate greater than 1.0 in the 10-year (two-generation) period preceding reclassification.
3. Habitat: In each of the SHRUs where the abundance and productivity criterion have been met, there is a minimum of 7,500 units of accessible and suitable spawning and rearing habitats capable of supporting the offspring of 1,500 naturally reared adults.

Biological Criteria for Delisting of the GOM DPS will be considered when all of the following criteria are met:
***1. Abundance*:** The DPS has a self-sustaining annual escapement of at least 2,000 wild origin adults in each SHRU, for a DPS-wide total of at least 6,000 wild adults.
2. Productivity: Each SHRU has a positive mean population growth rate of greater than 1.0 in the 10-year (two-generation) period preceding delisting. *In addition*, at the time of delisting, the DPS demonstrates self-sustaining persistence, whereby the total wild population in each SHRU has less than a 50-percent probability of falling below 500 adult wild spawners in the next 15 years based on population viability analysis (PVA) projections.
3. Habitat: Sufficient suitable spawning and rearing habitat for the offspring of the 6,000 wild adults is accessible and distributed throughout the designated Atlantic salmon critical habitat, with at least 30,000 accessible and suitable Habitat Units in each SHRU, located according to the known migratory patterns of returning wild adult salmon. This will require both habitat protection and restoration at significant levels.

Dams and road stream crossings (factor A): A combination of dam removals, passage improvements at dams, passable road crossing structures, and removal or redesign of any other instream barriers to fish passage provides salmon access to sufficient habitat needed to achieve the habitat criterion for reclassification

Dams (factor A): Upstream and downstream passage at dams deemed essential to the conservation of Atlantic salmon are improved by dam removal and/or through operational or structural changes. Dam removals and structural changes must provide access to spawning and nursery habitats (freshwater habitat that is categorized as accessible or fully accessible habitat will be counted toward meeting this recovery criterion), reduce direct and indirect mortality of

[7] In 2009, the Distinct Population Segment (DPS) of the endangered Atlantic salmon was expanded, and critical habitat was delineated for three Salmon Habitat Recovery Units (SHRUs) within the expanded DPS: the Merrymeeting Bay SHRU, Penobscot Bay SHRU, and Downeast SHRU. The Merrymeeting Bay SHRU includes the Kennebec, Androscoggin, Sheepscot, Pemaquid, Medomak, and St. George watersheds.

upstream and downstream migrating salmon, and provide for properly functioning critical habitat features.

7.3 ASMFC Plans

The Atlantic States Marine Fisheries Commission (ASMFC) is an Interstate Compact, ratified by the member states and approved by the U.S. Congress in 1942, to manage the states' shared migratory fishery resources and to cooperate in promoting and protecting Atlantic coastal fishery resources. Maine is an active member of ASMFC, and MDMR scientists represent the State on the Shad and River Herring Technical Committee and the American Eel Technical Committee.

Pertinent goals and objectives of the Shad and River Herring Fishery Management Plan (ASMFC 1985) are to:

- Improve habitat accessibility and quality, including addressing fish passage needs at dams and other obstructions, improving water quality, addressing river flow allocations to support habitat needs, and preventing mortality at water withdrawal facilities.
- Initiate stocking programs in historical alosine[8] habitat that do not presently support natural spawning migrations, expand existing stock restoration programs, and initiate new programs to enhance depressed stocks.

Pertinent goals and objectives of the American Eel Fishery Management Plan (ASMFC 2000) are to:

- Protect and enhance the abundance of American eel in inland and territorial waters of the Atlantic states.
- Contribute to the viability of American eel spawning populations.
- Protect and enhance American eel abundance in all watersheds where eel now occur.
- Where practical, restore American eel to those waters where they had historical abundance but may now be absent by providing access to inland waters for glass eel, elvers, and yellow eel and adequate escapement to the ocean for pre-spawning adult eel.

8. Project description

8.1 Project Location

The Shawmut Project is an existing hydropower facility located in the Kennebec River in the towns of Skowhegan, Fairfield, Clinton, and Benton and in Kennebec County and Somerset County, Maine. It is the third of 10 FERC licensed dams on the main stem Kennebec River. In ascending order, the projects are Lockwood, Hydro Kennebec, Shawmut, Westin, Abenaki, Anson, Williams, Wyman, Moxie, and Moosehead.

8.2 Project description

The Shawmut Project consists of a concrete gravity dam, an enclosed forebay, an intake and headworks section, and two powerhouses. The dam is approximately 1,480-feet long and

[8] Alosine refer to fish in the Genus *Alosa*, such as American shad, alewife and blueback herring.

includes, from west to east, a non-overflow section adjacent to the forebay headworks structure, 380 feet of 4-foot high hinged flashboards, a 25-foot wide sluice, and a 730-foot long section topped with 3 sections of inflatable bladder, each 4.46-feet high. The headworks and intake structure are integral to the dam. The forebay intake section contains 11 headgates fitted with trash racks and 2 filler gates. The forebay is enclosed by 2 powerhouse structures. The intake section of the northern 1912 powerhouse (Units 1-6) has six openings and a continuous trash rack with 1.5-inch clear spacing which extends from elevation 115.0 ft down to elevation 88.0 ft. The southern 1982 powerhouse (Units 7 and 8) has 2 intakes, each fitted with a trash rack with 3.5-inch clear spacing that extends from elevation 115.25 ft to 88.0 ft. A 10-foot-high by 7-foot-wide Tainter gate and a 6-foot-high by 6-foot-wide deep gate lie between the two powerhouses. A narrow, angled strip of ledge/land (about 460-feet total length) separates the tailraces of the two powerhouses. The 1912 powerhouse contains six horizontal, four-runner, Francis-type turbines each with a hydraulic capacity of 674 cfs. The 1982 powerhouse contains two horizontal tube-type hydraulic turbines each with a hydraulic capacity of 1,200 cfs.

8.3 Project operation

According to the FLA, the Shawmut Project operates as a run-of-river facility and the impoundment experiences little fluctuation during normal operations, maintaining the pond level within a foot of the normal full pond elevation of 112.0 feet U.S. Geological Survey (USGS) datum. After maximum powerhouse capacity (6,690 cfs) is reached, excess water is spilled through the spillway sluice (capacity is 1,840 cfs). When flow exceeds the capacity of the spillway sluice, sections of the rubber dam are deflated, and the hinged flashboards are dropped, to pass additional water. The project units and spillway can pass approximately 40,000 cfs while maintaining a pond elevation of approximately 112.0 ft.

8.4 Project fishways

The Shawmut Project fishways are described in detail in Section 3.4 (page 6). Briefly, the Project currently provides downstream fish passage for diadromous fish and upstream passage for juvenile (yellow) American eel. The effectiveness of existing downstream passage has only been tested for Atlantic salmon smolts (2013-2015) and adult American eels (2014-2015).

8.5 Fish resources historical and current

The 1993 Plan contained detailed information about the biology, historical range, and historical and current (in 1993) fisheries for Atlantic salmon, American shad, blueback herring, alewife, rainbow smelt, shortnose sturgeon, Atlantic sturgeon, and striped bass in the Kennebec River. Section 4 of this document includes current information about the status of Atlantic salmon, American shad, blueback herring, and alewife and two additional species, American eel and sea lamprey, that were not included in the 1993 Plan.

The Kennebec River, Maine’s second largest drainage, historically supported large populations of the State’s native anadromous species, which began to decline dramatically throughout Maine in the 1800s. In 1867, the Governor appointed two Commissioners of Fisheries under a legislative resolve to restore anadromous fish to the rivers and inland waters of the state. The

Commissioners surveyed the fisheries in Maine's major river systems and concluded in their first report that the decline of anadromous species was caused by impassable dams, overfishing, and pollution of the water (Foster and Atkins 1867; Atkins 1887).

The Shawmut Project is located within the documented or presumed historical range of Atlantic salmon, American shad, blueback herring, alewife, American eel, and sea lamprey (Table 2). Foster and Atkins (1868) and Akins (1887) stated that the original upstream limit of Atlantic salmon on the mainstem Kennebec River probably was about 12 miles above the Forks (confluence of the Kennebec and Dead River) and at Grand Falls on the Dead River. They further stated that Atlantic salmon ascended many miles in the Carrabassett River and the Sandy River, and these two river probably were their principal spawning grounds. Foster and Atkins (1868) and Akins (1887) reported that alewife and American shad ascended as far upstream as Norridgewock Falls, current location of the Abenaki and Anson projects, and into the lower part of the Sandy River. Blueback herring likely had the same range as the closely related alewife and American shad. The historic upstream limit of American eel and sea lamprey is not precisely known, but American eels currently are found in the Williams Project impoundment.

When the Shawmut Project was licensed on January 5, 1981, the five anadromous species had been extirpated from significant amounts of historic spawning/nursery habitat in the Kennebec River watershed for more than 140 years due to the presence of hydropower dams without fish passage. The catadromous American eel was still found throughout the watershed, although dams may have reduced their abundance compared to pre-colonial times.

MDMR has made significant progress in the restoration of anadromous fish to some parts of the Kennebec River in the intervening years. The removal of Edwards Dam in 1999 allowed shortnose sturgeon, Atlantic sturgeon and striped bass free access to all their historic habitat on the mainstem of the Kennebec River), allowed American shad and blueback herring free access to about 21% of their historic spawning habitat (Table 1, Table 2), and the reach now supports the greatest abundance and biomass of American eel above the head-of-tide (Yoder et al 2006).

Section 10(a) Consistency with Comprehensive Plans

Recommendation #1

As a state agency responsible for managing diadromous fish and their habitat, MDMR recommends that the Shawmut Project be decommissioned and removed. This recommendation is consistent with multiple comprehensive plans, our management goals and activities, and analysis of river-specific data. MDMR finds that the cumulative impacts of the four lowermost hydropower projects in the mainstem Kennebec River, including the Shawmut Project will result in significant adverse impacts on the recovery of endangered Atlantic salmon and on the restoration of alewife, blueback herring, American shad, sea lamprey, and American eel to their historic habitat in the Kennebec River.

Justification

Our section 10(a) recommendation for decommissioning and removal is consistent with the following Commission approved comprehensive plans for Maine:

- Maine State Planning Office. 1993. Kennebec River Resource Management Plan.
- Atlantic States Marine Fisheries Commission. 1999. Amendment 1 to the Interstate Fishery Management Plan for shad and river herring.
- Atlantic States Marine Fisheries Commission. 2009. Amendment 2 to the Interstate Fishery Management Plan for shad and river herring.
- Atlantic States Marine Fisheries Commission. 2010. Amendment 3 to the Interstate Fishery Management Plan for shad and river herring.
- Atlantic States Marine Fisheries Commission. 2000. Interstate Fishery Management Plan for American eel (*Anguilla rostrata*).
- Atlantic States Marine Fisheries Commission. 2008. Amendment 2 to the Interstate Fishery Management Plan for American eel.
- Atlantic States Marine Fisheries Commission. 2013. Amendment 3 to the Interstate Fishery Management Plan for American eel.
- Atlantic States Marine Fisheries Commission. 2014. Amendment 4 to the Interstate Fishery Management Plan for American eel.
- U.S. Fish and Wildlife Service and NMFS. 2019. Recovery plan for the Gulf of Maine Distinct Population Segment of Atlantic salmon (*Salmo salar*).

These comprehensive plans consider the economic and social value of diadromous fish for the public, and they collectively recognize the reduced abundance and reduced distribution of these species from habitat loss. The Comprehensive Plans all point to barriers (e.g. dams) that prevent these species from being able to migrate between growth habitat and spawning/nursery habitat in order to complete their life cycle. The Recovery Plan (USFWS and NMFS 2019) states that dam removal might be necessary for the reclassification or delisting of the endangered Atlantic salmon. The 1993 Plan[9] (MSPO 1993) recommended the removal of Edwards Dam to restore and enhance populations of shortnose sturgeon, Atlantic sturgeon, striped bass, and rainbow smelt to historical habitat in the Kennebec River.

Removal of Shawmut Dam would eliminate direct project impacts and reduce cumulative impacts on indigenous diadromous species in the Kennebec River. These impacts include mortality and injury of adults and juveniles, migratory delays, reduced river productivity, thermal alteration, water quality impairment, predation due to impoundment, reductions in nutrient and energy exchange between freshwater and marine ecosystems, alteration of the natural hydrologic regime, and restriction to sediment and organic material transfer. MDMR's analysis has shown that self-sustaining populations of diadromous fish, especially the endangered Atlantic salmon, are possible in the Kennebec River, now or in the future, only if very high-performance standards for fish passage are consistently achieved at each of the mainstem project dams. MDMR's review of effectiveness studies conducted in Maine demonstrates that our recommended performance standards may not be achievable.

The Licensee commissioned a study, *Energy Enhancements and Lower Kennebec Fish Passage Improvements Study* (Feasibility Study), for stakeholder review and comment on May 20, 2019

[9] The Kennebec River Management Plan is in the process of being amended.

FERC Accession #s 20190701-5155 and 20190701-5154). The Feasibility Study considered several fish passage options, one being dam removal, for the Shawmut, Lockwood, and Weston projects. Removal of the Shawmut Dam was determined to be feasible and reasonably practical. Therefore, this recommendation should be given full consideration.

In our 10(j) Terms and Conditions for the Shawmut Project, MDMR has recommended new upstream and downstream fish passage facilities capable of passing Atlantic salmon, American shad, blueback herring, alewife, sea lamprey, and American eel. In developing performance standards for assessing the effectiveness of the new facilities, we have determined that passage efficiency needs to be nearly perfect to protect the endangered Atlantic salmon – a minimum of 99% upstream and downstream passage effectiveness with minimal delays (48 hours upstream and 24 hours downstream). We are not aware of any man-made fish passage facilities that consistently achieve this level of efficiency for any species (e.g. Table 7), including projects designed and operated using USFWS Fish Passage Criteria (USFWS 2019). We propose performance standards for assessing the facilities for American shad. At this time no standards have specifically been developed for the Kennebec River. Therefore, we have adopted standards from the Connecticut River, a minimum of 90% downstream within 24 hours and 75% upstream within 48 hours. We also propose performance standards for upstream sea-lamprey passage at 80% and within 48 hrs., which is a conservative standard achieved this spring/summer at Brookfield's facility at Milford on the Penobscot River. Standards for other species, such as alewife, blueback herring, and American eels and downstream passage standards for sea lamprey are in development and may be proposed by MDMR and/or federal agencies during this relicensing period.

Section 10(j) Recommendations

MDMR makes the following 10(j) recommendations if FERC determines that the Shawmut Project should be relicensed.

Recommendation #1 Upstream Passage for anadromous fishes

A. The Licensee shall be responsible for providing, operating, maintaining, and evaluating a volitional upstream fish passage facility at the Shawmut Project that shall be capable of passing a maximum of 1,535,000 blueback herring, 134,000 alewife, 177,000 American shad, 12,000 Atlantic salmon, and an unknown number of sea lamprey annually in a safe, timely, and effective manner (defined in a, b, c, and d).
    a. The facility will be considered to be performing effectively if at least 99% of the adult Atlantic salmon that pass upstream at the next downstream dam (or approach within 200 m of the Shawmut powerhouse) pass upstream at the Shawmut Project within 48 hours.
    b. The facility will be considered to be performing effectively if at least 75% of the adult American shad that approach within 200 m of the Shawmut Project powerhouse pass upstream at the Shawmut Project within 48 hours.

c. The facility will be considered to be performing effectively if at least 92% of the adult alewife that approach within 200 m of the Shawmut Project powerhouse pass upstream at the Shawmut Project within 48 hours.

d. The facility will be considered to be performing effectively if at least 80% of the adult sea lamprey that approach within 200 m of the Shawmut Project powerhouse pass upstream at the Shawmut Project within 48 hours.

B. The Licensee shall operate the upstream passage daily (24 hours/day) from May 1 through July 30 and during daylight hours from August 1 through November 10 in order to pass all species (Table 10).

C. The upstream passage facility shall adhere to the USFWS design criteria (USFWS 2019).

D. After upstream passage becomes operational at the two downstream hydropower projects, the Licensee shall immediately conduct three consecutive years of effectiveness testing using radio telemetry or an equivalent technique for each of the five species (Atlantic salmon, American shad, blueback herring, alewife, and sea lamprey). The study plans shall be developed in consultation with, and require approval by the MDMR and the Maine Department of Environmental Protection (MDEP). Annual reports that describe the study, its results, and conclusions shall be submitted to the resource agencies by December 1 of each year the study is conducted. Based on the results of the annual reports, the MDEP and MDMR may require adjustments to the study methodology for the next year's evaluation.

E. If MDEP and MDMR determine the results **in any year** of the 3-year study show that the fish passage facility is not performing effectively, MDEP and MDMR shall require the construction of a new upstream fishway, to be operated concurrently with the existing fishway. The new upstream fishway shall be designed using USFWS passage criteria within 2 years of the determination by MDEP and MDMR that the upstream fish passage is not performing effectively. The new facility shall meet all of the criteria in paragraph A.

F. After the new fishway becomes operational, the Licensee shall immediately conduct three consecutive years of effectiveness testing using radio telemetry or an equivalent technique for each of the five species (Atlantic salmon, American shad, blueback herring, alewife, and sea lamprey) as described in paragraph D.

Justification

We support the need for safe, timely, and effective upstream passage at this site to meet our diadromous fish goals of restoring these indigenous species to their historic habitat. The Licensee has proposed to conduct up to two years of adult salmon studies to evaluate the performance of the new upstream passage facility. We find this completely inadequate. This is a new facility that will impact six species of diadromous fish for 40-50 years.

The waters within the Shawmut Project area are habitat for six indigenous species of diadromous fishes – species that must migrate between marine and freshwater to complete their life cycle in order to sustain a population. When passage becomes available at the Lockwood, Shawmut and

Weston projects, the Shawmut Project area will be used by 1) Atlantic salmon as a migratory corridor to and from spawning habitat in Sandy River, Carrabassett River, and/or Kennebec River; 2) American shad, blueback herring, and sea lamprey as a migratory corridor and spawning and nursery habitat, and 3) American eel as a migratory corridor and growth habitat. If survival of adults and juveniles as they pass through the Shawmut project area is not sufficiently safe, timely, and effective, then the Class B and Class C waters of the Project will not be supporting indigenous aquatic life. The situation is especially dire for Atlantic salmon, because all high-quality spawning habitat lies above 4 or 6 dams. Therefore, we have recommended studies to test the effectiveness of the passage facility, performance standards by which to evaluate the results of the studies, and additional measures (an additional fishway) if the facility does not meet the performance standards.

Recommendation #2 Downstream passage

A. The Licensee shall be responsible for providing, operating, maintaining, and evaluating a volitional downstream fish passage facility at the Shawmut Project that shall be capable of passing adult and juvenile Atlantic salmon (kelts and smolts), adult and juvenile American shad, adult and juvenile blueback herring, adult and juvenile alewife, adult American eel (silver eel), and juvenile microphthalmia sea lamprey in a safe, timely and effective upstream passage (defined in a, b, c, and d).
    a. The facility will be considered to be performing effectively if at least 99% of the Atlantic salmon smolts and kelts that pass downstream at the next upstream hydropower dam (or approach within 200 m of the Shawmut spillway) pass downstream at the Shawmut Project within 24 hours.
    b. The facility will be considered to be performing effectively if at least 95% of the adult and juvenile American shad that pass downstream at the next upstream hydropower dam (or within 200 m of the Shawmut spillway) pass the Shawmut project within 24 hours.
    c. The facility will be considered to be performing effectively if at least 93% of the adult and juvenile alewife that pass downstream at the next upstream hydropower dam (or within 200 m of the Shawmut spillway) pass the Shawmut project within 24 hours.

B. The downstream passage facility shall adhere to the USFWS design criteria (USFWS 2019).

C. The Licensee shall operate the downstream passage daily (daylight hours) from April 1 through August 14, daily (24 hours/day) from August 15 through October 31, and daily (daylight hours) from November 21 through December 31 (or until winter shutdown) in order to pass all species and life stages (Table 10).

D. After downstream passage becomes operational, the Licensee shall immediately conduct three consecutive years of effectiveness testing using radio telemetry or an equivalent technique for adult and juvenile Atlantic salmon, adult and juvenile American shad, adult and juvenile blueback herring, adult and juvenile blueback alewife, adult American eel, and microphthalmia sea lamprey. The study plans shall be developed in consultation with, and require approval by the MDMR and the MDEP. Annual reports that describe the study, its results, and conclusions shall be submitted to the resource agencies by December 1 of each year the study is conducted. Based on the results of the annual reports, the MDEP and MDMR may require adjustments to the study methodology for the next year's evaluation.

E. If MDEP and MDMR determine the results **in any year** of the 3-year study show that the fish passage facility is not performing effectively, MDEP and MDMR shall require additional measures including, but not limited to: 1) increased downstream passage flow during the passage season, 2) reduced generation and spill during the passage season, 3) screening of turbine intakes, or 4) construction of a new bypass channel. Measures 1 or 2 would be instituted immediately. Measures 3 or 4 would be instituted within 2 years of the determination by MDEP and MDMR that the downstream fish passage is not performing effectively. The additional measures shall be designed using USFWS passage criteria and shall meet all of the criteria in paragraph A.

F. After the new measures become operational, the Licensee shall immediately conduct three consecutive years of effectiveness testing using radio telemetry or an equivalent technique for each of the species and life stages as described in paragraph D.

Justification

We support the need for safe, timely, and effective upstream passage at this site to meet our diadromous fish goals of restoring these indigenous species to their historic habitat. The Licensee has proposed to 1) install a fish guidance boom (e.g., Worthington boom) in the forebay (in front of Units 7 and 8) to direct downstream migrants to the existing downstream bypass; 2) continue to operate the existing downstream fish passage facility and maintain the forebay fish guidance boom; and 3) conduct up to three years of additional downstream passage studies to reevaluate smolt. We find this proposal inadequate. Except for the Worthington boom, this is an existing facility that will impact six species of diadromous fish for 40-50 years, but has never been tested for adult Atlantic salmon (kelts) nor adult and juvenile American shad, blueback herring, and alewife. It was minimally tested for adult American eels in 2015. The Licensee did not specifically mention downstream passage of American eel or sea lamprey in its proposed environmental measures. The Licensee currently provides downstream passage for adult American eel "by opening a deep gate to pass approximately 425 cfs and tuning off unit for 7-8 hours during the night from September 15-November 15." The plunge pool which receives flow from the deep gate is not described anywhere in the FLA. MDMR has reviewed harvest data for the now closed commercial fishery of silver eels, and we have extended the passage season to be more protective.

The waters within the Shawmut Project area are habitat for six indigenous species of diadromous fishes – species that must migrate between marine and freshwater to complete their life cycle in order to sustain a population. The Shawmut Project area is currently used by 1) Atlantic salmon as a migratory corridor from the Sandy River to the ocean, 2) American shad, blueback herring, and sea lamprey as a migratory corridor from spawning and nursery habitat to the ocean, and 3) American eel as a migratory corridor from growth habitat to spawning habitat in the ocean. If survival of adults and juveniles as they pass through the Shawmut project area is not sufficiently safe, timely, and effective, then the Class B and Class C waters of the Project will not be supporting indigenous aquatic life. Therefore, we have recommended studies to test the effectiveness of the passage facility, performance standards by which to evaluate the results of the studies, and additional measures if the facility does not meet the performance standards.

Recommendation #3 Upstream eel passage

A. The Licensee shall be responsible for providing, operating, maintaining, and evaluating a volitional upstream fish passage facility at the Shawmut Project that shall be capable of passing juvenile American eel (elvers and yellow eel) in a safe, timely and effective manner.
B. The Licensee shall continue using the existing upstream eel facilities until upstream and downstream fish passage recommended by MDMR has been operation for one year (shake down period).
C. After the shakedown period, the Licensee shall conduct siting studies, designed in consultation with the resource agencies, to determine the best location(s) for upstream eel passage.
D. The downstream passage facility shall adhere to the USFWS design criteria.
E. The Licensee shall operate the upstream passage from June 1 through September 15.
F. The Licensee shall conduct one year of monitoring to determine the number of American eels using the passage facility and the size distribution of the eels. The Licensee shall conduct one year of effectiveness testing to be designed in consultation with the agencies

Justification

The existing upstream passages for American eel are not volitional, and their ability to attract juvenile American eels may be compromised by changes in flow patterns if existing facilities and operations are changed.

Recommendation #4 Stocking Plan

A. Within one year of license issuance, the Licensee shall develop a plan, in consultation with the USFWS, NMFS, MDMR, and the Penobscot Indian Nation, to acquire uniquely marked Atlantic salmon smolts (or other appropriate life stage) for stocking upstream of the Shawmut Project. These fish will serve as a source of imprinted adult fish (i.e., fish homing to areas upstream of Shawmut Dam) needed to support any required upstream effectiveness testing.

Justification

In order to conduct upstream adult salmon studies to determine passage efficiency for the Projects on the Lower Kennebec River (Lockwood, Hydro-Kennebec, Shawmut, Weston; all owned by the Licensee), the Licensee, in conjunction with the above-mentioned entities, will need to develop a plan. This plan will evaluate the best method to provide sufficient returning adults to make upstream passage efficiency studies meaningful at all four Projects. Juveniles will need to be stocked above the Project to provide imprinted adult fish. Significant numbers will need to be stocked to account for river and ocean mortality, so enough adults return and provide meaningful passage efficiency results. Procurement of fish for studies is the responsibility of the licensee.

References

74 FR 23900 (2009, June 19) Endangered and Threatened Species; Designation of Critical Habitat for Atlantic Salmon (Salmo salar) Gulf of Maine Distinct Population Segment

Atkins, C.G. 1887. The River Fisheries of Maine. *In*: Goode, B.G. et al. The Fisheries and Fishery Industries of the United States., Section V, Volume 1, pages 673- 728.

ASMFC (Atlantic States Marine Fisheries Commission). 1985. Fishery management plan for the anadromous alosid stocks of the eastern United States: American shad, hickory shad, alewife, and blueback herring: Phase II in interstate management planning for migratory alosids of the Atlantic coast. Washing ton, DC. XVIII+347 pp.

ASMFC (Atlantic States Marine Fisheries Commission). 2000. Interstate Fishery Management Plan for American eel. Washington, DC. 79 pp

ASMFC (Atlantic States Marine Fisheries Commission). 2012. Stock Assessment Report No. 12-01 of the Atlantic States Marine Fisheries Commission American Eel Benchmark Stock Assessment.

ASMFC (Atlantic States Marine Fisheries Commission). 2014. Addendum IV to the Interstate Fishery Management Plan for American eel.

ASSRT (Atlantic Sturgeon Status Review Team). 2007. Status Review of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). Report to National Marine Fisheries Service, Northeast Regional Office. February 23, 2007. 174 pp.

Barber, B. L., A. J. Gibson, A. J. O'Malley, and J. Zydlewski. 2018. Does what goes up also come down? Using a recruitment model to balance alewife nutrient import and export. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 10: 236-154.

Baum, E.: 1983, *The Penobscot River, an Atlantic Salmon River Management Report*, Atlantic Sea-Run Salmon Commission, Bangor, ME.

BBHP (Black Bear Hydro Partners, LLC). 2018. Stillwater Project (FERC No. 2712); Orono Project (FERC No. 2710); Milford Project (FERC No. 2534); 2017 Diadromous fish passage report for Alosines and American Eels

BBHP (Black Bear Hydro Partners, LLC). 2019. Stillwater Project (FERC No. 2712); Orono Project (FERC No. 2710); Milford Project (FERC No. 2534); West Enfield Project (FERC No. 2600). 2018 Diadromous fish passage report

Beamish, F.W.H. 1980. Biology of the North American Anadromous Sea Lamprey, *Petromyzon marinus*. Can.J.Fish.Aquat.Sci. 37: 1924-1943.

Bilkovec, D. M., C. H. Hershiner, and J. E. Olney. 2004. Macroscale assessment of American shad spawning and nursery habitat in the Mattaponi and Pumunkey rivers, Virginia. North American Journal of Fisheries Management. 22: 1176-1192.

Brown, J. J., K. E. Limburg, J. R. Waldman, K. Stephenson, E. P. Glenn, F. Juanes, and A. Jordaan. 2013. Fish and hydropower on the U.S. Atlantic coast: failed fisheries policies from half-way technologies. Conservation Letters 6: 280-286.

BWPH (Brookfield White Pine Hydro, LLC). 2018. Brookfield White Pine Hydro, LLC Energy Enhancements and Lower Kennebec Fish Passage Improvements Study

Castro-Santos, T. and B. H. Letcher. 2010. Modeling migratory energetics of Connecticut River American shad (*Alosa sapidissima*): implications for the conservation of an iteroparous fish. Can.J.Fish.Aquat.Sci. 67: 806-830.

Castro-Santos, T. Shi, X., and A. Haro. 2016. Migratory behavior of adult sea lamprey and cumulative passage performance through four fishways. Canadian Journal of Fisheries and Aquatic Sciences. 74(5):790-800. doi:10.1139/cjfas-2016-0089

Collette, B.B. and G. Klein-MacPhee [eds]. 2002. Bigelow and Schroeder's Fishes of the Gulf of Maine. 2002. Bruce B. 3rd edition. Smithsonian Institution Press.

CRASC (Connecticut River Atlantic Salmon Commission). 2017. Connecticut River American Shad Management Plan. Sunderland, Massachusetts. https://www.fws.gov/r5crc/pdf/CRASC_Shad_Plan_6_13_17_FINAL.pdf

Crecco, V., T. Savoy, and L. Gunn. 1983. Daily mortality rates of and larval and juvenile American shad (*Alosa sapidissima*) in the Connecticut River with changes in year-class strength. Can.J.Fish.Aquat.Sci. 40: 1719-1728.

Crecco, V. and T. Savoy. 1984. Effects of fluctuations in hydrographic conditions on year-class strength of American shad (*Alosa sapidissima*) in the Connecticut River. Can. J. Fish. Aquat. Sci. 41: 1216-1223.

Crecco, V. and T. Savoy. 1985. Effects of biotic and abiotic factors on growth and relative survival of young American shad, *Alosa sapidissima*, in the Connecticut River. Can.J.Fish.Aquat.Sci. 42: 1640-1648.

Elliott, J.M., and Elliott, J.A. 2010. Temperature requirements of Atlantic salmon Salmo salar, brown trout Salmo trutta and Arctic charr Salvelinus alpinus: predicting the effects of climate change. J. Fish. Biol. 77: 1793–1817. doi:10.1111/j. 1095-8649.2010.02762.x. PMID:21078091.

Exelon. 2012. American shad passage study: Susquehanna River American shad model production runs. Prepared by Normandeau Associates, Inc. and Gomez and Sullivan Engineers P.C.

Fay, C., M. Bartron, S. Craig, A. Hecht, J. Pruden, R. Saunders, T. Sheehan, and J. Trial. 2006. Status Review for Anadromous Atlantic Salmon (Salmo salar) in the United States. Report to the National Marine Fisheries Service and U.S. Fish and Wildlife Service. 294 pages.

Frechette, D.M, Dugdale, S.J., Dodson, J.J., and Bergeron, N.E. 2018. Understanding summertime thermal refuge use by adult Atlantic salmon using remote sensing, river temperature monitoring, and acoustic telemetry. Can. J. Fish. Aquat. Sci. 75: 1999–2010.

FERC (Federal Energy Regulatory Commission). 2004. Evaluation of Mitigation Effectiveness at Hydropower Projects: Fish Passage. Division of Hydropower Administration and Compliance, Office of Energy Projects. 63 pages.

Foster, N.W. and C.G. Atkins. 1868. Reports of the Commissioners of Fisheries of the State of Maine for the Years 1967 and 1868: Second Report 1868. Owen and Nash, Printers to the State, Augusta.

Guyette, M., Loftin, C., Zydlewski, J., and R. Cunjak. 2014. Carcass analogues provide marine subsidies for macroinvertebrates and juvenile Atlantic salmon in temperate oligotrophic streams. Freshwater Biology 59, 392–406

Hasler, C.T., Cooke, S.J., Hinch, S.G., Guimond, E., Donaldson, M.R., Mossop, B., and Patterson, D.A. 2012. Thermal biology and bioenergetics of different upriver migration strategies in a stock of summer-run Chinook salmon. J. Therm. Biol. 37: 265–272. doi:10.1016/j.jtherbio.2011.02.003.

Hogg, R.S., S.M. Coghlan Jr., J. Zydlewski, and K. Simon. 2014. Anadromous sea lamprey are ecosystem engineers in a spawning tributary. Freshwater Biology 59:1294-1307.

Jonsson, B., and Jonsson, N. 2009. A review of the likely effects of climate change on anadromous Atlantic salmon Salmo salar and brown trout Salmo trutta, with particular reference to water temperature and flow. J. Fish. Biol. 75: 2381–2447. doi:10.1111/j.1095-8649.2009.02380.x. PMID:20738500.

Johnson, E.L., Caudill,C.C., Keefer,M.L., Clabough,T.S., Peery,C.A., Jepson,M.A., and Moser,M.L. 2012. Movement of Radio-Tagged Adult Pacific Lampreys during a Large-Scale Fishway Velocity Experiment. Trans.Am.Fish.Soc. 141: 571-579.

Keefer, M.L., Boggs,C.T., Peery,C.A., and Caudill,C.C. 2013a. Factors affecting dam passage and upstream distribution of adult Pacific lamprey in the interior Columbia River basin. Ecology of Freshwater Fish 22: 1-10.

Keefer, M.L., Caudill,C.C., Clabough,T.S., Jepson,M.A., Johnson,E.L., Peery,C.A., Higgs,M.D., and Moser,M.L. 2013b. Fishway passage bottleneck identification and prioritization: a case study of Pacific lamprey at Bonneville Dam. Can.J.Fish.Aquat.Sci. 70: 1551-1565.

Kircheis F.W. (2004) Sea Lamprey. F.W. Kircheis L.L.C, Carmel, ME.

Legault, C.M., 2005. Population viability analysis of Atlantic salmon in Maine, USA. Transactions of the American Fisheries Society, 134(3), pp.549-562.

Martin, B.T., R. M. Nisbet, A. Pike A, C. J. Michel, and E. M. Danner EM. Sport science for salmon and other species: ecological consequences of metabolic power constraints. Ecol Lett. 2015 Jun;18(6):535-44. doi: 10.1111/ele.12433. Epub 2015 Apr 8. PMID: 25858695.

McCormick, S. D., L. P. Hansen, T. P. Quinn, and R. L. Saunders. 1998. Movement, migration, and smolting of Atlantic salmon (Salmo salar). Canadian Journal of Fisheries and Aquatic Sciences 55:77–92

MDMR and MDIFW (Maine Department of Marine Resources and Maine Department of Inland Fisheries and Wildlife). 2008. Strategic Plan for the Restoration of Diadromous Fishes to the Penobscot River

Moore, J.W., Hayes, S.A., Duffy, W., Gallagher, S., Michel, C.J., and D. Wright. Nutrient fluxes and the recent collapse of coastal California salmon populations. Canadian Journal of Fisheries and Aquatic Sciences, 2011, 68:1161-1170.

MSPO (Maine State Planning Office). 1993. Kennebec River Resource Management Plan. Augusta, Maine. February 1993. 16 pp.

NAS (National Academy of Sciences). 2004. Atlantic Salmon in Maine. Washington, D.D. National Academies Press.

Naughton, G. P., Caudill, C. C., Peery, C. A., Clabough, T. S., Jepson, M. A., Bjornn, T. C., & Stuehrenberg, L. C. (2007). Experimental evaluation of fishway modifications on the passage behaviour of adult Chinook salmon and steelhead at Lower Granite Dam, Snake River, USA. River Research and Applications, 23(1), 99-111.

NextEra Energy. 2009. NextEra Energy Diadromous Fish Passage Report for the Lower Kennebec River Watershed during the 2009 Migration Season. Accession number 20090518-5014 at https://elibrary.ferc.gov/eLibrary/search

Nieland J.L., T. F. Sheehan, R. Saunders, J.S. Murphy, T. R. Trinko Lake, J. R. Stevens. 2013. Dam. Impact Analysis Model for Atlantic Salmon in the Penobscot River, Maine. US Dept Commerce, Northeast Fish Sci Cent Ref Doc. 13-09; 524 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at http://www.nefsc.noaa.gov/nefsc/publications

Nieland JL, Sheehan TF. 2020. Quantifying the effects of dams on Atlantic Salmon in the Penobscot River Watershed, with a focus on Weldon Dam. NEFSC Ref Doc 19-16; 90 p. Available from https://www.fisheries.noaa.gov/feature-story/dam-impact-analysis-model-helps-researchers-assess-atlantic-salmon-survival

Nislow, K.H. and Kynard, B.E. 2009. The role of anadromous sea lamprey in nutrient and material transport between marine and freshwater environments. Am.Fish.Soc.Symp. 69: 485-494.

(NMFS) National Marine Fisheries Service. 1998. Recovery Plan for the Shortnose Sturgeon (*Acipenser brevirostrum*). Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland. 104 pages.

Orciari, R.D., Leonard, G.H., Mysling, D.J. and Schluntz, E.C. (1994), Survival, Growth, and Smolt Production of Atlantic Salmon Stocked as Fry in a Southern New England Stream. North American Journal of Fisheries Management, 14: 588-606. doi:10.1577/1548-8675(1994)014<0588:SGASPO>2.3.CO;2

Pereira et al. 2016 salmon

Pörtner, H.O., and Farrell, A.P. 2008. Physiology and climate change. Science, 322: 690–692. doi:10.1126/science.1163156. PMID:18974339.

Rand, P. S., & Hinch, S. G. (1998). Swim speeds and energy use of upriver-migrating sockeye salmon (Oncorhynchus nerka): simulating metabolic power and assessing risk of energy depletion. Canadian Journal of Fisheries and Aquatic Sciences, 55(8), 1832-1841.

Saunders, R., M. A. Hachey, and C. W. Fay. 2006. Maine's diadromous fish community: past, present, and implications for Atlantic salmon recovery. Fisheries 31: 537-547.

Scott, W. B. and E. J. Crossman. 1973. Freshwater fishes of Canada. Bulletin 184. Fisheries Research Board of Canada, Ottawa,Canada

Shepard, S.L. 2015. American eel biological species report. U.S. Fish and Wildlife Service, Hadley, Massachusetts. xii +120 pages.

Solomon, D. J. and M. H. Beach, M H. 2004. Fish pass design for eel and elver (*Anguilla anguilla*). Environment Agency, Bristol (UK).

Sousa,R., Araujo,M., and Antunes,C. 2012. Habitat modifications by sea lampreys (Petromyzon marinus) during the spawning season: effects on sediments. Journal of Applied Ichthyology 28: 766-771.

SRAFRC (Susquehanna River Anadromous Fish Restoration Cooperative). 2010. Migratory Fish Management and Restoration Plan for the Susquehanna River Basin.

(SSRT) Shortnose Sturgeon Status Review Team. 2010. A Biological Assessment of shortnose sturgeon (*Acipenser brevirostrum*). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010. 417 pp.

Stevens, J. R., J. F. Kocik, and T. F. Sheehan. 2019. Modeling the impacts of dams and stocking practices on an endangered Atlantic salmon Salmo salar population in the Penobscot River, Maine, USA. Canadian Journal of Fisheries and Aquatic Sciences.

Stich D. S., Sheehan, T F; and Zydlewski, J D. 2019. A dam passage performance standard model for American shad. Canadian Journal of Fisheries and Aquatic Sciences 76: 762-779.

USASAC (U. S. Atlantic Salmon Assessment Committee). 2019. Annual Report of the U.S. Atlantic Salmon Assessment Committee. Report Number 31 - 2018 activities. Portland, Maine 91 pp.

USFWS. 2019. Fish Passage Engineering Design Criteria. USFWS, Northeast Region R5, Hadley, Massachusetts.

USFWS and NMFS (U.S. Fish and Wildlife Service and National Marine Fisheries Service. 2019. Recovery plan for the Gulf of Maine Distinct Population Segment of Atlantic salmon (*Salmo salar*). 74 pp.

U.S. Energy Information Administration at https://www.eia.gov/

Weaver, D. M., Coghlan, S. M., Zydlewski, J., Hogg, R. S., & Canton, M. (2015). Decomposition of sea lamprey Petromyzon marinus carcasses: Temperature effects, nutrient dynamics, and implications for stream food webs. Hydrobiologia, 760, 57–67.

Weaver, D. M., S. M. Coghlan Jr., and J. Zydlewski. 2016. Sea lamprey carcasses exert local and variable food web effects in a nutrient-limited Atlantic coastal stream. Can. J. Fish. Aquat. Sci. 73:1616–1625

Weaver, D.M., S.M. Coghlan Jr., H.S. Greig, A.J. Klemmer, L.B. Perkins, and J. Zydlewski. 2018. Subsidies from anadromous sea lamprey (Petromyzon marinus) carcasses function as a reciprocal nutrient exchange between marine and freshwaters. River Research and Applications 34:824-833.

Wippelhauser, G.S. and T.S. Squiers, Jr. 2015. Shortnose Sturgeon and Atlantic Sturgeon in the Kennebec River system, Maine: a 1977-2001 retrospective of abundance and important habitat. Transactions of the American Fisheries Society 144: 591–601.

Wippelhauser, G.S., G.B. Zydlewski, M. Kieffer, J. Sulikowski, and M.T. Kinnison. 2015. Shortnose Sturgeon in the Gulf of Maine: use of spawning habitat in the Kennebec system and response to dam removal. Transactions of the American Fisheries Society. 144: 742–752.

Wippelhauser, G.S., J. Sulikowski, G.B. Zydlewski, M. Kieffer, and M.T. Kinnison. 2017. Movements of Atlantic Sturgeon of the Gulf of Maine inside and outside the geographically defined DPS. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science* 9: 93-107.

Wippelhauser, G.S. Submitted. The Kennebec River Diadromous Fish Restoration Project: before and after the removal of Edwards Dam

Yoder, C.O., B.H. Kulik, and J.M. Audet. 2006. The spatial and relative abundance characteristics of the fish assemblages in three Maine Rivers. MBI Technical Report MBI/12-05-1. Grant X-98128601 report to U.S. EPA, Region I, Boston, MA.

Table 1. List of major events leading to the restoration of diadromous species in the Kennebec River, Maine.

Year(s)	Major events
1987	**First Kennebec hydro Developers Group (KHDG) Settlement Agreement**
1987	MDMR initiates stocking of alewife and American shad into historic spawning habitat above Edwards Dam
1987-1997	MDMR stocks 1,849 adult American shad , 44.6 million Americas shad fry, and 197,176 American shad fingerlings into historic spawning habitat above Edwards
1987-2006	MDMR stocks 1.3 million river herring into historic habitat above Edwards
1992	Interim upstream passage (fish pump) installed at Edward Dam
1988-2006	Interim, downstream passage operational at Benton Falls, Fort Halifax, Burnham, Lockwood, Shawmut, and Hydro-Kennebec projects, respectively
1998	**Lower Kennebec River Comprehensive Hydropower Settlement (1998 Settlement)**
1999	Removal of Edwards Dam
1999	MDMR completes upstream fish passage at Stetson Pond (Sebasticook River)
1999-2011	Installation of upstream eel passage at seven KHDH Dams
2002	MDMR removes Guilford Dam and completes upstream passage at Plymouth Pond Dam (Sebasticook River)
2003	MDMR completes upstream passage at Sebasticook Lake (Sebasticook River)
2003	MDMR initiates salmon stocking (eggs, fry, returning adults) in Sandy River
2006	Fish lifts operational at Benton Falls and Burnham projects (Sebasticook River) and Lockwood Project (Kennebec River)
2006	Fish lift operational at Lockwood Project (Kennebec River)
2006	MDMR ceases stocking alewife into 6 accessible lakes and ponds
2006	Removal of Madison Electric Works Dam (Sandy River)
2008	Removal of Fort Halifax Dam (Sebasticook River)
2009	MDMR completes upstream passage at Webber Pond Dam (Seven Mile Stream)
2012-2013	Interim Species Protection Plans (ISPP) for Atlantic salmon for Kennebec River and Androscoggin River
2012-2014	Downstream passage efficiency studies for Atlantic salmon smolts at Lockwood, Hydro Kennebec, Shaw, and Weston
2016-2017	Upstream passage studies of adult Atlantic salmon at the Lockwood Project
2016	Fish lift operational at Hydro Kennebec Project
2017-2020	MDMR and partners remove Masse Dam (2017) and Lombard Dam (2018) and install fish passage at Ladd Dam (2019) and Box Mills Dam (2020) in Outlet Stream (Sebasticook River)
2018	A total of 5,580,111 river herring return to the Sebasticook River, the largest self-sustaining run on the east coast
2019	MDMR and partners complete upstream fish passage at Togus Ponds

Table 2. Historic and currently accessible anadromous spawning habitat and catadromous growth habitat in the Kennebec River watershed. The Lockwood Project was constructed at Taconic Falls and the Abenaki and Anson projects were constructed at Norridgewock Falls.

Species	Historic range	Current accessible range
Rainbow smelt	Mainstem to Taconic Falls	Mainstem to Taconic Falls
Atlantic tomcod	Mainstem to head-of tide	Mainstem to head-of tide
Shortnose sturgeon	Mainstem to Taconic Falls	Mainstem to Taconic Falls
Atlantic sturgeon	Mainstem to Taconic Falls	Mainstem to Taconic Falls
Striped bass	Mainstem to Taconic Falls; Sebasticook River to BF	Mainstem to Taconic Falls; Sebasticook River to BF
American shad	Mainstem to Norridgewock Falls; Sandy River to Rt 4	Mainstem to Lockwood Dam (trucking upstream)
Blueback herring	Mainstem to Norridgewock Falls; Sandy River to Rt 4	Mainstem to Taconic Falls (trucking upstream)
Alewife	Mainstem to Norridgewock Falls; Sandy River to Rt 4	Mainstem to Taconic Falls (trucking upstream)
Atlantic salmon	Mainstem to Kennebec/Dead Rive confluence; Carrabassett River; Sandy River	Mainstem to Taconic Falls (trucking upstream)
Sea lamprey	Unknown-similar to salmon	Mainstem to Taconic Falls
American eel	Unknown-past Williams Project	Williams Project

Table 3. Amount of American shad, blueback herring, and alewife spawning habitat (source 1997 FEIS) in the Kennebec River above Edwards Dam (removed in 1999) and estimated production of adults of each species.

Habitat description	Surface area (ha)	% of total area	American shad production	Blueback herring production	Alewife production
Kennebec-ED to LO	524	20.9	106,332	626,461	
Kennebec-LO/HK to SH	212	8.4	42,966	253,135	
Kennebec SH to WE	512	20.4	103,965	612,514	
Kennebec WE to AB	415	16.5	84,215	496,156	
Sandy to Rt 4 bridge	356	14.2	72,345	426,223	
Sebasticook to EB-WB	489	19.5	99,212	584,515	
Wesserunsett Lake	585				578,400
Sandy (4 lakes)	474				468,400
Totals			509,035	2,999,004	1,046,800

Table 4. Number of river herring, estimated number that were alewife and blueback herring based on biological sampling, American shad, and striped bass captured at the Fort Halifax Project (FH), Benton Falls Project (BF) and Lockwood Project (LO).

Site	Year	Total river herring	Alewife	Blueback Herring	American Shad	Striped Bass
FH	2000	137,658	137,658			
FH	2001	142,845	142,155	690		
FH	2002	151,574	150,743	831		
FH	2003	131,633	131,616	17		
FH	2004	143,697	143,663	34		
FH	2005	81,576	81,265	311		
FH	2006	46,960	43,865	3,095		
FH	2007	458,491	457,464	1,027		
FH	2008	401,059	388,692	12,367		
BF	2009	1,327,861	1,263,015	64,846	9	
BF	2010	1,628,187	1,201,559	426,628	3	4
BF	2011	2,751,473	2,537,226	214,247	54	
BF	2012	1,703,520	1,499,216	204,304	163	1
BF	2013	2,272,027	1,964,613	307,414	113	14
BF	2014	2,379,428	1,784,425	595,003	26	22
BF	2015	2,158,419	1,725,165	433,254	48	3
BF	2016	3,128,753	2,131,789	996,964	18	3
BF	2017	3,547,698	2,339,419	1,208,279	65	314
BF	2018	5,579,901	4,201,838	1,378,063	26	3
BF	2019	3,287,701	2,086,545	1,201,156	114	169
LO	2006	3,152				83
LO	2007	4,534			30	
LO	2008	90,940	89,121	1,819		
LO	2009	45,428				10
LO	2010	75,072	59,363	15,709	28	4
LO	2011	31,066				8
LO	2012	156,428				11
LO	2013	95,314				31
LO	2014	108,256	73,883	34,373	1	22
LO	2015	89,496	55,433	34,063	26	33
LO	2016	206,941	88,463	118,478	830	214
LO	2017	238,481	73,595	164,886	201	137
LO	2018	238,953	145,267	93,686	275	109
LO	2019	182,987	118,921	64,066	22	

Table 5. Number of Atlantic salmon fry and eggs stocked in the Sandy River, and number of returning adults captured at the Lockwood Project and trucked to the Sandy River.

Year	Number of fry stocked	Number of eggs stocked	Total number of adult returns	Total naturally reared returns	Proportion naturally reared
2003	39,000				
2004	55,000	12,000			
2005	30,000	18,000			
2006	6,500	41,800	15	5	
2007	15,400	18,000	16	8	0.50
2008		245,500	21	8	0.38
2009		166,494	33	11	0.33
2010		567,920	5	3	0.60
2011		859,893	64	43	0.67
2012		920,888	5	4	0.80
2013		691,857	8	7	0.88
2014		1,159,330	18	16	0.89
2015		274,383	31	29	0.94
2016		619,364	39	39	1.00
2017		447,106	40	40	1.00
2018		1,227,353	11	10	0.91
2019		917,613			
Total	145,900	8,187,501	306	223	

Table 6. Estimated adult returns to the Kennebec River given realistic scenarios of marine survival (M) and freshwater (F) productivity as a function of number of mainstem dams on the river. The 5-dam scenario assumed Shawmut has been removed, 4 dam scenario assumed Shawmut and Lockwood had been removed, and 2 dam scenario assumes Weston, Shawmut, Kennebec Hydro, and Lockwood had been removed.

Number of dams	Downstream mortality/dam	Upstream mortality/dam	Low M low F survival	Low M high F survival	High M low F survival	High M high F survival
6	0.01	0.01	91	274	730	2,190
6	0.04	0.05	64	193	514	1,541
5	0.01	0.01	107	321	856	2,568
5	0.02	0.02	99	296	790	2,371
5	0.03	0.03	91	274	730	2,189
5	0.04	0.04	84	252	673	2,019
4	0.01	0.01	123	369	984	2,951
4	0.02	0.02	116	347	927	2,780
4	0.03	0.03	109	327	873	2,618
4	0.04	0.04	103	308	822	2,465
4	0.04	0.05	100	299	797	2,392
2	0.01	0.01	150	451	1,203	3,609
2	0.02	0.02	147	440	1,173	3,520
2	0.03	0.03	143	429	1,144	3,433
2	0.04	0.04	140	419	1,116	3,348
2	0.04	0.05	137	412	1,099	3,297

Table 7. Baseline and adjusted downstream passage efficiencies for Atlantic salmon smolts.

Project	Year	Baseline efficiency	Adjusted efficiency
Weston	2013	0.957	
Shawmut	2013	0.963	
Hydro Kennebec	2013	0.941	
Lockwood	2013	1.000	
Weston	2014	0.895	0.875
Shawmut	2014	0.936	0.895
Hydro Kennebec	2014	0.980	0.900
Lockwood	2014	0.977	0.947
Weston	2015	0.997	0.660
Shawmut	2015	0.906	0.838
Hydro Kennebec	2015		
Lockwood	2015	0.980	0.888

Table 8. Number of American shad adults, fingerlings, and fry stocked into the Kennebec River (KE) or the Sebasticook River (SE) between 1987 and 2007. Adults were obtained from the Kennebec River, Narraguagus River (NA), Connecticut River (CO), Saco River, (SA), and Merrimack River (ME).

Year	Source	Adults released	Fry released (KE)	Fry released (SE)	Fingerlings released
1987	KE	16			
1987	NA	183			
1988	CO	616			
1989	NA	174			
1989	CO	444			
1989	KE	1			
1990	NA	36			
1990	CO	568			
1991	CO	639			
1992	CO	994			
1993	CO	880	186,000		16,000
1994	CO	898	51,000		15,600
1995	CO	1,518	388,000		27,841
1996	CO	462	599,990	320,000	3,070
1997	CO	420	1,484,908	474,313	60,261
1997	SA		459,241		
1998	CO		1,348,937	725,420	27,907
1999	CO		2,020,838	839,068	13,141
2000	CO		3,346,727	500,004	27,685
2001	ME		1,489,913	618,879	6,671
2002	ME		5,671,856	1,034,207	
2003	ME		5,989,358	1,857,184	
2004	ME		4,931,174	510,962	
2005	ME		1,105,343		
2006	CO		262,131		
2007	ME		7,937,841	422,518	
	Total	7,849	37,273,257	7,302,555	198,176

Table 9. American shad passage standards for the Connecticut, Penobscot, and Susquehanna river systems.

River	Standard	Species/stage	Percent passed
Connecticut	Downstream	all stages American shad	≥95% within 24 hrs.
Penobscot	Downstream	all stages American shad	≥90% within 24 hrs.
Penobscot	Downstream	all stages American shad	≥98% within 48 hrs.
Susquehanna	Downstream	adult Alosines	≥80%
Susquehanna	Downstream	juvenile Alosines	≥95%
Susquehanna	Downstream	Adult American eel	≥85%
Connecticut	Upstream	adult American shad	≥75% within 48 hrs.
Penobscot	Upstream	all stages American shad	≥75% within 24 hrs.
Penobscot	Upstream	all stages American shad	≥80% within 48 hrs.
Susquehanna	Upstream	adult American shad	≥75%
Susquehanna	Upstream	adult American shad	≥75%

Table 10. Fish passage season for the Kennebec River.

Species	Upstream migration period	Downstream migration period
Atlantic salmon	May 1–November 10	April 1 – June 15 (smolts and kelts) October 15 – December 31 (kelts)
American shad	May 15–July 31	July 15 – November 15 (juveniles) June 1 – July 31 (adults)
Alewife	May 1–July 1	June 1 – July 31 (adults) July 15 – November 15 (juveniles)
Blueback herring	May 1–July 1	June 1 – July 31 (adults) July 15 – November 15 (juveniles
American eel	June 1–September 15	August 15–October 31 (adults; night)
Sea lamprey	May 1-July 30 (night)	Late fall and spring (night)

Figure 1. Estimated adult returns to the Kennebec River as a function of marine survival, freshwater production, and number of mainstem dams. Dark blue bars are low marine survival and low freshwater production. Light blue bars low marine survival and high freshwater production. Light gray bars are high marine survival and low freshwater production. Dark gray bars are high marine survival and high freshwater production. Dashed red line is minimum number of returns for downlisting and solid red line is minimum required for recovery. Downstream passage morality was set at .04 and upstream at .05 except 6 dams 1% (far right) where .01 was used. Scenarios are: 6 dams (Anson, Abenaki, Weston, Shawmut, Kennebec Hydro, and Lockwood), 5 dams (Shawmut removed), 4 dams (Shawmut and Lockwood removed), 2 dams (Weston, Shawmut, Kennebec Hydro, and Lockwood removed).

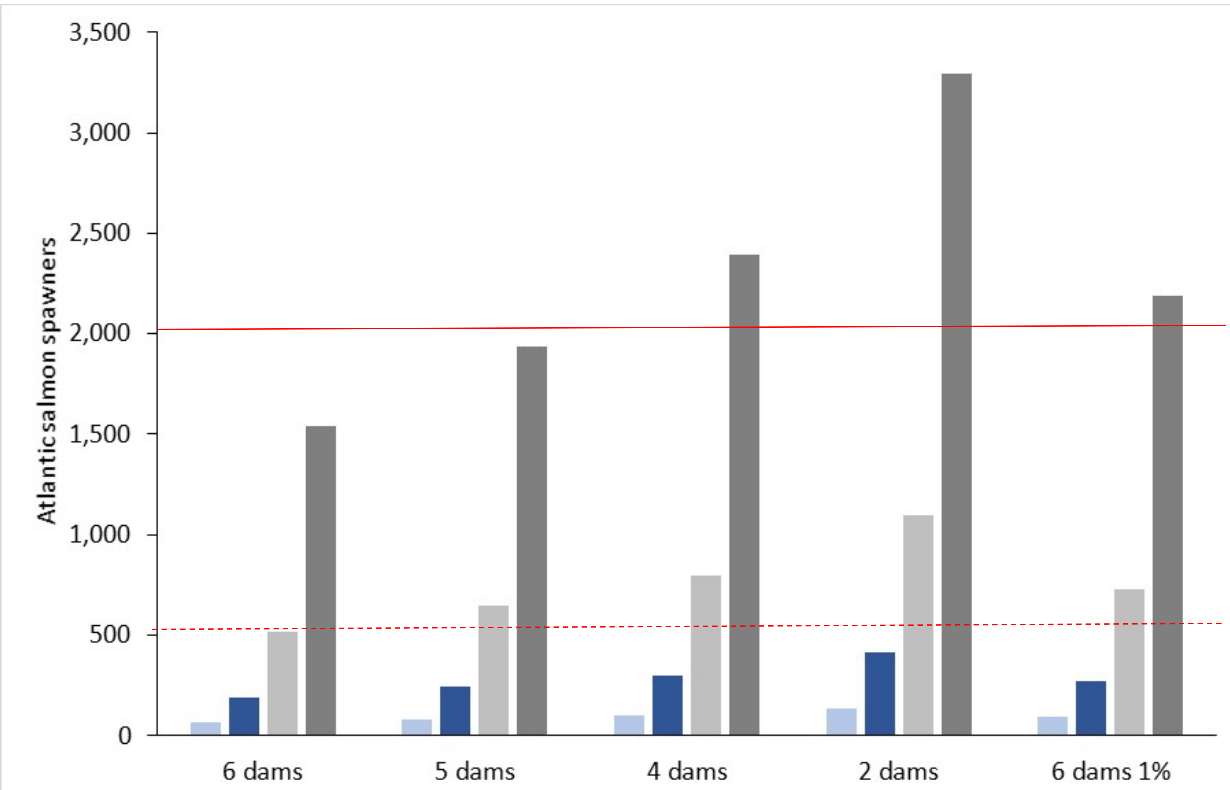

Figure 2. Aerial view of the Lockwood Project tailrace showing locations (green polygons) where American shad were captured for a radio telemetry study in 2015.

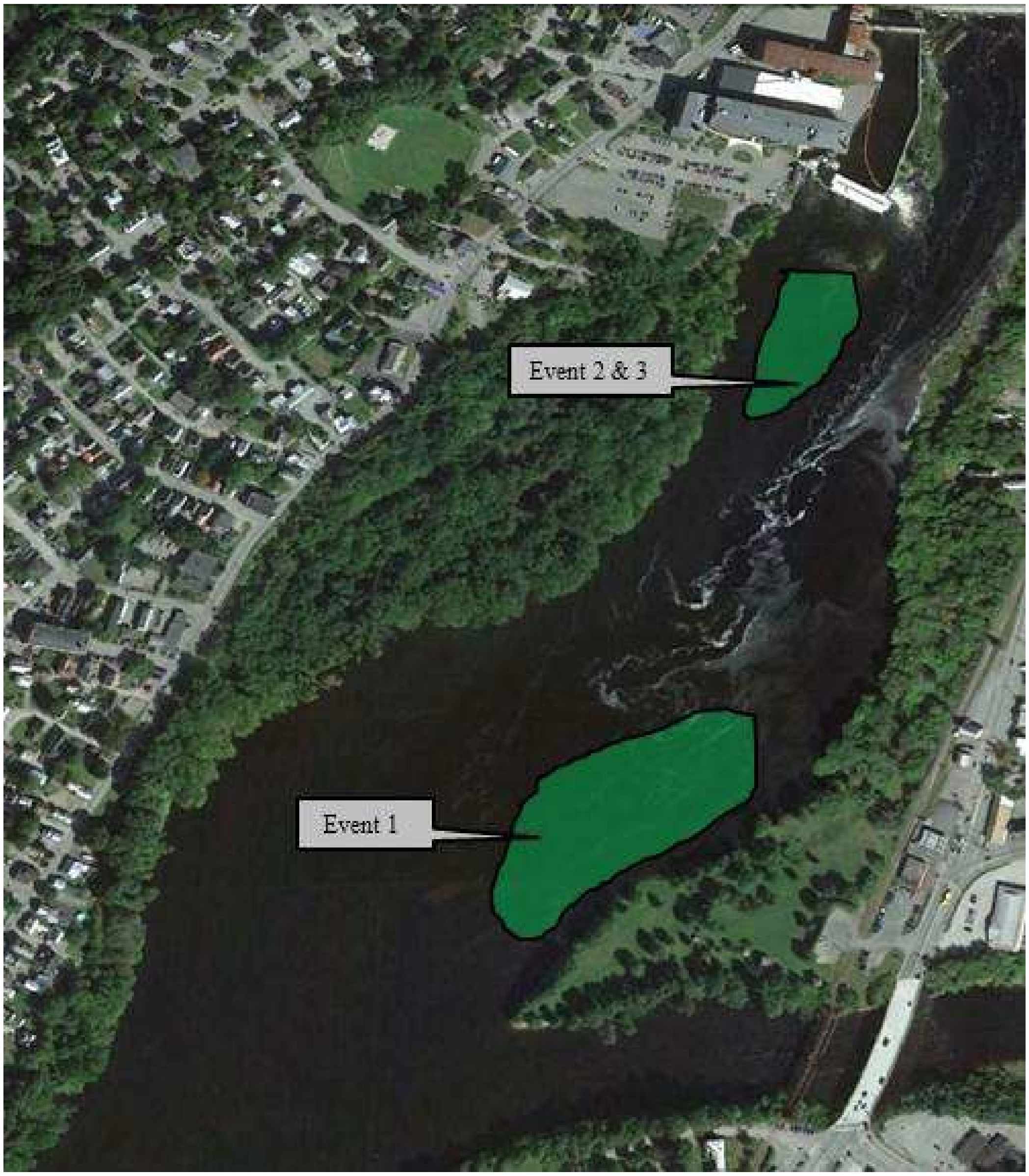

Figure 3. Modeled total number of adult alewife reaching spawning habitat above the Lockwood Project with four (Lockwood, Hydro Kennebec, Shawmut, and Weston) or three dams (Shawmut removed) in the Kennebec River, and upstream and downstream passage survival ranging from 85-95%. Minimum production is based on 235 fish/acre; average production is based on 400 fish/acre.