STATE OF MAINE
DEPARTMENT OF MARINE RESOURCES
21 STATE HOUSE STATION
AUGUSTA, MAINE
04333-0021

JANET T. MILLS
GOVERNOR

PATRICK C. KELIHER
COMMISSIONER

December 22, 2021

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, D.C. 20426

RE: Notice Of Intent To Prepare An Environmental Impact Statement For The Proposed Project Relicense, Interim Species Protection Plan, And Final Species Protection Plan, Request For Comments On Environmental Issues, Schedule For Environmental Review, And Soliciting Scoping Comments on the Lockwood (FERC No. 2574), Hydro-Kennebec (FERC No. 2611), Shawmut (FERC No. 2322), and Weston (FERC No. 2325) Hydroelectric Projects.

Dear Secretary Bose:

The Maine Department of Marine Resources (MDMR) has received the Commission's request for comments on the scope of issues to address in the EIS for the Lockwood (FERC No. 2574), Shawmut (FERC No. 2322), Hydro-Kennebec (FERC No. 2611), and Weston (FERC No. 2325) projects. MDMR offers the attached comments on alternatives and impacts, as well as identification of information, studies, and analyses concerning impacts affecting the quality of the human environment.

Please contact Casey Clark at Casey.Clark@maine.gov or at 207-350-9791 if you have any questions.

Sincerely,

Patrick Keliher
Commissioner

cc: Sean Ledwin, Paul Christman, MDMR
John Perry, Jason Seiders MDIFW
Kathy Howatt, MDEP
Peter Lamothe, Julianne Rosset, Bryan Sojkowski, USFWS
Julie Crocker, Matt Buhyoff, Dan Tierney, Don Dow, NOAA

OFFICES AT 32 BLOSSOM LANE, MARQUARDT BUILDING, AUGUSTA, MAINE
http://www.Maine.gov/dmr
PHONE: (207) 624-6550 FAX: (207) 624-6024

The Maine Department of Marine Resources (MDMR) is writing to provide comments in reference to the Federal Energy Regulatory Commission's (FERC) NOTICE OF INTENT TO PREPARE AN ENVIRONMENTAL IMPACT STATEMENT FOR THE **PROPOSED PROJECT RELICENSE, INTERIM SPECIES PROTECTION PLAN, AND FINAL SPECIES PROTECTION PLAN**, REQUEST FOR COMMENTS ON ENVIRONMENTAL ISSUES, SCHEDULE FOR ENVIRONMENTAL REVIEW, AND SOLICITING SCOPING COMMENTS that was issued on November 23, 2021. In addition, MDMR has provided comments in response to Brookfield's November 5, 2021 letter to FERC (Responses to Comments on DEA for Shawmut Hydroelectric Project (FERC No. P-2322-069), which are included in Appendix A and B.

MDMR is a cabinet level agency of the State of Maine 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 translocates every adult salmon that enters the Lockwood Project fish lift, stocks every egg that contributes to those runs in the Sandy River, monitors and enumerates the parr and outmigrating smolts, permits the new smolt stocking program by USFWS, stocks river herring (Alewife and Blueback Herring) and American Shad into habitat upstream of the Lockwood Project, chairs the Merrymeeting Bay Salmon Habitat Recovery Unit Interagency committee that focuses on the Kennebec River, manages recreational and commercial harvests of sea-run fish in the drainage, and reports on the science and health of the runs through various technical and scientific forums. MDMR scientists are experts on the biology and fish passage needs of Atlantic salmon and other diadromous fish species in the Kennebec River and have expended considerable effort to develop recommendations and models based on the best available science to recommend to regulators.

FERC staff recommendations in the Draft Environmental Assessment (DEA) for the Shawmut Project did not adequately rely upon the expertise of MDMR, Maine's resource agency for restoration of diadromous species. While not mandatory, the conditions recommended by MDMR should be considered an "integral part" of the evaluation of the Lockwood, Hydro-Kennebec, Shawmut, and Weston Projects per the Fish and Wildlife Coordination Act (FWCA), which requires consultation "with a view to the conservation of wildlife resources by preventing loss of and damage to such resources." It was clearly Congress's intent in passing the 1986 amendments to the Federal Power Act (Act of October 16, 1986, Public Law 99-495, 100 Stat. 1243), based on the statute and House report on the amendment, that the federal and state fish and wildlife agencies recommendations should be "requiring heavy reliance and acceptance by FERC." MDMR should be adequately consulted with, and our recommendations more seriously considered in the EIS, as the state manager of diadromous fisheries resources in the Kennebec River. While MDMR appreciates that FERC has indicated that they will take a more comprehensive look at the four projects through an Environmental Impact Statement (EIS), the recent initiation of ESA consultation using the existing proposals and analysis, lack of communication regarding the future status of our 10(j) meeting, and lack of directed effort with MDMR to resolve outstanding issues is concerning. MDMR is cautiously optimistic that this expanded EIS will provide an opportunity for FERC to pay significant attention to, and pay a high level of concern for, all environmental aspects of hydropower development, including fish and wildlife protection, mitigation, and enhancement recommendations by MDMR and other resource agencies, as required.

The Lockwood, Hydro Kennebec, Shawmut, and Weston dam sites are complex and present significant uncertainty regarding the ability to effectively pass fish with the proposed fishways. 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. This includes fishways developed using best practices such as USFWS design criteria (USFWS 2019). The cumulative impacts of four dams and associated fishways will require reliance on very high passage performance at each project to ensure Atlantic salmon recovery and other important species goals are achievable. In addition to impeding access to critical headwater habitat, dams and associated impoundments also impose thermal challenges for diadromous species that can compound the effects of climate change. The large area of impounded water and significant numbers of dams between the only climate resilient habitat for Atlantic Salmon in the Kennebec River (the Sandy River, upper Kennebec River, and Carrabassett River) and significant areas of habitat for other species, creates an increasing urgency to find new and comprehensive solutions within the Kennebec drainage to ensure safe, timely, and effective passage. Without meaningful measures and protections proposed for American Shad, Alewife, Blueback Herring, American Eel, and Sea Lamprey, the individual and cumulative impacts to these species are significant.

MDMR continues to advocate that specific performance measures and standards be required for the target species (Atlantic Salmon, American Shad, Alewife, Blueback Herring, Sea Lamprey), and improved passage of American Eel, beyond those proposed in the Staff Recommendations with Mandatory Conditions in the DEA. MDMR has also recommended specific alternative fish passage approaches, technologies, and management, including on the Shawmut Project Interim Species Protection Plan[1] and the Lower Kennebec Species Protection Plan and Draft Biological Assessment[2], that should be incorporated by reference into our comments on the EIS.

In this filing in response to FERCs request, MDMR summarizes our specific recommendations for alternatives at each project, requests specific analysis, provides updates on new information for consideration during EIS development, and responds to sections of two letters submitted by Brookfield in Appendix A and B.[3] Our recommendations and supporting documentation for the

---

[1] Accession Number: 20210915-5082.

[2] Accession Number: 20210825-5159.

[3] On October 11, 2021, Brookfield submitted to FERC a Response to Comments letter regarding the Lower Kennebec Species Protection Plan and Draft Biological Assessment for the Lockwood (FERC No. 2574), Hydro Kennebec (FERC No. 2611), and Weston (FERC No. 2325) Projects.

Shawmut relicensing and amendment process for the Lockwood, Hydro-Kennebec, and Weston Projects, should be considered pursuant to our roles defined in the Federal Power Act and FWCA, with the stated purpose to adequately and equitably protect, mitigate damages to, and enhance, fish and wildlife (including related spawning grounds and habitat) affected by the development, operation, and management of the projects. Analysis of ESA Atlantic salmon recommendations should be conducted consistent with FERC's proactive conservation mandate articulated in Section 7(a)(1) of the ESA and case law.

General Recommendations for the Lockwood, Hydro Kennebec, Shawmut, and Weston Project

The Licensee should be responsible for providing, operating, maintaining, and evaluating volitional upstream fish passage facilities at the Lockwood, Hydro Kennebec, Shawmut, and Weston projects that shall be capable of passing the minimum populations annually in a safe, timely, and effective manner. A high performance standard is required at each project to address the cumulative impacts of the four projects and meet agency goals. Therefore, FERC should require performance standards and performance testing for each of the target species and at all four projects. New information, such as Rubenstein (2021), new climate models by USGS, and a newly developed model by NMFS and MDMR to inform downstream passage timing for salmon smolts should be utilized to inform fish passage infrastructure needs and management at the dams. MDMR has also demonstrated that Sea Lamprey populations are affected by the project, are an important species requiring access to historic habitats, and that fishways at all projects should operate 24 hours per day to accommodate their predominately nocturnal upstream movement. MDMR requests that FERC not rely on the proposed guidance booms as safe, timely, and effective downstream passage for all species. USFWS has summarized passage data on guidance booms in a recent filing.[4] The data in their summary demonstrates that guidance booms do not provide safe, timely, and effective passage for salmon smolts or adult river herring and guidance booms to not meet current USFWS design criteria. MDMR recommends that all project passage measures comport with the USFWS Fish Passage Engineering Design Criteria (2019) and based on those criteria, we recommend screening all operating turbines with angled, full-depth bar racks with clear space less than or equal to 0.75 inches. The best available data indicate that racks with 0.5-inch clear space are most protective for multiple species and life stages. This size screening was recently recommended by NMFS at the Moosehead Project in the Penobscot River and is under consideration by resource agency engineers. Normal velocities, measured perpendicular to and one foot upstream of the racks, must be of two feet per second or less to avoid impingement of target species. The rack structures must be angled, with sweeping velocities greater than or equal to normal velocities, to promote guidance to one or more dedicated bypasses. MDMR does not support downstream passage through hydropower turbines for a highly endangered species such as Atlantic salmon, or other important diadromous

---

On October 12, 2021, Brookfield submitted to FERC a Response to Comments letter regarding Interim Species Protection Plan and Draft Biological Assessment for the Shawmut Project.

[4] Accession Number: 20211217-5213.

species, even in small numbers. Current study methods limit our ability to assess all aspects of potential impacts from passage through hydropower turbines, and instead these studies only bear information on instantaneous mortality and delay. Therefore, any allowance of this type of entrainment, when reasonable alternatives exist, is not in the best interest of restoration and sustainability of these important resources. MDMR notes that FERC has stated similar comments on the record for the West Enfield Project (FERC No. 2600), "it is **not** [emphasis added] our position that the primary means of downstream passage should be the turbines."[5]

Recommendations for the Lockwood Project

MDMR recommends that if the planned upstream bypass fishway moves forward as designed, Brookfield should also construct a flume with a trapping and sorting facility to connect the existing fish lift to the headpond. MDMR recommends the new fishway and lift with flume connection to the headpond operate concurrently as certain flow regimes will provide more attraction flows towards each section of the river at different times. MDMR understands Brookfield has already developed a design for the flume connection as stated in their 2016 ISPP Annual Report.[6][7] MDMR believes it would be impossible for Brookfield to meet their own proposed efficiency and timing standards for salmon without this action based on the false attraction issues, and the licensee would certainly not meet MDMR goals for the co-evolved species based on past performance of similar projects (see previous DMR comments on the SPP for more details). The new information from Rubenstein (2021), site conditions, and existing information at fishways (Table 2) provides a reasonable basis for the need to implement these fish passages proactively.

MDMR notes that upstream eel passage was not considered during the design process of the volitional bypass facility, and the current location of the upstream eel passage will not be accessible after the vertical slot fishway is constructed. There is no question that upstream eel passage will need to be relocated. MDMR also recommends that FERC require the development, with agency input and approval, of a new upstream eel passage.

MDMR recommends that the Tuff-Boom guidance device in the power canal be removed and Brookfield be required to follow the USFWS Fish Passage Engineering Design Criteria (2019) in designing and installing a full depth guidance structure. The structure should be angled relative to the bulk river flow and have a surface area of adequate size to ensure normal velocities of less than two feet per second across operating conditions.

Recommendations for the Hydro Kennebec Project

---

[5] Accession Number: 20170525-3014

[6] Accession Number: 20170331-5212

[7] 90% design drawings dated April 19th, 2017 were distributed to the resource agencies as "Issued for Bid". These designs will be filled separately as Critical Energy Infrastructure Information (CEII).

MDMR recommends that the Hydro Kennebec fish lift be rigorously tested and modified as necessary but has no specific additional recommendations for upstream passage at this time.

The Hydro Kennebec Project has two pit-type Kaplan turbine units that are each capable of operating over a flow range of 1,550 cfs to 3,961 cfs. The Hydro Kennebec trashracks have a bar spacing of 3.5 inches wide by 8.0 inches high clear spacing, which can cause entrainment of some Atlantic salmon kelts (EA Table 8).[8] The downstream passage facility at the Hydro Kennebec Project consists of a floating angled guidance boom that is intended to guide fish to a 4-foot wide by 8-feet deep gated surface bypass slot capable of passing 320-cfs (4% of station flow). The bypass slot discharges into a plunge pool which flows out to the tailrace.

MDMR recommends that the floating boom guidance device be removed, and Brookfield be required to follow the USFWS Fish Passage Engineering Design Criteria (2019) in designing and installing a full depth guidance structure. The structure should be angled relative to the bulk river flow and have a surface area of adequate size to ensure normal velocities of less than two feet per second across operating conditions. We support Brookfield's SPP proposal to relocate the bypass gate, which will be designed to pass at least 5% of station flow and will include an Alden weir, which should further improve attraction flow conditions resulting in a greater proportion of fish finding and using the bypass. We recommend that the bar rack extend to the downstream edge of the new bypass gate to ensure adequate guidance.

Recommendations for the Shawmut Project

MDMR believes it would be impossible for Brookfield to meet its own efficiency and timing standards without additional action based on the false attraction issues for salmon and would certainly not meet mandatory conditions for alosines or MDMR goals for co-evolved species. The new information from Rubenstein (2021), site conditions, and existing information at fishways (Table 2) provides a reasonable basis for the need to implement highly effective fish passages proactively. The failures to meet fish passage standards at Lockwood and Milford, described in previous comments, speak to the need for an alternative analysis, to be completed with the resource agencies, to explore options that accomplish passage goals and efficiency while preventing any impacts to the operations of the SAPPI Somerset Mill.
Alternatives, such as a Nature Like Fishway (NLF), may be feasible, practical and a reasonable alternative and that could improve the chances for Brookfield to meet agency goals and ESA requirements for passage efficiency and timing. This type of fish passage approach was used at the Howland site on the Piscataquis River successfully. Kleinschmidt, Brookfield's fisheries consultant, provided the following statement on that project "Fish passage effectiveness studies have shown that fish passage survival and efficiency is near 100% and exceeds the performance standards set by agencies to support species recovery. The project has also met the needs of the

---

[8] Accession Number: 20170526-5061

local population to assure agreed-upon impoundment levels."[9] While the Shawmut concept differs from Howland in the hydraulic head, spillway length, channel length, and operating status, it is of a reasonably similar scale, shares common configurational characteristics (long, competing spillway and other conveyances), and is a useful point of reference for the schematic NLF channel layouts. The proposed concept would meet agreed upon impoundment levels that would prevent any operational impacts to the Sappi Somerset mill.
MDMR recommends that Brookfield be required to follow the USFWS Fish Passage Engineering Design Criteria (2019) in designing and installing a full depth guidance structure. The structure should be angled relative to the bulk river flow and have a surface area of adequate size to ensure normal velocities of less than two feet per second across operating conditions. In 2011, the Licensee consulted with the resource agencies, conducted CFD modeling, and developed conceptual plans for an angled bar rack FERC should require this be implemented using updated USFWS Fish Passage Engineering Design Criteria (2019).[10]

Recommendations for the Weston Project
The Weston Project comes with added complexity due to a second channel. MDMR believes that current fishway proposal will be inadequate due to false attraction of fish to the secondary channel. MDMR believes it would be impossible for Brookfield to meet their own efficiency and timing standards for upstream passage without additional actions based on the false attraction issues for salmon and would certainly not meet MDMR goals for other species based on past performance of similar projects. The new information from Rubenstein (2021), site conditions, and existing information at fishways (Table 2) provides a reasonable basis to find solutions that address the complexity of this site. MDMR recommends that FERC require the development of alternatives, with agency input and approval, of a second fishway to be constructed concurrently with the existing fishway. MDMR also recommends the current fishway proposal be amended to include a second entrance to reduce delay of fish that approach the project from the opposite side of the powerhouse.

MDMR recommends that Brookfield be required to follow the USFWS Fish Passage Engineering Design Criteria (2019) in designing and installing a full depth guidance structure. The structure should be angled relative to the bulk river flow and have a surface area of adequate size to ensure normal velocities of less than two feet per second across operating conditions. The existing information from salmon smolt survival studies at the project provides reasonable basis for the need to implement this downstream fish passage measure proactively. Specifically, studies at Weston in 2013-2015 demonstrated that the debris boom at the project failed to guide

---

[9] Klienschmidt Group. (2017). Kleinschmidt Project Concludes Successful River Restoration in Maine [Press release]. Retrieved from https://www.acec.org/default/assets/File/2017-18%20FF%20Kleinschmidt-Howland%20Bypass%20PR.PDF.

[10] The Forebay Rack and Sluiceway Plan and CFD Modeling will be filled as an attachment to this filing. The concept designs for the Forebay Rack and Sluiceway will be filled separately as Critical Energy Infrastructure Information (CEII).

20-41% of smolts away from the current trash racks for the project turbines and those smolts were subsequently entrained.[11]

MDMR also recommends that FERC require the development, with agency input and approval, of a new downstream bypass at the South Channel dam adjacent to log sluice, which is currently proposed as the downstream bypass. The new downstream bypass should have both surface and submerged entrances and should be capable of passing a minimum flow of five percent of station hydraulic capacity in accordance with USFWS Fish Passage Engineering Design Criteria (2019). The existing information from Atlantic Salmon smolt survival studies at the project provides reasonable basis for the need to implement these downstream fish passage measures. The survival studies at the Weston Project have documented the log sluice as the route of passage with the lowest estimated survival.[12]

MDMR also recommends that FERC require the development, with agency input and approval, of a new project operation plan that would prioritize spill to ensure safe, timely, and effective downstream passage. Specifically, MDMR suggests the use of the Taintor gates or stanchion gates at the North Channel Dam should be explored during the downstream migration season. This measure is prudent because operation of the log sluice, which has a capacity of approximately 600 cfs and would be located directly adjacent to a new downstream bypass, would attract fish away from the new downstream bypass and therefore reduce survival of downstream migrants.

Recommendations for Analysis

MDMR requests that FERC compare mortality without and with full-depth screening at each of the four projects for all target species, with a focus on achieving mandatory conditions and MDMR performance standards. Specifically, FERC should conduct a blade strike analysis for each of the four projects for the following target species/life stages (adult and juvenile Atlantic salmon, alewife, blueback herring, American shad; adult American eel; and juvenile sea lamprey). This analysis would be an expanded version of Table 7 of the DEA. Further, FERC should estimate minimum sizes of each of the target species/life stages (adult and juvenile Atlantic salmon, alewife, blueback herring, American shad; adult American eel; and juvenile sea lamprey) that would be physically excluded from trash racks with 0.5-inch, 0.75-inch, 1 inch, and existing bar spacing for each of the four projects. This analysis would be an expanded version of Table 8 of the DEA. FERC should also estimate the normal and sweeping velocities for these rack structures, which would be an expanded version of Table 9 of the EA.

When using fish numbers for analysis, MDMR recommends FERC use production potential estimates or recovery targets to inform the contrast between alternatives rather than comparisons using existing poor baseline conditions, represented by very poor fish passage numbers at Lockwood dam. If existing runs are used, they should be properly caveated and use the most up

---

[11] Accession Number: 20160329-5151. 239-240.

[12] ID. 239-246.

to date information. For example, 100,000 smolts are now stocked in the Kennebec annually in addition to egg planting and natural spawning, therefore returns will be higher based on inputs than they were historically and more smolts are passing the projects during their downstream migration. For Atlantic salmon, the federal agencies just developed and finalized a final recovery plan, which is also an accepted comprehensive plan, so analysis should be conducted to demonstrate how any proposed project with conditions would meet those recovery goals and be consistent with the federal comprehensive plan.[13]

MDMR also requests FERC assess all proposed downstream measures to ensure they meet USFWS design criteria for downstream passage. Criteria for downstream passage are summarized below. Please refer to the 2019 USFWS guidance document for detailed information.

1. 3/4-inch or less clear spacing to physically exclude American eel, smolts, and adult alosines.
2. Normal velocities (perpendicular vectors measured one foot upstream of the rack) of two feet per second, or less, in order to avoid impingement.
3. Sweeping velocities greater than, or equal to, the normal velocity to promote guidance to one or more bypasses.
4. An angled or inclined orientation such that the rack physically guides fish towards one or more bypasses.
5. A total bypass flow at a minimum of five percent of station hydraulic capacity.

New Information

Delays at dams impact spawning success and iteroparity rates in Atlantic Salmon (Rubenstein 2021)

Recent research by the University of Maine at Orono, in collaboration with MDMR, indicated that upstream migrating Atlantic Salmon were delayed below both Lockwood Dam and Milford Dam on average two to three weeks (Rubenstein 2021), which is much longer the 48-hour passage that will likely be required at each of four projects on the Kennebec. Salmon delayed below dams experienced a much warmer temperature regime than they would have experienced if their migration was not impeded by dams. The high temperatures encountered by salmon downstream of dams often exceeded lethal thresholds and more frequently exceeded temperatures determined to be stressful to Atlantic Salmon than fish that were able to reach cooler, upstream reaches (Rubenstein 2021, Frechette et al. 2018). Rubenstein (2021) directly linked the warmer temperature regime experienced by salmon below dams to loss of critical energy stores, which translated to reductions in spawning success, survival, and ability to repeat spawn (Rubenstein 2021).

[13] NMFS and USFWS. 2019. Draft Recovery Plan for the Gulf of Maine Distinct Population Segment of Atlantic Salmon.

OFFICES AT 32 BLOSSOM LANE, MARQUARDT BUILDING, AUGUSTA, MAINE
http://www.Maine.gov/dmr
PHONE: (207) 624-6550 FAX: (207) 624-6024

Using a bioenergetics model (Lennox et al. 2018) parameterized with observed Kennebec and Penobscot River water temperatures, run timing, and passage efficiencies, Rubenstein (2021) clearly demonstrated that delays incurred at dams greatly reduce spawning success and rates of iteroparity in the Kennebec and Penobscot rivers, relative to a "no-dam" scenario. Such impacts of delay are well supported for sea-run species in the literature (Glebe and Leggett 1981; Jonsson et. al. 1997; Bowerman et. al. 2007; Martin et al. 2015; Fenkes et al. 2016).

Observed delays were similar at the Milford and Lockwood fish lifts (Rubenstein 2021), therefore, MDMR suggests that delays at Hydro-Kennebec, Shawmut, and Weston projects could also be comparable, and associated with an increase in the number of fish that would run out of energy before spawning, presumably to die unless they abandoned their migration (Rubenstein 2021). Specifically, using Kennebec River temperatures and a no dams present scenario, 93% of the migrating adult salmon would be expected to spawn successfully, of which nearly 17.4% would have enough energy to survive spawning and have the chance to spawn again (Rubenstein 2021). Under a one dam scenario, the number of fish that would die before spawning increased from 7% (no dams) to 10.5%; with four dams, 37.4% of salmon would be expected to die before even one spawning attempt, a previously unquantified estimate (Rubenstein 2021). This effectively means that for salmon spawning in a river upstream of four dams (as is the case for the Sandy River), more than one out of three returning adults would die prior to spawning because of delays caused by the dams. This is additional incremental mortality previously not quantified.

Under the four-dam scenario (like that experienced by Atlantic Salmon returning to spawn in the Sandy River without trucking), a mere 4.9% would arrive on the spawning grounds with sufficient energy to survive spawning and migrate downstream as kelts (Rubenstein 2021). In addition, this research shows that reasonable estimates of delay at four dams result in an approximately 72% decrease in the number of fish that would have the energy to recondition after spawning, which allows fish to return to spawn again in subsequent years, between the no-dam scenario and the four-dam scenario, and further negatively impacts population persistence of the Distinct Population Segment (DPS). This estimate does not account for additive downstream passage mortality of kelts, which was predicted by NOAA to be 49%-58% in their August 28, 2020 preliminary prescription for the Shawmut project. Taken together, it is unsurprising that iteroparity rates for Atlantic salmon have been reduced to near zero in Maine rivers (Lawrence et al. 2016, Maynard et al. 2017, Rubenstein 2021) and recovery has lagged. Repeat spawning Atlantic salmon are predominantly female, contribute disproportionately to productivity, and increase population persistence, particularly in years of low maiden-spawner returns (Fleming 1996; Lawrence et al. 2016; Bordeleau et al. 2020).

Smolt Run Timing

Using rigorously collected long-term datasets of smolt run timing from multiple trapping locations across Maine, MDMR and NMFS have developed a tool that will enable annual prediction of the timing of passage of downstream migrating smolts at each dam in the Kennebec and Penobscot rivers. Following appropriate review, this tool could be integrated into adaptive management for the Kennebec River in a spill or turbine curtailment plan if proper screening is not provided. Following the USFWS Fish Passage Engineering Design Criteria (2019) pertaining to screening for downstream passage would likely eliminate the need for shutdowns or additional spill protocols and be protective of all trust species. However, if less than adequate screening is installed to prevent turbine entrainment, FERC should consider full turbine shutdowns during the projected period of the run to mitigate for any injury or mortality associated with turbine entrainment. As MDMR currently operates a Rotary Screw Trap in the Sandy River, real world information could also be utilized as appropriate, however continued funding for this project is not assured. During 2021, the first smolt was captured in the Sandy River on day 104 (April 14) and the last was captured on day 157 (June 6), for a total run duration of 53 days.

Climate Resilient Habitat

The United States Geological Survey (USGS) has developed a body of research and tools related to climate change forecasts for eastern salmonids, which can be found at https://ecosheds.org/. Within these tools is the Interactive Catchment Explorer (ICE), a visualization tool for exploring catchment characteristics and model predictions, as well as for identifying priority cold water, resilient catchments across the Northeast region of the United States. It is notable that under a variety of scenarios, the tributaries to the Kennebec that incorporate the Sandy, Carrabassett, and upper river to the Williams dam are highly resilient to climate change as compared to much of the remaining area of the DPS of Atlantic salmon. The mainstem of the Kennebec River is expected to heat up considerably, which will cause more stress on salmonids and Alosines if delayed at each project due to expected poor passage. To maintain Atlantic salmon in the United States will likely require more reliance on areas such as the Sandy River tributaries as the climate warms, which in turn requires highly effective passage.

Sea Lamprey Passage Studies

Sea Lamprey are important ecosystem engineers that condition habitat and import subsidies of marine derived nutrients into river systems (Kircheis 2004; Sousa et al. 2012; Nislow and Kynard 2009; Weaver et al. 2018). Facilitating safe and effective Sea Lamprey passage at dams can restore these important ecosystem services to upstream river reaches. The University of Maine at Orono and MDMR launched a two-year program in 2020 to assess passage of Sea Lamprey at Milford Dam on the Penobscot River to help determine efficiencies and project passage timing.

During 2020, a total of 50 Sea Lamprey captured at Milford Dam were transported downstream to Sandy Point on the eastern shore of the Penobscot River where they were internally tagged with VHF radio-transmitters and released. During 2021, a total of 100 Sea Lamprey were captured and transported downstream for tagging and release; half of the lamprey were released at Sandy Point on the eastern shore (N = 50), while the other half were released at the southern tip of French Island (N = 50). In addition to detection on stationary antennas, an intense active tracking effort was employed in 2021 to identify the paths used by Sea Lamprey to return to the dam.

Approach time was very rapid during both years, with all Sea Lamprey returning to Milford Dam within 0 to 1 days. The high approach rate (100% in 2020) indicates that Sea Lamprey are wellsuited to passage studies, even though they do not home to natal reaches. Sea Lamprey entered the fish lift predominantly at night, indicating that dam passage measures implemented at night can very effectively promote passage. Additionally, the location of release (Eastern versus Western shore) did not influence search behavior or passage success.

Passage efficiency was variable both within and between years, with tagged Sea Lamprey exhibiting greater passage efficiency in 2020 than 2021. During 2020, the average time between approach and passage was two days, whereas during 2021, lamprey took 3 (Eastern release group) and 4 days (Western release group) to pass the dam after approach. The passage success rate was also slightly higher in 2020 (82%) than in 2021 (70% for the Eastern release group and 73% for the Western release group).

Sea Lamprey that successfully passed Milford Dam made extensive (>50 km) movements upstream, indicating a high capacity for the restoration of these fish and they ecosystem services they provide in response to effective passage at dams.

References

Frechette, D., Dudgale, 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, Canadian Journal of Fisheries and Aquatic Sciences 75:1999-2010.

Lawrence, E., Kaparinan, A. Hutchings, J. (2016). Influence of Dams on Population Persistence in Atlantic Salmon (Salmo salar). Canadian Journal of Zoology. 94(5). DOI:10.1139/cjz-2015-0195

Lennox, R. J., E. J. Eliason, T. B. Havn, M. R. Johansen, E. B. Thorstad, S. J. Cooke, O. H. Diserud, F. G.Whoriskey, A. P. Farrell, and I. Uglem. 2018. Bioenergetic consequences of warming rivers to adult Atlantic salmon *Salmo salar* during their spawning migration. Freshwater Biology 63(11):1381–1393. Blackwell Publishing Ltd.

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

Maynard, G. A., L. K. Izzo, and J. Zydlewski. 2018. Movement and mortality of Atlantic salmon kelts (Salmo salar) released into the Penobscot River, Maine. Fishery Bulletin 116.

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

Rubenstein, S.R. 2021. Energetic Impacts of Passage Delays in Migrating Adult Atlantic Salmon. Electronic Theses and Dissertations. 3468. https://digitalcommons.library.umaine.edu/etd/3468

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.

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.

Appendix A

MDMR Response to Brookfield October 2021 Review of MDMR Kennebec River Anadromous Fish Modeling Efforts and Fish Passage Needs for Atlantic Salmon, American Shad, Blueback Herring, Alewife, and Sea Lamprey.

MDMR has worked with the University of Maine, NOAA Fisheries Science Center, and numerous other partners to develop fish passage goals and performance standards that represent the best available scientific and commercial information. The fisheries goals and population dynamics that inform fisheries passage recommendations were developed independent of any predefined outcome and were not "intentionally manipulated" as Brookfield suggests in their comments. It is Brookfield and their consultants who are intentionally manipulating data to arrive at a pre-determined outcome to do the least possible for the fisheries resources of Maine. MDMR has not yet received any information from Brookfield as to how these projects will in fact meet their own stated goals, let alone be conducive for recovery of ESA listed Atlantic salmon and even a small portion of the potential production of millions of sea-run species. Any references and responses to Brookfields comments that reference the "Amendment" are outdated and irrelevant as MDMR has withdrawn that amendment proposal. Our responses are based on items we have included in comments, not the withdrawn amendment.

Brookfield's comments are italicized, and MDMR response appear after each comment in bold in Appendix A and B.

I. Introduction

"The following document provides Brookfield White Pine Hydro's detailed review and comments on MDMR's Kennebec River modeling efforts for Atlantic salmon and American shad. MDMR undertook these modeling efforts initially in late 2020 and into 2021 in support of a proposed rulemaking to amend the 1993 Kennebec River Management Plan (referred to here as the "2020 Plan Amendment")."

Brookfields's statement is incorrect. MDMR undertook the modeling exercise for salmon in 2019 following our September 8, 2017 comments to FERC that performance standards for salmon would have to be better than those in the Penobscot (96% DS and 95% US) based on the location and number of dams; fish passage discussions with the Licensee in 2018 that proved to be fruitless; and the May 11, 2019 Draft Biological Assessment (BA) which included performance standards that were determined to be less protective for salmon than those in the Penobscot. This is particularly important given that all of the high quality salmon habitat is above four dams in the Kennebec as opposed to the Penobscot where high quality habitat can be found above the first dam. MDMR contacted Dr. Daniel Stitch about his shad model approximately one year after his paper was published in a peer reviewed journal on July 30, 2018. MDMR supported the alewife model development through an International Joint Commission funded effort well before commenting to FERC on the Kennebec projects. MDMR staff also initiated the Sea Lamprey studies to inform fish passage standards earlier than Brookfield claims.

II. Detailed Comments on Atlantic Salmon Modeling
i. Applicability of the Model
"Deterministic population models do not account for annual/environmental variation, and therefore professional modelers caution that such models should be limited to assessing general trends, and to inform management decisions."

The deterministic model developed by MDMR was not used to predict the "probability of salmon recovery" as asserted by Brookfield. Rather, MDMR used the deterministic model to inform management decisions that could enable salmon in the Merrymeeting Bay SHRU, specifically the Kennebec River, to meet demographic recovery targets laid out in the 2019 Atlantic Salmon Recovery Plan (NMFS and USFWS 2019). MDMR therefore maintains that the use of the deterministic model was appropriate for making management recommendations. Because a stochastic model, incorporating annual and environmental variation, is not yet available for the Kennebec River, MDMR maintains that its deterministic model based on best-available data was an appropriate tool for informing upstream and downstream passage standards for the Kennebec River and represents the best available information. Further, use of a stochastic model would be expected to result in the need for stricter protection measures for Atlantic salmon, as a population viability analysis would certainly show that low populations require more assurances that impacts would be minimized and performance would be higher, not lower.

Brookfield states that MDMR recommendations "are inconsistent with passage survival goals established by federal agencies responsible for Atlantic salmon restoration and management.

As previously mentioned, the federal demographic goal for the Merrymeeting Bay SHRU is 2,000 returning adults (NMFS and USFWS 2019), most of which would need to be produced in the Kennebec River (NMFS 2009). MDMR is the only agency to date that has analyzed fish performance needed to achieve that goal, which is based primarily on the NOAA dam impact study assumptions. NOAA fisheries has not commented on the performance standards other than to signal that the goals must be higher than in the Penobscot. Upon this suggestion, Brookfield then, without scientific justification, made the performance standard one percentage point higher than in the Penobscot, without proposing any specific measures that would help achieve this, and has misrepresented that NOAA now accepts that standard, which it has not. It is unreasonable to believe that Brookfield can achieve its own standards and is likely attempting to delay capital expenditure while assuming there will be a lack of accountability when they inevitably do not meet even their own stated goals. Unfortunately, they have a good track record of delaying meaningful improvements in fish passage at other projects, including these projects, even when required standards are not met. Given the proactive conservation mandate of FERC in Section 7(a)(1) of the Endangered Species Act and case law that demonstrates that ESA species protection should be paramount and timely without consideration of costs, this type of deceptive strategy by Brookfield should not be allowed to be perpetuated.

OFFICES AT 32 BLOSSOM LANE, MARQUARDT BUILDING, AUGUSTA, MAINE
http://www.Maine.gov/dmr
PHONE: (207) 624-6550 FAX: (207) 624-6024

Brookfield repeatedly challenges the use of non-peer reviewed data by MDMR and at the same time asserts that MDMR should have used as model parameters data from recent but as yet unpublished studies.

MDMR uses the best available data, most of which is sourced from peer reviewed literature. Brookfield should demonstrate how their proposed action is compatible with species recovery as defined in the federal recovery plan. MDMR agrees with Brookfield's assertion that more salmon in the Sheepscot River and other areas within the Merrymeeting Bay SHRU (that are outside of the Kennebec River) would benefit the DPS overall. However, MDMR has a focus on the Kennebec River upstream of Weston Dam because the vast majority of the most climatically-resilient, high-quality spawning and rearing habitat within the SHRU is the Sandy River, the Carrabassett River and upper Kennebec River. These habitats represent the areas with the greatest recovery potential (NMFS 2009). A new tool developed by USGS (https://www.usgs.gov/apps/ecosheds/ice-northeast/) demonstrates that under a variety of climate scenarios, much of the Atlantic Salmon habitat in Maine will be too warm, however the Sandy River, Carrabassett, and upper Kennebec will remain suitable.

ii. Model Assumptions
a.Freshwater Mortality
Brookfield suggests that MDMR underestimates natural mortality based on "empirical estimates of the smolt freshwater mortality rate from the Penobscot River are roughly two to four times higher".

To be clear – this is the natural mortality in freshwater before smolts have passed any dams. The mortality specific to the Kennebec (0.0060 in 2014 and 0.0146 in 2015) occurred after the smolts had passed four dams. The studies that Brookfield suggests using are non-peer reviewed. MDMR used the best available data for the analysis which in this case was the peer reviewed paper. Any relative changes in an assumption of natural mortality would not change the proportion of the incremental impacts of the projects to fish. If natural mortality is in fact greater, that should require more protections from Brookfield as there would be fewer fish and more of an impact of the projects on population dynamics.

b. Natural Smolt Mortality in the Estuary
Brookfield suggests that MDMR should have considered data from a two-year study of smolt timing and survival from the Kennebec River in 2015 and 2016.

MDMR agrees that this would have been useful to consider site specific data; however, the Kennebec smolt study was limited to 100 smolts in both years combined and is still in the process of being peer reviewed. MDMR determined that the best available data was from Stevens et all (2019), which was also used by FERC in its analysis in the DEA.

d. Delayed Mortality
Brookfield suggests that telemetry studies results conducted on the Kennebec River demonstrate that MDMR"s model assumptions are wrong.

Once again MDMR used the best available data which in the case was both Stich et al. (2015) and Stevens et al. (2019). Brookfield's study in the Kennebec was extremely limited in scale and scope and was not peer reviewed or published.

e. Marine survival
Brookfield states that "the marine survival rate used by MDMR to inflate model outcomes in their salmon model is very high, unrealistically optimistic with little support and out of step with current survival rates going back decades".

MDMR's models are based on best available data and are scenarios, meant to demonstrate results of different management outcomes under low, medium, high, or very high marine survival. Brookfield and consultants have little expertise in this matter and fail to understand the point of the modeling. Fish passage is a controllable action whereas marine survival is highly variable and beyond control of FERC, therefore the models focus on the relative impact of the projects, which stays constant regardless of the marine survival rate used in a particular scenario. While it is very difficult to meet the demographic criteria in the recovery plan under low marine survival, modeling shows it is possible with highly effective fish passage and the right freshwater and marine survival conditions. The goals of 500 and 2000 fish are clear and part of an accepted comprehensive plan (USFWS and NOAA 2019). FERC has an affirmative mandate to assist in recovery of Atlantic salmon, which requires meeting those standards, under the ESA, and must ensure its actions are consistent with comprehensive plans. If recovery were impossible, the federal government would not have spent years developing the recent recovery plan and submitted it to FERC as a comprehensive plan.

Many of the marine survival estimates are empirical data from Maine rivers collected by MDMR and adjusted for PSAR (post-smolt to adult returns) according to the methods of Stevens et al. 2019. The marine survival estimates used are consistent with those used in the DIA model (Figure 3.9.4; for the base case, 90% of marine survival values for 1969-2008 ranged from 0.00124-0.01782, mean~0.00627, median = 0.00436; std dev~0.00598; marine survival was increased by a factor of 4 for the recovery case) and are considered reasonable by MDMR. Data for scenarios also used available Rotary Screw Trap estimates, which have reached marine survival rates of those considered in the last decade. For example, the Narraguagus River had a smolt to adult marine survival estimate of 2.7% in 2018 and the East Machias has averaged almost 2% marine survival since sampling started in 2013, with a high of 2.8% (USASAC Annual Report 2020). Baum (1983) uses 4% and other literature has historic rates above 6%.

f. Smolt Production
Brookfield suggests that the model overestimates the smolt production from rearing habitat and does not take into account potential effects of climate "change, water quality and pollution, sedimentation, non-hydro watershed connectivity issues and the presence of competing or predatory native and non-native fish species such as the pervasive smallmouth bass".

The direction and magnitude of these types of environmental changes specific to the Kennebec River are not possible to predict from currently available data. However it should be stated that the production estimates that MDMR used are the best available and are expected to encompass both high mortality and low mortality across the landscape.

The model used both a low (1 smolt/habitat unit) and high (3/unit) of smolt production and are based on best-available data. The low estimate was from empirical data collected in the Merrymeeting SHRU by MDMR and vetted through the Atlantic Salmon Assessment Committee (USASAC 2017). The high estimate was from published values in the peer-reviewed literature (Legault 2004, Orciari et al. 1994).

g. Spawning and Rearing Habitat
In this section Brookfield suggests that MDMR does not take into account Modeled Habitat below the Weston Dam.

MDMR agrees that it did not take this estimate into account in our production estimates. The Atlantic salmon juvenile rearing habitat model is a relatively coarse measure of gradient and does not reflect the ability to produce smolts. MDMR utilized its understanding of the Kennebec drainage, based on over 15 years of juvenile and adult assessments, to predict areas that meet the requirements for smolt production. While some localized areas below Weston Dam may be able to produce smolts it is expected to be of no significance in comparison to higher in the drainage.

References

Baum, E. T. 1983. The Penobscot River: An Atlantic Salmon River Management Report. Bangor.

Legault, C. M. 2004. Salmon PVA : A Population Viability Analysis Model for Atlantic Salmon in the Maine Distinct Population Segment. Northeast Fisheries Science Center Reference Document 04–02(January):98.

NMFS. 2009. Biological valuation of Atlantic salmon habitat within the Gulf of Maine Distinct Population Segment. Northeast Region, Gloucester, Ma.

NMFS and USFWS. 2019. Draft Recovery Plan for the Gulf of Maine Distinct Population Segment of Atlantic Salmon.

Orciari, R. D., G. H. Leonard, D. J. Mysling, and E. C. Schluntz. 1994. Survival, Growth, and Smolt Production of Atlantic Salmon Stocked as Fry in a Southern New England Stream. North American Journal of Fisheries Management 143:588–606.

Stevens, J. R., J. F. Kocik, and T. F. Sheehan. 2018. 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:1–13.

Stich D. S., Timothy F. Sheehan, and Joseph D. Zydlewski. A dam passage performance standard model for American shad. Canadian Journal of Fisheries and Aquatic Sciences. 76(5): 762-779. https://doi.org/10.1139/cjfas-2018-0008

USASAC (United States Atlantic Salmon Assessment Committee Report). 2017. Annual Report of the U.S. Atlantic Salmon Assessment Committee Report No. 30 – 2017 Activities. Annual Report 2017/30. Portland Maine – February 26-March 2, 2018. 129 pp. and appendices.

USASAC (United States Atlantic Salmon Assessment Committee Report). 2020. Annual Report of the U.S. Atlantic Salmon Assessment Committee Report No. 33 – 2020 Activities. Annual Report 2020/33. Virtual Meeting – March 1-March 5, 20201. 99 pp. and appendices.

III. Detailed Comments on American Shad Modeling

Section 6.0 of the MDMR July 17, 2021 Kennebec River Factual Background document identifies the goal for American Shad as to provide safe, timely, and effective upstream and downstream passage in order to achieve a minimum annual return of 1,018,000 wild adults to the mouth of the Kennebec River; a minimum annual return of 509,000 adults above Augusta; a minimum of 303,500 adults annually passing upstream at the Lockwood and Hydro Kennebec Project dams; a minimum of 260,500 adults annually passing upstream at the Shawmut Project dam; and a minimum of 156,600 adults annually passing upstream at the Weston Project dam." In order to achieve a minimum annual returns for the species to the Kennebec River, upstream passage of adults would need to be at least 70% effective at each of the four dams and downstream passage of adults and juveniles at each of the four dams would need to be at least 95% effective."

Rationale for these performance standards is provided by MDMR in Section 3.6 of the recently withdrawn proposed 2020 amendment (2020 Amendment) to the 1993 Kennebec River Resource Management Plan which described a stochastic, life-history based, simulation model10 developed by Dr. Daniel S. Stich (Stich 2020). This model is evidently similar in concept to a model previously developed for Penobscot River shad (Stich et al 2019). MDMR notes that "Dr. Stich ran 48 scenarios to explore the effects of downstream passage survival (1.00, 0.95, and 0.90) in combination with varying upstream passage efficiency (0.70-1.00) and time-to-pass (1, 3, 7, and 20 days per dams) on American shad distribution and abundance in the Kennebec River."

The model is not only similar in concept to the Stich et al. (2019) and Stich (2020) model, it is in fact the same model but uses life-history data specific to the Kennebec River (age and growth, maturity, and mortality) based on updated estimates from ASMFC (2020) and Gilligan et al. (2021).

BWPH acknowledges the utility and usefulness of the Stich et al. (2019) model with regard to understanding the impacts of several passage scenarios on a simulated population of American shad. That said, MDMR has used results from this apparently unreviewed Kennebec River version of the model to recommend specific outcomes that range up to and include dam removal. Given the costly and far-ranging impact of these recommendations, BWPH would like to address questions regarding the appropriateness of the application of the Stich model by MDMR in addition to questions regarding specific parameters assigned/utilized by MDMR during the model evaluation process.

This is the same model that was previously published but with system-specific inputs, just as Stich et al. (2019) indicated was readily achievable and has since been updated as indicated in Gilligan-Lunda et al. (2021) based on new information from ASMFC (2020).

The software package that runs the model was updated to include this and several other rivers (Gilligan 2020) and to incorporate user-facing options for testing sensitivities to various assumptions. The model itself has, in effect, been continually reviewed and updated based on best available information but is still the model that was published originally.

i. Applicability of the Model

First, the model described in Stich et al. (2019) is undoubtedly very comprehensive and well parameterized. Despite this, the Stich model still has limitations in its applicability which are rooted in the inherent assumptions behind the model and the overall model type. The dam passage performance model for American shad presented in Stich et al. (2019) is an individual based model (IBM) with a one-dimensional movement analysis incorporated. The model focuses on the mean modeled population projections as indicators of the necessity of specific suites of passage performance criteria to achieve Plan targets. That approach is misapplied because it undermines the inherent stochasticity of the model and considers the result as deterministic. The model incorporates environmental stochasticity and inter-annual variability by drawing from parameterized distributions for many input variables. It is appropriate to use the model as a tool to assess the relative population trends, but not to consider the output as deterministic.

It is unclear here how the approach undermines the stochastic nature of the model. The software package still allows assessment of sensitivity. All graphical results of the 48 management scenarios run were presented as mean and 95% confidence intervals to show uncertainty associated with stochastic inputs. Population trends within the results were the output that was used to inform potential passage criteria based on a wide range of potential scenarios.

In a simplified sense, the model utilizes several pre-defined parameters of importance such as the starting total number of age-1 individuals in the population, marine survival, and temperatures of initial and terminal spawning dates, in addition to several derived parameters based on arrival date in the estuary and several biological characteristics such as growth and fecundity parameters which are interpolated from data obtained in the Connecticut River, not the Kennebec River.

Life-history parameters are specific to the Kennebec River or are based on ASMFC (2020) regional and stock-specific estimates as indicated in the software documentation and on the website. Any phenological events (e.g., initial and terminal spawn dates) are based on relationships to temperature and are thus transferrable between systems by inputting system-specific temperature data. These details are described in Stich et al. (2019) and are extensively documented both in the software package documentation and on the software website.

ii. Evaluating Model Fitness

The greatest limitation of using an IBM-type model for projecting fish populations may be the inability to calibrate the model to observed data such as count data. This is a critical step in the review of a model prior to its use to make management decisions because it will reveal whether the model is capable of accurately representing the species in question.

Assessing a model's fit to an observed data set gives the model developer and managers an opportunity to evaluate their model performance in comparison with what is being observed in the river system in question. Some model types lend themselves to an analysis of retrospective 'peels,' which will indicate whether a model tends to over-predict, under-predict, or if the model can be considered accurate within an acceptable margin of error. This stepwise process allows for step specific assessments of model fit and for adjustments to be made post-hoc to improve model performance, explanatory capability, and increase the accuracy or reliability of model outputs.

MDMR agrees that calibrating the model to count data from the Kennebec River would be ideal. Unfortunately, American Shad simply are not attracted to the entrance of the Lockwood Project fish lift and annual counts are mostly zero. However, this does not negate the "the utility and usefulness of the Stich et al. (2019) model with regard to understanding the impacts of several passage scenarios on a simulated population of American shad" as stated by Brookfield.

Unfortunately, this is not possible for an individual based model because it must run out the amount of time specified in the simulation and because it is based only on a few initial pieces of data, rather than continuously collected data. As a result, there is no quantifiable metric by which to decide whether the simulated adult returns predicted by the Stich model are representative of the observed data collected by MDMR and Brookfield biologists each year.

We are uncertain what is meant by "it must run out the amount of time specified in the simulation". The software package can be used to run retrospective peels by simply running it for a given set of conditions representing different years. If fish passage and fish abundance are both "known" in a given year, the model can easily be used to assess whether predictions match observations. In reality, passage rates, true abundance states, and exploitation rates are virtually never "known", so models such as this or others are frequently used to understand "potential" values of passage, fishing mortality, etc., based on what we do know (estimates of fish growth and mortality, fecundity, recruitment rates, etc.).

iii. General Model Assumptions

Within the selection of model type and parameter assignments, there are several assumptions, including:

• There are no significant differences in population structure, individual behavior, or biological parameters between shad in the Connecticut River and shad in the Kennebec River; and

Neither the model nor the software package makes any assumption about population structuring. In fact, the model was developed as an IBM due to current lack of indication about population structuring or homing at the sub-catchment level (Hasselman 2010).

• Fish make only one attempt at passage per day. And if the fish fails to pass, then it is assessed a time delay penalty of 24 hours. In reality, fish can and do make multiple attempts to pass upstream within a 24 hour period.

This was a simplifying assumption in Stich (2019). It is not an inherent assumption of the current model.

• Fish move upstream regardless of saturation of the downstream spawning habitat and the energetics of continued migration.

There is no scientific evidence to date that suggests Alosine fishes move upstream regardless of habitat saturation and energetics. Energetics is directly related to phenology because of seasonal changes in temperature. Phenological events within the model are based on temperature due to previous findings (Castro-Santos and Letcher 2010).

• The model currently includes an unrealistic single, common downstream passage effectiveness/survival input value for both adult and juvenile shad. It should include separate effectiveness/survival input values for each life stage.

The current version of the software package includes separate adult and juvenile passage efficiencies.

a. Marine Survival

Additionally, following the assumption that the model input parameters and output results are representative of shad in the Kennebec River, it is explicitly stated by Stich (2019) that the shad passage model outputs are highly sensitive to changes in the parameter estimate for marine survival, which is based on age-invariant rate of 0.62 (62%) for each annual period from young of year up until age-9 (maximum age in model) (ASMFC 2007).

Although a range of values were considered, Stich explicitly states "our ability to make more precise predictions would be improved by better information." This raises the question of the appropriateness of assuming not only a constant mortality across age classes, but also the validity of assuming that this rate of survival has remained unchanged over the past 14 years.

Lacking information, the Stich model incorporates a fixed rate of at-sea mortality within a given model run. Most fish species exhibit a type III survivorship pattern where mortality losses are generally associated with the earlier portion of life. Whereas assumption of a constant marine survival rate for older shad may be appropriate, the assumption of a single representative rate for first year fish with repeat spawners may not be appropriate.

Although the Stitch [sic] model accounts for simulated variability in this parameter, it is still informed by a single value which may be outdated and misrepresentative of the various age classes present in the population at any given moment.

The model does not use a fixed age-invariant mean of 0.62. Also, M of 0.62 is not equal to 62% annual because it is an instantaneous rate. This suggests a fundamental misunderstanding of how fishery mortality rates are applied. The model was updated during the most recent stock assessment as documented in ASMFC (2020), Gilligan (2020), Gilligan-Lunda et al. (2021) and in the software documentation and website. The model now uses regional- or system-specific estimates of growth and mortality based on these most recent and currently most reliable estimates from coast-wide stock assessment. As additional data become available (e.g. age-variant mortality rates) they will continue to be incorporated, but no such scientifically supported estimates currently exist to our knowledge.

b. Assumed Similarity of Connecticut River Population Data

Stich (2019) also states explicitly that "model outputs were sensitive to changes in growth of American shad in this study. This indicates that system-specific data would be preferable to using growth information from the Connecticut River population." This statement inherently casts doubt on the usefulness of the current Kennebec River model, as the incorporation of Connecticut River shad data may be likely to exhibit significant differences in key biological parameters that would have a large influence on model outputs. MDMR has provided no evidence that these differences were explored or considered, furthering the question of whether or not this model is appropriate to forecast Kennebec River shad populations.

Please see previous response. The data in the model are region- or system-specific depending upon availability of data or estimates. They are not derived exclusively from the Connecticut River.

c. Assumed Passage Attempts per Day

Furthermore, a critical assumption that is not explored in the Stitch et. al. (2019) publication is that fish make only one attempt at passage per day. This is evidenced in the upstream passage model description when Stitch et. al. (2019) states that "each fish was allowed one attempt per day to pass a dam."

Despite the various parameters that were highlighted in the model's sensitivity analysis as having a large influence over the output, this critical assumption is not tested and it does not *appear that any variability in passage attempts has been, or can be, incorporated into the models constructed by MDMR.*

This unquestioned assumption is a potential fatal flaw: diadromous species approaching a dam, as has been well documented, can make several attempts at passage per day. MDMR has not discussed or supported their upholding of this assumption with any literature or observational evidence to indicate how this assumption may impact model results or impact the various time-to-pass parameters explored by MDMR.

This was a simplifying assumption in Stich et al. (2019). It is not an inherent assumption of the model. Users may adjust upstream passage efficiencies to achieve whatever justifiable number of attempts per day they choose.

iv. Lack of Detailed Documentation

As noted above, it is worth addressing these questions regarding the appropriateness of MDMR's use of this model as a means of making projections about shad populations to assess the proposed passage criteria in this amendment. In the 2020 Amendment MDMR stated the use of 48 scenarios under which three values of downstream passage survival were used with a combination of four values of delay and a range of passage efficiency values.

However, this model building process is not described in any detail that would indicate the results of each of these 48 scenarios, no tables were provided stating the assumed starting values needed to run these model scenarios, the number of iterations within each scenario is not described, and, most importantly, there is no discussion of which specific scenario(s) (and with what parameters) rendered the proposed passage criteria in this amendment.

The 48 scenarios included all possible combinations of variable upstream passage efficiency (0.7. 0.8, 0.9,1.0) applied over different upstream passage times (1, 3, 7, or 20 days) and with variable downstream passage efficiencies for adults and juveniles (0.9, 0.95, and 1.0). The impact of these scenarios on catchment-wide abundance, abundance upstream of the Weston Dam, and projected abundances under a seasonal timing standard was modeled. For each scenario run, the values for input parameters were randomly sampled, and each 50-year simulation repeated 50,000 times. These parameters and the relative distribution of spawning habitat in the Kennebec River are the only parameters that are not explained in Stich et al. (2019) or other citations herein/in software package.

v. Lack of Peer Review Input

As described by MDMR, the shad passage model used to inform the passage standards provided in Section 6.2 of the 2020 Amendment comes from the 'Shadia' package in the statistical program R published by Dr. Stich. On the provided website and in the subsequent links it is stated: "These models are in various stages of completion but are provided for transparency in their development and application [emphasis added]."

Specific to the Kennebec River shad model, "This model has undergone preliminary review with fishery and habitat managers at Maine Department of Marine Resources and the National Oceanic and Atmospheric Administration Habitat Division." It is unclear from either the website or content provided by MDMR as to what the preliminary review has consisted of or whether or not the issues described above have been considered.

To be clear: this statement on the website exists to prevent individuals from using these tools inappropriately or without thought. It is not because the model "still needs to be peer-reviewed".

vi. Conclusions

While Stich et al. 2019 remains a useful tool to evaluate potential population impacts, MDMR relies on an unreviewed, and largely undocumented Kennebec River American shad model to develop recommendations that would have significant cost and social implications. A review of the model results as depicted in the 2020 Amendment raises significant questions regarding the applicability of the model, fundamental assumptions loaded into the model, and as such any conclusions MDMR has drawn from limited use of the model.

The vast majority of the model is unchanged from the original, aside from incorporation of updated scientific information for species (American shad and blueback herring) and systems (temperature data and habitat amounts/configuration relative to dams). It is unclear at this time why the tool is any less applicable to the Kennebec River than it is to any of the other six rivers to which it has been applied (including to inform criteria on Penobscot and Connecticut rivers). It is not unreviewed and undocumented. It is a modification to a published model and is extensively documented within the software used to run it: software that is freely available and openly versioned.

References

ASMFC (Atlantic States Marine Fisheries Commission). 2020. 2020 American Shad Benchmark Stock Assessment and Peer Review Report. http://www.asmfc.org/uploads/file/5f999ba1AmShadBenchmarkStockAssessment_PeerReviewReport_2020_web.pdf

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.

Gilligan, E. K. 2020. Understanding climate impacts on American shad recovery, fisheries management, and influences of dams. Master's thesis, State University of New York College at Oneonta, NY.

Gilligan-Lunda, E.K., D, Stich, K. E. Mills, M. M. Bailey, and J. D. Zydlewski. 2021. Climate Change May Cause Shifts in Growth and Instantaneous Natural Mortality of American Shad Throughout Their Native Range. Transactions of the American Fisheries Society. 2021.150: 407-421.

Hasselman DJ (2010) Spatial distribution of neutral genetic variation in a wide ranging anadromous clupeid, American shad (Alosa sapidissima). Doctoral dissertation. Dalhousie University, Halifax, Nova Scotia.

IV. Detailed Comments on Blueback Herring Modeling

Section 6.0 of the MDMR July 17, 2021 Kennebec River Factual Background document identifies the goal for blueback herring as "to provide safe, timely, and effective upstream and downstream passage in order to achieve a minimum annual return of 6,000,000 wild adults to the mouth of the Kennebec River; a minimum annual return of 3,000,000 adults above Augusta; a minimum of 1,788,000 adults annually passing upstream at the Lockwood and Hydro Kennebec Project dams; a minimum of 1,535,000 adults annually passing upstream at the Shawmut Project dam; and a minimum of 922,400 adults passing upstream at the Weston Project dam." In order to achieve the minimum annual returns for the species to the Kennebec River, upstream passage of adults would need to be at least 90% effective at each of the four dams and downstream passage of adults and juveniles at each of the four dams would need to be at least 95% effective."

Rationale for the upstream performance standard is provided by MDMR in Section 3.7 of the recently withdrawn proposed 2020 amendment (2020 Amendment) to the 1993 Kennebec River Resource Management Plan which described an unpublished stochastic, life-history based, simulation model developed by Dr. Daniel S. Stich (Stich unpublished). This model is evidently similar in concept to a model previously developed for Penobscot River shad (Stich et al. 2019) and which has been presumably modified to be representative for Kennebec River blueback herring. MDMR did not include any reference to a proposed downstream passage standard for adult or juvenile blueback herring as part of their recently withdrawn 2020 amendment.

Again, the model is not similar. It is the same model. Stich (unpublished) is not the appropriate citation for the software package or the mathematical framework to which it provides access.

Many of BWPH's comments and concerns regarding the Kennebec River blueback herring model echo our comments and concerns regarding the similar Kennebec River American shad model (Section III, above). BWPH acknowledges the utility and usefulness of the original Stich et al. (2019) model with regard to understanding the impacts of several passage scenarios on a simulated population of American shad.

That said, MDMR has used results from this unpublished and unreviewed model to recommend specific outcomes that range up to and include dam removal. Given the costly and far-ranging impact of these recommendations, BWPH questions the applicability of using this model to develop blueback herring passage standards without adequate peer review. Brookfield is also concerned about the near-total lack of documentation of model inputs or assumptions used in developing the model runs.

See the previous response. Extensive work has gone into review of model routines and inputs at state and federal levels during the past 7 years, including publication of the general modeling framework.

a. Applicability of the Model

According to the description provided by the author (Stich, unpublished) the current Kennebec River blueback herring model incorporates some species-specific data from the Hudson River and assumes the majority of movement data for the species are the same as that for American shad.

While BWPH understands the adoption of surrogate data for this less studied species, it does raise questions with regards to the predictive abilities of the model and the legitimacy and accuracy of the associated performance standards that are being put forth by MDMR for blueback herring specific to the Kennebec River.

There are no data from the Hudson River that are used in the Kennebec River implementation of the model. We assume the description being referred to above was that from the project website (https://shadia-ui.github.io/about_kennebec.html), which was updated some time ago to correct a typographical error that said this (due to use of a template for river-specific implementations). Perhaps this is where the comment above stems from?

Although the model described in Stich et al. (2019) is comprehensive and well parameterized, it was originally built and described exclusively for shad passage. This limitation was specifically recognized by Stich et al. (2019) wherein the author's state "Differences between species in addition to site-specific considerations further complicate this problem and preclude a one-size-fits-all solution of fish passage."

This was not the context of that statement in the paper, and it is unclear how it could be misconstrued as such. In fact, the paper suggested that the model would be readily adapted to other systems and species. This statement was saying there was not a one-size-fits all solution to how much passage is needed for each species and system.

i. General Model Assumptions

Further on Stich et al. (2019) notes that the model can be readily extended to other species given alterations to input data, such as biological parameters, path information, etc. However, MDMR has failed to present these parameters, how they are different from the shad model, and what evidence supports the use of these parameters and their assumed values.

The only differences are in species-specific life-history data, which have been collected through regular MDMR surveys and data warehousing.

Similar to details provided by MDMR in the 2020 Amendment for American shad, model details in the plan for blueback herring are limited to a single line describing a set of model scenarios. No supporting documentation associated with model inputs or the 48 outputs used to develop the proposed fish passage effectiveness standard for blueback herring are provided.

As described for the shad model, the 48 scenarios included all possible combinations of variable upstream passage efficiency applied over different upstream passage times and with variable downstream passage efficiencies for adults and juveniles. The impact of these scenarios on catchment-wide abundance, abundance upstream of the Weston Dam, and projected abundances under a seasonal timing standard was modeled. For each scenario run, the values for input parameters were randomly sampled, and each 50-year simulation repeated 50,000 times. These parameters and the relative distribution of spawning habitat in the Kennebec River are the only parameters that are not explained in Stich et al. (2019) or other citations herein/in software package.

V. Detailed Comments on Alewife Habitat and Production Estimates

Section 3.8 of the MDMR's 2020 Amendment to the 1993 Kennebec River Resource Management Plan (1993 Plan) lays out a series of measures to support restoration of alewife (Alosa pseudoharengus). MDMR claims that "In order to achieve a minimum number of spawners (608,200 adult alewife) to historic habitat in the Kennebec River, upstream passage of adults would need to be at least 90% effective at each of the four dams and downstream passage of adults and juveniles at each of the four dams would need to be at least 95% effective." MDMR explains that these passage standards were developed through alewife habitat and production estimate modeling.

Brookfield agrees that effective passage in both directions is vital to restore and maintain self- sustaining populations of migratory fish. However, a review of MDMR's explanation of how its new effectiveness standards were derived raises serious questions about MDMR's methodologies, documentation, and conclusions. MDMR appears to have inappropriately used a deterministic model, failed to adequately document and disclose its core assumptions, and then failed to discuss any reasonable alternatives to achieving its management goals.

The model and its core assumptions have been described by Barber et al. (2018) in a peer-reviewed journal. The model subsequently was adapted to provide an open-access tool to evaluate the impact of fish passage at dams. The user has the ability to define the river system – specifically how much spawning habitat is located upstream of a maximum of nine dams – and the ability to vary the upstream and/or downstream passage efficiency for adults and juveniles. One output is the estimated number of spawning adults after a specified number of years.

a. Applicability of the Model

A deterministic population model produces results that are entirely driven by the parameters that are programed into its calculations. Changing key assumptions in the inputs directly changes the output. While useful for many purposes, deterministic population models have several well-known and well-documented limitations.

All models (deterministic or stochastic) are entirely driven by the parameters programmed into their calculations.

In attempting to use this model on the Kennebec River, MDMR failed to heed the warnings and instructions explicitly stated by the model developers: that users of this model should "not make detailed predictions about the exact number of alewife that will return in a given time frame." (Barber et al. 2018).

Barber et al. (2018), explains that deterministic models such as this one address general trends in a population and can help inform management decisions by testing sensitivities within *life histories, but because variation in the spawning run is averaged, these models are not predictive.*

As a result, this model is intended for the sole purpose of comparing different management strategies and understanding their general impacts, but is unable to forecast accurate, well-informed projections of alewife abundance or population size. Barber et al. stresses that key assumptions of the model which can greatly impact model output must be kept in mind when interpreting the results of the model. Among these key assumptions are the following:

- *Environmental parameters are constant within and between years;*
- *Inputs values (life history, behavioral, and biological characteristics) are representative of that which is occurring in the natural system (i.e. the Kennebec River); and*
- *Quality of spawning habitat in the Kennebec River does not vary spatially.*

The reference cited (Barber et al. 2018) is inappropriate. The paper reported on nutrient dynamics and did not discuss the impacts of fish passage at dams. Nearly all of the assumptions and limitations noted by Brookfield appear in the technical documents section at https://umainezlab.shinyapps.io/alewifepopmodel/

The technical documents section states "The alewife population model was developed to compare theoretical spawner abundance between scenarios with different dam passage rates. Spawner abundance was calculated using a deterministic population model. This type of model defines inputs using averages applied to groups. A deterministic model is used to explore general trends and compare the results of scenarios when different average values are used as inputs. For example, we can compare the difference in spawner abundance at a dam when the average rate is 80% successful passage versus when it is 90% successful passage."

b. General Model Assumptions

As discussed above and as explicitly identified by model developers, the use of population-averaged input values is strongly discouraged in population modeling due to the uncertainty introduced by the failure to account for population variance, outlying values, etc.

Uncertainty has been introduced to these model outputs through the use of fixed environmental constants, population averaged input values, and through assumptions disregarding spatial variability (i.e. that St Croix alewife populations are biologically and behaviorally similar to Kennebec River populations in addition to assuming all habitat is of equal production quality).

MDMR has failed to provide any written or circumstantial evidence to justify these assumptions when making management decisions regarding alewife in the Kennebec River system. These are all assumptions which form the cornerstone of the model developers' warnings as to why this model is not intended and, more importantly, unable to make accurate, well-

informed projections of abundance or population size. Brookfield acknowledges the importance of this model as a tool for comparing management scenarios to understand general impacts and resulting trends but questions its appropriation as a population projection and management decision tool by MDMR.

MDMR agrees that a stochastic model would be more accurate than the deterministic model, but as Barber noted such a model would require a lot of data in order to provide a realistic range of values associated with each input. This amount of data is not available for the Kennebec River nor for the majority of alewife populations along the east coast of the United States (ASMFC 2017). This lack of data is evident from the source of parameter values used in the model (Barber et al 2018, Table 2). We are glad that Brookfield acknowledges the importance of the model as a tool for comparing management scenarios. For example, Figure 5 of the technical report shows that increasing downstream passage efficiency is more important than increasing upstream passage efficiency to maintain an adult age structure.

We note that the impact of dams can be assessed in the absence of any biological data. We used EXCEL to create a variation of Figure 4 (in Technical Documents), assuming 1) a starting population of 1000 fish that need to pass four dams to reach spawning habitat with (in ascending order) 90%, 80%, 80% and 90% efficiency, 2) downstream passage survival of 90% at each dam that a fish passed going upstream, and 3) no additional mortality. In the first year, 46.6% of the starting population spawned and 71.7% survived to reach the ocean. In the second year, 33.3% of the starting population spawned and 55.5% survived to reach the ocean. The question of course, is the population sustainable given this level of impact in addition to natural mortality.

c. Failure to Document Modeling Efforts

Ignoring the inappropriateness of this model to project alewife population estimates and the violated assumptions discussed, MDMR proceeded to use the model to develop upstream and downstream passage standards without providing the information necessary to support those specific requirements.

As can be seen in Figure 3 from the 2020 Amendment, MDMR's model lacks measurements of uncertainty around the estimate lines. It displays no confidence limits, no error bars, etc. on the forecasts generated from the population model to allow readers to see where the estimated populations sit relative to the Maine and ASMFC escapement goals. Lines presented in Figure 3 from the 2020 Amendment provide only the mean estimates of alewife spawner abundances for a series of upstream and downstream passage effectiveness rates relative to fixed values of mean Maine and minimum ASMFC escapement goals for the species. Failure to provide a measurement of error around those abundance estimates prevents the reader from understanding the magnitude of variation around those values.

Without referencing any form of uncertainty around the estimates, it is not possible to understand the margin of error behind these outputs, consequently bringing to question the reliability of the estimate. Presenting a single line with no variance is misleading and makes it look as though targets are either always achieved or never achieved, which is not realistic.

In 2017, MDMR reviewed multiple years alewife harvest data at multiple sites and determined that 235-400 spawners/surface acre of spawning habitat resulted in a sustainable population. We used this range of returns (multiplied by amount of spawning habitat in the Kennebec River above Waterville) as our confidence limits to assess passage efficiency using the alewife model. The goal was to find the level of upstream and downstream passage efficiency that would result in returns between the minimum escapement (235) and the average escapement (400). Only the 95% downstream passage scenario provided a range of upstream passage effectiveness less than 100%.

d. Failure to Consider Alternatives

It would be naïve to assume the proposed passage standards are the only viable way to achieve a return of adult alewives upstream of Lockwood Dam in excess of 600,000 fish, particularly given the success of adults returns observed in the adjacent Sebasticook River. Since 2006, alewife passage in the Sebasticook has regularly numbered 2-5 million individuals. At present, alewife returns to the Sebasticook must navigate the fish lift facility at Benton Falls (only designed to pass 600,000 alewives annually), the Burnham fish lift (design details not provided by MDMR in the 2020 Amendment) and the fish ladder at Sebasticook Lake. In addition to those obstructions there are several other fishways located at lake dam outlets within the drainage.

To BWHP's knowledge, these unexpectedly abundant returns to the Sebasticook River have occurred in the absence of comprehensive/rigorous passage efficiency studies at the three sites, application of passage standards at the three sites (such as the unrealistically demanding standards being required in the MDMR 2020 Amendment for the 4 mainstem dams owned by Brookfield subsidiary companies), and despite the seemingly under-designed fish lift at Benton Falls Dam.

The current abundance of alewife in the Sebasticook River occurred after removal of two mainstem dams two dams (Edwards and Fort Halifax), the construction of swim-through fish lifts at the two lowermost hydropower dams (Benton Falls and Burnham) in 2006, the construction of fishway at non hydropower dams at lake outlets, and years of maintenance stocking. Currently, in the Sebasticook 56% (2046 acres) of spawning habitat is above 2 hydropower dams, 33% is above 1 hydropower dam (1217 acres) and 11% (419 aces) is above no hydropower dams. During the upstream passage season the Licensee of the Benton Falls Project cycles the fish lift every 15 minutes.

e. Existing Passage and Stocking Conditions in the Kennebec River Basin

MDMR undertakes the trucking of migratory species from the Lockwood lift, including the trucking of river herring both within and outside of the Kennebec River basin. As shown in the table and figure below, an approximate average of 30% of the river herring captured at the Lockwood lift from 2009 to 2020 annually were trucked to other rivers and ponds outside of the Kennebec River basin. The MDMR's goals for river herring restoration on the Kennebec are perplexing given MDMR's current management practices of relocating river herring out of the Kennebec.

Brookfield is incorrect. According to MDMR's stocking database, we stocked 1,709,809 river herring from the Lockwood Project between 2006 and 2020 of which 91% were stocked in the Kennebec River basin. BREG's count for river herring lifted at Lockwood for that same time period is 1,998,487 individuals (per their 2020 report). In all but two years, the BREG number of fish lifted is greater than the number of fish MDMR stocked (Table 1). The discrepancy is due to fish being lifted without being stocked (e.g. more fish are lifted than the capacity of the stocking trucks and holding tanks, and the fish are sluiced downstream.).

References

ASMFC (Atlantic States Marine Fisheries Commission). 2017. *River Herring Stock Assessment Update. Volume I: Coastwide Summary. http://www.asmfc.org/species/shad-river-herring*

MDMR comments on the EIS for Lockwood, Shawmut, Hydro-Kennebec and Weston

Table 1. Reported number of River Herring counted and stocked in the Kennebec River.

Year	BREG count	DMR stocked	BREG minus MDMR
2006	4,094	3,152	942
2007	3,448	4,537	-1,089
2008	131,201	91,964	39,237
2009	45,969	45,436	533
2010	76,745	75,114	1,631
2011	37,847	31,094	6,753
2012	179,358	156,449	22,909
2013	103,242	105,255	-2,013
2014	115,667	108,282	7,385
2015	91,850	89,502	2,348
2016	224,990	206,971	18,019
2017	289,188	238,493	50,695
2018	307,035	237,453	69,582
2019	240,594	182,937	57,657
2020	143,259	133,170	10,089
Total	1,994,487	1,709,809	284,678

VI. Detailed Comments on Sea Lamprey Habitats and Kennebec River Populations

The sea lamprey population is not dependent on reproduction in the Kennebec watershed, nor spawning in any single river, or any given year.

MDMR does not necessarily agree with this statement, as the inputs from large watersheds such as the Kennebec may be critical to population viability. Poor to nonexistent Sea Lamprey passage on the Kennebec River dams has eliminated the important ecosystem services provided by this species from upstream reaches. The State's goal is to restore the full suite of co-evolved diadromous fish in Maine, which includes Sea Lamprey. Restoration of this species to river reaches upstream of dams on the Kennebec will restore these critical ecosystem functions and improve habitat for Atlantic Salmon and other species. FERC and Brookfield have a long record of providing specific passage for another species that does not hone to its natal rivers, American Eel. Sea Lamprey dispersal is likely much more limited (Spice et al 2012) that eels, therefore protections in the Kennebec are likely highly beneficial to continued runs in the Kennebec and surrounding rivers.

no management has ever been implemented in Maine MDMR

Brookfield is incorrect, as MDMR currently passes and manages Sea Lamprey on the Penobscot River. As such, the inclusion of Sea Lamprey management and restoration does not constitute a "dramatic shift in management" for this species within the state and instead represents a step toward righting past misconceptions and misinformation about the species (i.e., that they are detrimental to other fish species, when in fact they are not only not detrimental, they are beneficial). By including Sea Lamprey recommendations in our 10(j) comments, MDMR is indicating our contemporary goals for the species.

public opinion of Maine residents might be opposed to the presence of a non-threatened parasitic species in waters where prized game fish are present"

This conjecture is a misrepresentation of facts. Anadromous sea lamprey are NOT parasitic during their freshwater life stages in Maine. They are only parasitic during the marine phase of the life cycle, thus present no threat to prized game fish in Maine waters. Brookfield uses reference to an outdated management practice of culling Sea Lampreys for salmon protection under the 1993 Plan as part of its arguments against the lamprey passage standards proposed. This argument fails to acknowledge that Sea Lamprey are not only no longer considered to be detrimental to Atlantic Salmon (Gephard 2019), they are considered beneficial due to their function as ecosystem engineers and as a conduit for marine derived nutrients (Kircheis 2004, Weaver et al. 2018). MDMR used best available science to inform the potential range of this species within the Kennebec River drainage and inform passage standards.

References:

Gephard, S. 2019. Restoration of Anadromous Sea Lamprey to the Connecticut River and Adjacent Watersheds. In From Catastrophe to Recovery: Stories of Fishery Management Success. Edited by Charles C. Krueger, William W. Taylor, and So-Jung Youn. Bethesda (Maryland): American Fisheries Society. ISBN 978-1-934874-55-4.

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

Spice EK, Goodman DH, Reid SB, Docker MF (2012) Neither philopatric nor panmictic: microsatellite and mtDNA evidence suggest lack of natal homing but limits to dispersal in Pacific lamprey. Mol Ecol 21:2916–2930

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.

Table 2. Results of fish passage effectiveness testing at multiple sites. Studies to determine the effectiveness (survival) of downstream (DS) and upstream (US) passage facilities were conducted on adult fish. The time for 50% of the fish to successfully pass also is provided.

Species	Year	Type	Project	River	Survival estimate	Confidence Interval	Median time
Alewife	2019	DS	Pejepscot	Androscoggin	80.9%	75% CI = 76.3-85.7%	0.9 hr
Alewife	2015	DS	Lockwood	Kennebec	85.0%	75% CI = 69.0-100.0%	10.7 hr
Alewife	2018	DS	Milford	Penobscot	86.1%	75% CI = 82.1-89.7%	0.6 d
Alewife	2018	DS	West Enfield	Penobscot	93.7%	75% CI = 90.9-96.7%	0.7 d
Alewife	2018	DS	Stillwater	Penobscot	94.6%	75% CI = 92.4-97.8%	0.4 d
Alewife	2018	DS	Orono	Penobscot	97.8%	75% CI = 96.0-98.8%	2.1 hr
Alewife	2016	DS	Hydro Kennebec	Kennebec	100.0%	75% CI = 98.4-100.0%	3.3 d
American Shad	2019	DS	Pejepscot	Androscoggin	51.4%	75% CI = 41.6-61.1%	5.3 d
American Shad	2017	DS	Milford	Penobscot	76.6%	75% CI = 71.1-82.2%	1.6 d
American Shad	2018	DS	Milford	Penobscot	86.2%	75% CI = 82.4-89.9%	1.1 d
American Shad	2017	DS	Orono	Penobscot	87.0%	75% CI = 82.4-91.2%	1.6 d
American Shad	2018	DS	West Enfield	Penobscot	88.0%	75% CI = 84.4-91.9%	3.9 d
American Shad	2018	DS	Orono	Penobscot	94.4%		8.1 hr
American Shad	2018	DS	Stillwater	Penobscot	94.7%		0.3 d
American Shad	2017	DS	Stillwater	Penobscot	95.8%	75% CI = 91.7-97.9%	4.7 d
American Shad	2015	DS	Vernon	Connecticut			11.9 hr
American Shad	2016	DS	Vernon	Connecticut			11.6 hr
American Eel	2018	DS	Garvins Falls	Merrimack	70.1%	75% CI = 62.9-76.4%	0.2 hr
American Eel	2017	DS	West Enfield	Penobscot	84.0%		2.0 hr
American Eel	2018	DS	Amoskeag	Merrimack	84.1%	75% CI = 76.0-89.9%	0.6 hr
American Eel	2018	DS	Lowell	Merrimack	84.2%	75% CI = 74.1-90.3%	0.3 hr
American Eel	2019	DS	Garvins Falls	Merrimack	88.3%	75% CI = 82.7-92.3%	1.6 hr
American Eel	2018	DS	Lawrence	Merrimack	88.9%	75% CI = 79.8-94.2%	-
American Eel	2019	DS	Pejepscot	Androscoggin	90.0%	75% CI = 86.0-94.0%	2.1 hr
American Eel	2016	DS	Milford	Penobscot	90.0%		1.2 d
American Eel	2018	DS	Hooksett	Merrimack	90.5%	75% CI = 83.8-94.6%	0.1 hr
American Eel	2019	DS	Hooksett	Merrimack	90.6%	75% CI = 84.8-94.3%	0.2 hr
American Eel	2019	DS	Amoskeag	Merrimack	91.7%	75% CI = 85.8-95.3%	1.5 hr
American Eel	2016	DS	Stillwater	Penobscot	92.0%		1.8 hr
American Eel	2016	DS	Orono	Penobscot	98.0%		1.6 hr
American Eel	2015	DS	Wilder	Connecticut			0.2 hr
American Eel	2015	DS	Bellows Falls	Connecticut			0.2 hr
American Eel	2015	DS	Vernon	Connecticut			0.2 hr
American Shad	2010	US	Conowingo lift	Susquehanna	44.9%	±10.4%	
American Shad	2012	US	Conowingo lift	Susquehanna	25.8%	±10.6%	
American Shad	2015	US	Conowingo lift	Susquehanna	21.6%	±9.5%	
American Shad	2015	US	Lockwood	Kennebec	0.0%		
American Shad	2019	US	Pejepscot	Androscoggin	0.0%		
American Shad	2018	US	Holtwood	Susquehanna	4.2%		
American Shad	2019	US	Holtwood	Susquehanna	6.5%		
Alewife	2019	US	Pejepscot	Androscoggin	19.8%	75% CI = 14.8-24.9%	
Alewife	2019	US	Milford	Penobscot	65.1%	95% CI = 56.9-73.8%	

OFFICES AT 32 BLOSSOM LANE, MARQUARDT BUILDING, AUGUSTA, MAINE
http://www.Maine.gov/dmr
PHONE: (207) 624-6550 FAX: (207) 624-6024

Appendix B

TECHNICAL MEMORANDUM: Clarifications Regarding Nature-like Fishway Conceptual Analysis Shawmut Dam, Kennebec River, Maine

TECHNICAL MEMORANDUM

To:	Sean Ledwin, Maine Department of Marine Resources
From:	Michael Burke, P.E.
Date:	December 17, 2021
Re:	Clarifications Regarding Nature-like Fishway Conceptual Analysis Shawmut Dam, Kennebec River, Maine

1. Introduction

On July 20, 2021, Inter-Fluve issued a memorandum to the Maine Department of Marine Resources, Division of Sea Run Fisheries and Habitat (MDMR) summarizing conceptual analysis of options to develop a large-scale nature-like fishway (NLF) at the Shawmut Dam site on the Kennebec River, Fairfield, Maine (IFI 2021). MDMR included the memorandum in their comments to the draft Environmental Assessment (EA) for the Shawmut Hydropower Project (FERC No. 2322) which is owned and operated by Brookfield White Pine Hydro LLC (BWP).

BWP filed a response to FERC regarding the MDMR comments on the draft EA on November 5, 2021. Included with the BWP response were two sets of review comments that in part addressed the conceptual analysis summarized in our July 20 memorandum. The two sets of review comments were prepared by Kleinschmidt (dated September 15, 2021) and by Alden Research Laboratory, Inc. (Alden, dated October 7, 2021).

The purpose of this memorandum is to provide clarifications on the NLF conceptual analysis concerning a subset of the BWP-filed comments detailed in the Kleinschmidt and Alden memoranda.

2. Clarifications Based on Review Comments

The following paragraphs provide selected clarifications regarding the NLF conceptual analysis, in response to the comments filed by BWP (2021). The clarifications address apparent inconsistencies with or misinterpretations of the conceptual analysis memorandum that were included in the BWP-filed comments (BWP 2021).

LEVEL OF DESIGN DEVELOPMENT AND CHARACTERISTICS OF DETAILED NLF DESIGN

In the conceptual analysis memorandum, schematic NLF drawings were included for illustrative purposes. The BWP-filed comments include statements regarding expected NLF conditions based on the apparent interpretation that the schematic design was fully representative of the eventual detailed design and the actual project that would be constructed at the site. Interpretation of the schematic layouts as indicative of a fully developed NLF design is an inaccurate assumption with premature conclusions concerning NLF performance.

The schematic layouts depict average channel gradients and general NLF cross section geometry. The grading reflected in the schematic layouts was developed based on these characteristics to estimate the size of NLF channel that could be fit within the constrained space at the site. The grading was based on average channel gradient that would be anticipated to facilitate safe, timely and effective volitional passage for the target native species.

This grading and layout development was completed as a conceptual analysis. Subsequent design development would detail the NLF characteristics that would be constructed, refining the average channel gradient and general cross section shape, along with other features such as entrance and exit areas, to an advanced level of design development.

If the project is advanced, the objectives for the final design would include analysis and designs that result in channel and flow field characteristics that emulate conditions that fish may encounter elsewhere in the native channel network. It is anticipated that the response of fish to these characteristics would be more intuitive and less stressed than their response to hydraulic conditions and forms that are highly disparate from conditions encountered outside the zone of passage. While the NLF would provide conveyance and fish passage potential through the zone of passage, the intent would be for the channel to emulate a side channel of the Kennebec River that fish would not distinguish from other channel areas.

Projected NLF Channel Condition

The average channel gradient that appears viable for the site (2% or less) is within the range that pool-riffle channels are found in natural settings (Montgomery & Buffington 1997). Hence, if the project were advanced to detailed design and implementation, we anticipate that the NLF channel would be refined to exhibit a pool-riffle profile through the low flow channel, with varying channel cross slopes and an array of additional microhabitats and refuge areas distributed throughout the channel and overbank area. This array of naturalized morphological features such as pools, riffles and refuge areas would provide a diversity of flow field characteristics and habitat resources for fish to utilize as they traverse the zone of passage. The pool-riffle profile would fit within the average channel gradient, with riffle and pool hydraulic profiles locally steeper and flat respectively, relative to the average gradient.

The BWP-filed comments conclude selected interpretations of internal NLF characteristics based on the schematic NLF layouts and the average channel gradient. One set of the comments referred to the NLF as a 'roughened' channel which we generally concur with, as the NLF would be a boulder-based channel with a high degree of hydraulic boundary roughness. We would supplement this characterization with the pool-riffle characterization for the low flow channel area described in the paragraphs above.

The second set of comments refer to the NLF as a 'rock ramp' which we disagree with. In our experience, rock ramps installed for fish passage, though constructed with stone materials, often embrace relatively uniform geometry utilizing hydraulic features in configurations (distribution, orientation, shape, width, slope) that do not form in natural channel settings, most often at gradients that are notably steeper than reflected in the schematic layouts in the conceptual analysis memorandum. We do not anticipate that a refined NLF design will be similar to or mimic rock ramp designs that have been designed and installed at other sites.

NLF MORPHOLOGIC AND FLOW FIELD CHARACTERISTICS

The BWP-filed comments suggest, based on the schematic layouts, that the constructed NLF would have a continuous, uniform channel profile and homogenous flow characteristics over the entire NLF channel length extending over 1,200 feet, essentially acting as a canal with prismatic geometry. We disagree with this characterization. The paragraphs above characterize the level of development of the schematic layouts included in the conceptual analysis memorandum, and the expected characteristics of the fully developed design if the project were advanced to a detailed design phase.

Channel Profile and Resting Pools

The BWP-filed comments make specific points regarding the lack of resting pools and pool-riffle profiles in the schematic layouts, representing this as partial evidence that the NLF would not be able to comply with prevailing fish passage engineering design guidance and criteria, and furthermore may block fish passage. The comments include an unfavorable comparison of the schematic layouts, and the lack of resting pools and pool-riffle profile, to the detailed design and constructed condition of the Howland NLF (discussed in more detail later in this memorandum) which did incorporate these elements.

Inter-Fluve concurs with the importance of the noted geomorphological features in developing a successful NLF detailed design and implementing a successful NLF at the site. We disagree with the misinterpretation presented in the BWP-filed comments that resting pools and other morphologic features would not be included in the Shawmut NLF, and also disagree with the associated suggestion that the NLF would not be able to meet prevailing fish passage design guidance and criteria (Turek et al. 2016, USFWS 2019) to the extent that they are applicable to an NLF of this scale.

As noted in the BWP-filed comments, the Howland NLF low-flow channel includes five riffles 120 to 150 feet in length, with local slopes of 2.4%, and four large pools 75 feet in length with flat local slope. Together these features comprise an average channel thalweg gradient of 1.6% to 1.7% and average hydraulic gradient of approximately 1.5%.

For the potential NLF at the Shawmut site, the precise tie-in locations for the channel require further design development, based in part on securing design-level terrain and bathymetry data, and other considerations. The final design of the NLF channel also requires substantial detailed development.

However, we anticipate that the channel length would be approximately 1,200 feet long with an average hydraulic gradient of approximately 2%.

Based on these characteristics, we anticipate that the low flow channel of a fully developed NLF design could include six riffle segments of 120 to 160 feet in length laid on local channel slopes of 2.5% to 3%, which are comparable to riffles that occur in natural channel settings. Riffles are short segments of plane-bed channel morphology, which has a typical channel gradient range of up to 3% (Montgomery & Buffington 1997). The riffles would alternate with five large pools 60 to 75 feet long, laid at a flat local slope, to result in a varied channel profile that together comprise the average channel gradient. We disagree with the BWP-filed comments that substantially-greater channel length would be required to integrate resting pools in an NLF at the Shawmut site

The BWP-filed comments estimate the resting pool volume requirements for the Shawmut site at 13,500 cubic feet of water in order to comply with USFWS (2019) resting pool criteria, roughly 62.5% of the volume provided by the Howland NLF pools. Since the potential pool volume at the Shawmut NLF site could exceed that provided at the Howland NLF, with notably reduced required volume (~40% lower), the USFWS (2019) resting pool requirements appear to be potentially easily met at the Shawmut NLF site.

Channel Velocity Criteria and Estimates

The BWP-filed comments also report preliminary estimates of channel flow velocities based on the interpretation of the NLF as a continuous, homogenous, prismatic channel. The reported velocity estimates are subsequently compared to critical 'weir notch' velocity criteria cited in the federal inter-agency NLF design guidelines (Turek et al. 2016). We understand the convenient use of the weir notch velocity criteria as generally indicative criteria for short zones of passage requiring fish to 'burst' to ascend. These velocity criteria values are reasonably similar to those that would be suggested by other resources, such as fatigue and survival models developed by Haro et al. (2004) which were used to inform spacing of refugia (pools, refuge boulders) for the Howland NLF.

While the weir notch velocity criteria can be a useful and convenient reference point, considering the complexity of the NLF flow field characteristics, we would caution strict application of the weir notch velocity criteria to simplistic cross-sectionally-averaged velocity estimates based on presumed prismatic channel conditions to support the conclusion of deficient passage conditions, as was the case with the BWP-filed comments.

In general, we would also caution strict application of the inter-agency NLF guidelines for this project due to differences in project scale and characteristics. The NLF design guidelines suggest a design approach that is typical to stepped or step-pool NLF channels (essentially naturalized pool and weir fishway segments), for smaller channels, and shorter lengths. Step-pool channels develop in natural settings at channel gradients of 3% to approximately 8% (Montgomery & Buffington 1997), with channel widths that rarely exceed 30 to 35 feet. Thus, caution is required when selecting the aspects of the NLF design guidelines that would apply to a large-scale NLF at the Shawmut site, because the expected characteristics are dramatically different. The weir notch itself is a specific design feature recommended for step-pool NLF channels designed to pass non-leaping fish to ensure flow continuity at discrete profile steps at low discharges.

The preliminary velocity estimates that were compared to the weir notch velocity criteria in the BWP-filed comments were reported to have been calculated assuming hydraulic roughness values of 0.045 to 0.08. In these estimates, higher velocity values correlate with lower roughness values. Hydraulic roughness in open channel flow varies with the depth of water relative to the size of the channel substrate or other roughness elements present, such as refuge boulders. For the NLF, the low end of the hydraulic roughness range (0.045) cited in the comments is lower than would be supported by hydraulic engineering literature for the boulder-based, roughened channel bed condition that is expected (Kleinschmidt 2014). The exception where this may be applicable is in the low flow channel in a high flow condition where the depths and velocities would be expected to be much higher than other portions of the channel. This area would not be expected to provide primary fish passage opportunities at high flows relative to other zones of the diverse flow field patterns in the NLF channel.

The inclusion of the low roughness values in these preliminary velocity estimates, along with the simplistic geometry upon which the calculations are based, results in overestimation of hydraulic conditions along zones of passage. This simplistic approach leads to negative depiction of fish passage potential that is not representative of the anticipated fully developed design and implemented project.

As noted in the conceptual analysis memorandum, if the project is advanced to the detailed design phase, substantial hydraulic evaluation would be required to realistically represent the diverse flow field characteristics of the NLF channel, aid in design development and refinement, and confirm provision of fish passage potential. We do not concur that the preliminary estimates included in the BWP-filed comments (particularly those that employ the low roughness values) provide accurate or representative depiction to the passage conditions provided by a fully-developed NLF design.

REFERENCES TO THE HOWLAND NLF PROJECT

In the conceptual analysis memorandum (IFI 2021), the Howland NLF project was noted for relevance to the Shawmut site, primarily for application of the general channel design philosophy as an analog for the schematic layouts included in the memo. Although certain aspects of the Howland NLF are represented favorably in the BWP-filed comments (such as resting pools, pool-riffle, and refugia characteristics, described above), the comments nevertheless challenge the reference to the Howland project elsewhere, highlighting differences in hydraulic head, spillway length, channel length, and the fact that the Shawmut project is an operating hydrogeneration facility, while the Howland site is a decommissioned site. We acknowledge these differences, in particular the differing operational status and associated potential flow control needs at the Shawmut site. We nevertheless contend that the Howland NLF, the largest NLF implemented in the region, is of reasonably similar scale as considered for the Shawmut site, shares common configurational characteristics (long, competing spillway and other conveyances), and is a useful point of reference for the schematic NLF channel layouts.

Comparison to Prevailing Fish Passage Guidelines and Criteria

The BWP-filed comments also suggest that the Howland NLF may not be a viable example of an NLF intended to meet current agency passage criteria, because it was designed (2014) and constructed (2015-16) before publication of the prevailing U.S. Fish and Wildlife Service fish passage engineering design criteria (USFWS 2019, first issued in 2016) and federal inter-agency NLF design guidelines (Turek et al. 2016). In particular, the comments point out that the minimum depth design criteria established for the Howland NLF (1.5 feet, established through inter-agency coordination) is less than that suggested by the inter-agency guidelines (2.25 feet for Atlantic salmon and American shad).

The difference in established minimum depth design criteria for the Howland project and the inter-agency guidelines is noted, but the fact is that the functioning Howland NLF, as constructed, does meet the inter-agency depth criteria. Moreover, the conceptual analysis did not indicate that the Shawmut NLF design would be a carbon copy of the Howland design. Rather, the conceptual analysis and associated schematic layouts utilized a similar general channel design philosophy. This includes a broad channel cross section with a deeper portion to concentrate lower flow conditions, and a sloping bed profile to accommodate increasing flow volumes while maintaining a zone of passage, even though velocities in the deeper portion may become increasingly swift with increasing discharge.

This philosophy aligns with the USFWS (2019) criteria document, which acknowledged this general approach to large-scale NLF roughened channel designs in the 2019 document revision, potentially in response to observations of the implemented Howland NLF. The channel design philosophy will also facilitate meeting recommended flow field and fish passage engineering design criteria as the channel layout is advanced from schematic to detailed design. As stated previously, a fully developed NLF design would not be a carbon copy of the Howland NLF such that the filed comments seem to imply.

As discussed earlier in this memo, it should be clearly noted that the layouts included in the NLF conceptual analysis memorandum are schematic in nature, utilizing preliminary average channel grades, primarily to assess the potential grading requirements within the constrained space available at the site. The schematic layouts should not be interpreted to reflect the refined channel morphologic features that would be integrated in subsequent design phases to represent the detailed design of the channel and produce the fine-scale flow field characteristics characteristic of a successful NLF design.

The BWP-filed comments also stress that comprehensive monitoring of the effectiveness of the Howland NLF has not been conducted. This is noted. The inclusion of the reference to Howland was not as validation of a NLF at the Shawmut site. Nevertheless, as noted in the conceptual analysis memo, review of the Howland NLF has been favorable from the fisheries agencies, to the extent that the Northeast Region Fish Passage Engineering Design Criteria webpage[1] uses a photo of the Howland NLF as its home image. These factors suggest the use of the Howland NLF as a point of reference for the Shawmut NLF schematic layouts was valid. We have also heard anecdotal accounts from regional biologists that fish appear to be using the Howland NLF as if it were a part of the river itself, and not distinguishing it from the surrounding riverine habitat, with selected species even using the NLF for rearing. Accounts such as these would seem to support the notion that the NLF function allows intuitive response from the fish population.

Flow Distribution and Hydraulic Inlet

Lastly, an additional detail relative to the Howland NLF bears clarification. When discussing the potential need for a flow control structure, the BWP-filed comments make the statement that there is not such a structure at Howland because all of the flow passes through the NLF during most of the passage season. This is an incorrect statement. The proportion of total river flow in the Howland NLF ranges from approximately 80% at the low passage flow, to approximately 18 % at the high passage flow, with the remainder of the river flow conveyed through the downstream passage chute and over the spillway. The proportion of flow through the NLF ranges between 50% and 18% over most of the fish passage season (Kleinschmidt 2014).

The Howland NLF hydraulic inlet was carefully designed to maximize the flow into the bypass channel during the fish passage season to optimize fish attraction, and to moderate the proportion of flood flows routed through the channel. The inlet operates passively over a large range in river flow to optimize the flow distribution at the site, while maintaining a minimum impoundment level. Its design is inextricably linked with the hydraulics of the 570-foot-long spillway combined with the downstream passage chute (Kleinschmidt 2014). The geometry of the hydraulic inlet varies from the rest of the bypass channel.

We concur that an inlet structure may be required at the Shawmut site. The clarification is offered to dispute the summary dismissal of the Howland case as overly simplistic and irrelevant. There are clearly differences between the sites, and development of the entrance and exit configurations for an NLF at Shawmut would require careful, detailed evaluation and design, depending on many factors, including coordination of the availability of flow. However, we anticipate design solutions that may include a hydraulic inlet control structure to balance the competing requirements and performance objectives would be able to be determined.

[1] https://www.fws.gov/northeast/fisheries/fishpassageengineering.html

NLF EFFECTIVENESS STUDIES AND CHARACTERISTICS

Prior Studies of NLF Effectiveness

An inventory of NLF effectiveness monitoring studies was included in the BWP-filed comments. The inventory reports effectiveness values ranging from 0% to 94%. The studies that evaluated alosine passage in North America were for channels with slope range of 3.5% to 6.3%, and those studies conducted in New England were for channels with slope range of 5% to 6.3%. It should be noted that these channel gradients are at or exceed the maximum slope recommendations (5%) included in the inter-agency NLF guidelines (Turek et al. 2016), but agency biologists and fish passage engineers presently discourage even step-pool NLF designs at greater than 3%. Based on the slope ranges cited for the performance studies, we expect that these channels were designed as smaller step-pool channels characterized by fundamentally different morphologic and hydraulic conditions than the Howland NLF, the Saccarappa NLF on the Presumpsot River (1.5% to 2% roughened channels 900 feet in length), or the scale of NLF proposed for the Shawmut site.

The differences between the studied sites which are steeper, smaller, step-pool type channels and the larger-scale roughened channel sites such as the Howland or Saccarappa projects demonstrate the lumping of different types of design approaches into the NLF classification, similar to the way varied designs are lumped into the technical fishway classification. While all of these sites may be generalized under the NLF umbrella, they are not comparable in terms of performance. The mediocre effectiveness study results are based on fundamentally differing channel conditions and should not be misapplied as indicative of the likely performance of an NLF at the Shawmut site. As noted, comprehensive effectiveness evaluations are not available for the Howland or Saccarappa projects.These projects are most similar in terms of design approach, flow field characteristics and scale as may be considered at the Shawmut site, and would provide more appropriate reference to potential fish passage effectiveness at the site.

Effect of NLF Length

The BWP-filing includes comments on the potential length of the NLF at the Shawmut site, as it would be longer than the previously constructed major NLF channels (Howland, Saccarappa) by 200 feet or more. We understand this concern, and concur on the unprecedented length. If the extra length were in a technical or NLF fishway that exhibited hydraulic and environmental conditions that cue complex behavioral responses and are disparate from natural channel conditions, or that include interior fishway spaces that were confined and small relative to fish size, we would concur with the concern. However, due to the anticipated character of the NLF hydraulic conditions in terms of large scale and native flow field characteristics, we are less concerned that this extra length may impair fish utilization. Their response to the NLF is anticipated to be intuitive due to the flow field conditions, with less distinction between the experience within the zone of passage compared to the experience outside the zone of passage. The intent for a fully developed NLF design would be for the channel to act as a side channel of the Kennebec River, and the extra length would equate one to two additional channel widths. Conversely, in a technical fishway, this extra length may equal twenty to fifty additional channel widths. Paired with the nature of the interior technical fishway environmental conditions, we suspect this extra length could be significant in such a technical fishway case.

Fishway Attraction

The BWP-filing includes comments regarding the complexities and uncertainties regarding attraction to the entrance of the NLF. We concur with the need to study fishway attraction in greater detail. The comments include reference to the fish lift siting study as evidence that fish do not congregate near the NLF entrance location shown on the schematic layouts. While we recognize the value of this study, we don't concur that its results prove that fish would not find the NLF entrance, either as shown in the schematic layouts, or modified through future design optimization. This is primarily based on the fact that the hydraulic signal represented by the NLF discharge was not in place at the time of the study.

OTHER PROJECT CONSIDERATIONS

The BWP-filed comments include discussion of several additional engineering considerations and other essential factors that would need to be resolved for the implementation of major NLF project. These considerations were also predominantly identified in the conceptual analysis memorandum, but the resolution of them was out of scope for that study. We concur with the importance assigned to all of these factors, which are also out of the scope of this memorandum, but will require intensive coordination, evaluation, and design in future planning and detailed design phases if the project is advanced towards implementation.

3. References

Alden Research Laboratories, Inc. (Alden) 2021. Review of Maine Department of Marine Resources' Nature-like Fishway Concepts for the Shawmut Hydroelectric Project (FERC Project No. 2322). October 7. Attachment to BWP 2021, Response to Comments on DEA - Shawmut Hydroelectric Project FERC No. 2322-060. November 5.

Brookfield White Pine Hydro LLC (BWP) 2021. Response to Comments on DEA - Shawmut Hydroelectric Project FERC No. 2322-060. November 5.

Haro, A., Castro-Santos, T., Noreika, J. and Odeh, M. 2004. Swimming performance of upstream migrant fishes in open-channel flow: a new approach to predicting passage through velocity barriers. Canadian Journal of Fisheries and Aquatic Sciences, 61(9), pp.1590-1601.

Inter-Fluve (IFI) 2021. Nature-like Fishway Conceptual Analysis, Shawmut Dam, Kennebec River, Maine. July 20.

Kleinschmidt 2021. Review of MDMR's Comments and NLF Conceptual Designs Filed with FERC for the Shawmut Project (P-2322). September 15. Attachment to BWP 2021, Response to Comments on DEA - Shawmut Hydroelectric Project FERC No. 2322-060. November 5.

Kleinschmidt 2014. Howland Dam Bypass Functional Design Report. Prepared for Penobscot River Restoration Trust, Augusta, Maine. Prepared by Kleinschmidt with Inter-Fluve.

Montgomery, D. and Buffington, J. 1997. Channel-reach morphology in mountain drainage basins. Geological Society of America Bulletin 109, 596–611.

Turek, J., Haro, A., and Towler, B. 2016. Technical Memorandum. Federal Interagency Nature-like Fishway Passage Design Guidelines for Atlantic Coast Diadromous Fishes.

US Fish and Wildlife Service Northeast Region (USFWS) 2019. Fish Passage Engineering Design Criteria. USFWS Region 5. June.