UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
GREATER ATLANTIC REGIONAL FISHERIES OFFICE
55 Great Republic Drive
Gloucester, MA 01930

March 20, 2023

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

RE: Endangered Species Act Section 7 Formal Consultation for the Shawmut Hydroelectric Project Relicensing (P-2322-069), and amendments to existing licenses for the Shawmut (P-2322-071), Lockwood (P-2574-092), Hydro-Kennebec (P-2611-091), and Weston (P-2325-100) Hydroelectric Projects.

Dear Ms. Bose:

Enclosed is our Biological Opinion (Opinion), issued under section 7(a)(2) of the Endangered Species Act (ESA), for the Federal Energy Regulatory Commission's (FERC) proposal to issue a subsequent operating license at the Shawmut Hydroelectric Project (FERC No. 2322) and amend the operating licenses for the Lockwood (FERC No. 2574), Hydro-Kennebec (FERC No. 2611), Shawmut, and Weston (FERC No. 2325) Hydroelectric Projects. The proposed actions considered in this Opinion include long-overdue commitments to improve facilities and operations at these dams to protect ESA-listed Atlantic salmon in the lower Kennebec River in Maine.

In the Opinion, we conclude that the proposed actions may adversely affect but are not likely to jeopardize the continued existence of the Gulf of Maine distinct population segment (GOM DPS) of Atlantic salmon, shortnose sturgeon, or the GOM DPS of Atlantic sturgeon or result in the destruction or adverse modification of critical habitat designated for the GOM DPS of Atlantic salmon. We also conclude that the continued operation of the Lockwood Project is not likely to adversely affect critical habitat designated for the GOM DPS of Atlantic sturgeon.

As required by section 7(b)(4) of the ESA, an incidental take statement (ITS) is provided with the Opinion. The ITS exempts an identified amount of incidental take of Atlantic salmon, shortnose sturgeon, and Atlantic sturgeon from the ESA section 9 prohibitions on take. This incidental take will result from activities associated with the ongoing operation of the hydroelectric facilities consistent with the description of the proposed actions in the Opinion. The ITS also specifies Reasonable and Prudent Measures (RPMs) and implementing Terms and Conditions necessary and appropriate to minimize the impact of these activities on ESA-listed species. In order to be exempt from the prohibitions on take, FERC must comply (or must ensure that the licensee, Brookfield Renewable Energy, complies) with the RPMs and their implementing terms and conditions. These additional requirements are designed to minimize the amount or extent of ESA-listed species, including Atlantic salmon. A key component of the proposed actions is implementation of an adaptive management framework to ensure that necessary changes to project operations and/or facilities are implemented, and to ensure that

FERC and Brookfield will pursue any necessary additional changes to avoid exceeding the amount of take exempted by the ITS. Annual reporting that is required by the ITS will continue to supply information on the level of take resulting from the proposed action.

Following the full implementation of the improvements described in the proposed actions, Atlantic salmon will be able to swim in the Kennebec River from the Atlantic Ocean to their freshwater habitat in interior Maine for the first time since the dams were constructed in the 19th century. The improvements will also benefit other sea run species, including river herring, providing a host of ecosystem and economic benefits from the Kennebec River watershed to the Gulf of Maine. However, the proposed actions will not eliminate all negative effects of dams on migrating Atlantic salmon, and they will continue to impact the species in the Kennebec River. Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. We encourage FERC to evaluate additional measures within your authority that could be implemented to further reduce effects of these projects on Atlantic salmon and other sea run fish. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. We have included appropriate conservation recommendations in the Opinion.

This Opinion concludes consultation for the FERC's proposed relicensing of the Shawmut Project and amendment of the licenses for the Lockwood, Hydro-Kennebec, Shawmut, and Weston Projects. As described in 50 CFR 402.15, the action agency has several responsibilities following issuance of a biological opinion. As such, FERC is obligated to: (a) Determine whether and in what manner to proceed with the actions in light of your section 7 obligations and our biological opinion; and (b) notify us of your final decision on the action. We look forward to hearing from you on these matters.

As outlined in 50 CFR 402.16, reinitiation of consultation is required and shall be requested by FERC or by NOAA's National Marine Fisheries Service (NMFS), where discretionary Federal involvement or control over the action has been retained or is authorized by law and: (1) The amount or extent of taking specified in the incidental take statement is exceeded; (2) new information reveals effects of the action that may not have been previously considered; (3) the identified action is subsequently modified in a manner that causes an effect to listed species not considered in the Opinion; or (4) a new species is listed or critical habitat designated that may be affected by the identified action. Should the lower Kennebec dams fail to achieve the benchmark commitments for safe and effective fish passage in the period of time outlined in the Opinion, reinitiation of consultation will be required and FERC and Brookfield will need to work with us to evaluate new options for protecting federally listed sea run fish at these projects.

We understand that FERC is preparing a draft Environmental Impact Statement pursuant to the National Environmental Policy Act (NEPA) on the actions considered in this Opinion. We look forward to engaging in the NEPA process for these projects. We will continue to work towards and support efforts to improve fish passage and habitat for Atlantic salmon and other sea run species in the Kennebec River watershed and throughout the range of endangered Atlantic salmon in Maine.

If you have any questions or concerns about the consultation, please contact Matt Buhyoff or Dan Tierney in our Protected Resources Division at (207) 370-2797 or Matt.Buhyoff@noaa.gov or at (207) 866-3755 or Dan.Tierney@noaa.gov.

Sincerely,

Michael Pentony
Regional Administrator

NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT
BIOLOGICAL OPINION

Agency: Federal Energy Regulatory Commission (FERC)
US Army Corps of Engineers (ACOE)

Activity Considered: Issuance of a new license at the Shawmut (FERC # 2322) Hydro Project; Amendments of the licenses at the Lockwood (2574), Hydro-Kennebec (2611), Shawmut, and Weston (2325) Hydro Projects

GARFO-2021-03216

Conducted by: National Marine Fisheries Service
Greater Atlantic Regional Fisheries Office

Date Issued: March 20, 2023

Approved by: ______________________

Michael Pentony
Regional Administrator

Table of Contents

1 Introduction and Background

This is the biological opinion (Opinion) of NOAA's National Marine Fisheries Service (NMFS) issued under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. §§ 1531-1543) concerning the effects of the Federal Energy Regulatory Commission's (FERC) proposed issuance of a new operating license at the Shawmut Hydroelectric Project, as well as their approval of applications to amend the operating licenses for the Lockwood, Hydro-Kennebec, and Weston Projects to incorporate provisions described in a proposed species protection plan (SPP). In addition, this Opinion considers the effects of FERC's proposed amendment of the existing Shawmut license to incorporate measures of an Interim Species Protection Plan. FERC issues new or subsequent hydropower licenses for terms of 30-50 years. We have contacted FERC regarding the anticipated license term for any new Shawmut license, but they could not clarify. Therefore, for the purposes of this analysis, we consider that the new license could cover a period of up to 50 years, from approximately 2023 to 2073. The amended licenses for Lockwood, Hydro-Kennebec, and Weston will be in effect until the conclusion of the next relicensing process, which is currently anticipated to occur in 2036. However, in this Opinion, we must consider the length of the actions in their entirety, which includes the potential for a 50 year license term at Shawmut. As we do not know if Lockwood, Hydro-Kennebec, and/or

Weston will be relicensed or what the conditions of any new licenses will be, we assume for this analysis that they will continue to operate as proposed under the terms of their amended licenses for the duration of the new Shawmut license. As such, in this analysis we will consider the anticipated effects of all four projects over a 50 year time horizon. We note that any proposed relicensing of Lockwood, Hydro-Kennebec, and Weston projects will still require consultation under section 7 of the ESA be conducted.

All four projects are existing hydroelectric projects located on the mainstem of the Kennebec River in Maine. The Lockwood Dam is located at river kilometer 103 and is the first dam on the river. The Hydro-Kennebec (two kilometers upstream of Lockwood), Shawmut (nine kilometers upstream of Hydro-Kennebec), and Weston (21 kilometers upstream of Shawmut) projects are the second, third, and fourth dams on the river, respectively. We note here that we are considering five independent federal actions (i.e., the issuance of a new license at the Shawmut Project, and the amendment of four existing licenses issued under the Federal Power Act) in this one Opinion.

In a letter dated March 14, 2018, FERC designated Brookfield White Pine Hydro, LLC (Brookfield or Licensees) as their non-federal representative to conduct informal ESA consultation with us. In two June 1, 2021 letters to FERC, Brookfield requested that FERC amend the licenses for: 1) the Lockwood, Hydro-Kennebec, Shawmut and Weston Projects to incorporate the provisions of a species protection plan (SPP) for Atlantic salmon, Atlantic sturgeon, and shortnose sturgeon; and 2) the Shawmut Project to incorporate the provisions of an interim species protection plan (interim plan or ISPP). In a letter dated July 9, 2021, and in two letters filed on July 26, 2021, all addressed to the National Marine Fisheries Service (NMFS), FERC included requests for the initiation of formal section 7 consultation under the ESA for the five federal actions described above. In its letters, FERC indicated that all information required to initiate formal section 7 consultation was included in two Biological Assessments, filed by Brookfield on June 1, 2021 and on July 1, 2021, or in the draft Environmental Assessment (DEA) for the Shawmut Project relicensing. In an August 26, 2021 letter to FERC, we requested additional information before initiating consultation. Brookfield filed the requested information with FERC on September 16, 2021. On December 2, 2021, FERC transmitted the requested information to us and once again requested formal consultation with us.

On March 2, 2022, we requested from FERC a 60-day extension of the consultation period. On March 8, FERC concurred with our request. On May 23, we met with Brookfield to discuss our preliminary analyses, which indicated that effects of these actions on Atlantic salmon and their designated critical habitat were more substantial than had been contemplated in Brookfield and FERC's analyses of project impacts and could result in a jeopardy/adverse modification finding. At that time, we indicated to Brookfield that it should consider modifying its proposal or working with us on the development of Reasonable and Prudent Alternatives (RPAs). On July 15, after Brookfield indicated its intent to work with us to identify possible measures suitable for the development of RPAs or a proposal modification, we requested from FERC a 90-day extension (from July 15, 2022 to October 13, 2022) to facilitate that consultation. On August 8, 2022, FERC concurred with our extension request. Between July 7, 2022 and September 1, 2022, we participated in over 13 consultation meetings with Brookfield. On September 21, 2022, Brookfield filed with FERC a "supplement to the Lower Kennebec Species Protection Plan and Draft Biological Assessment…" (modified proposal). In an October 17, 2022 letter to FERC, we indicated that the changes contained in the modified proposal and the underlying new information were significant enough to be considered as a new consultation. We asked FERC if it would request consultation on the modified proposal. On November 1, 2022, FERC requested formal consultation on the modified proposal. In a response on December 2, 2022, we notified FERC that we had initiated formal section 7 consultation, with an initiation date of November 4, 2022. In the response, we noted that section 7 regulations require that formal consultation be concluded within 90 calendar days of initiation, and the biological opinion be delivered to the action agency within 45 days after the conclusion of formal consultation (i.e., March 20, 2023).

Brookfield will apply to the U.S. Army Corps of Engineers (ACOE), for permits for the construction of the new fishways at the Lockwood and Weston Projects. The ACOE would authorize the proposed actions pursuant to section 404 of the Clean Water Act and section 10 of the Rivers and Harbors Act for wetlands impacts and fill associated with the projects. The ACOE has already issued a permit for the construction of the new Shawmut fishway. Pursuant to the section 7 regulations (50 C.F.R. § 402.07), when a particular action involves more than one Federal agency, the consultation responsibilities may be fulfilled through a lead agency. FERC is the lead Federal agency for the proposed actions under consideration in this consultation.

This Opinion is based on the best scientific and commercial data available, including but not limited to, information provided in: 1) Brookfield's June 1, 2021 Shawmut Interim Plan Biological Assessment (BA); 2) Brookfield's Lockwood, Hydro-Kennebec, and Weston Species Protection Plan (SPP) BA; 3) FERC's July 1, 2021 Shawmut DEA; 4) additional information filed by Brookfield on September 16, 2021; and 5) Brookfield's applications for the construction of the Lockwood and Weston fishways submitted to the ACOE on July 13, 2021; 6) Brookfield's September 21, 2022 modified proposal; and 7) additional information submitted by Brookfield on November 4, 2022 and through January 2023. A complete administrative record of this consultation will be maintained at our Maine Field Office in Orono, Maine. Formal consultation was initiated on November 4, 2022.

1.1 Consultation History

- **March 14, 2018 –** FERC designated Brookfield to act as its non-federal representative in conducting informal consultation under section 7 of the ESA regarding federally listed species at the Lockwood, Hydro-Kennebec, Shawmut, and Weston Projects (lower Kennebec projects).

- **June 12, 2018; July 26, 2018; August 24, 2018; September 17, 2018; September 27, 2018** – Meetings were held by Brookfield with the state and federal agencies to discuss the lower Kennebec SPP.
- **February 14, 2019; February 28, 2019; March 6, 2019; March 15, 2019; March 22, 2019; April 12, 2019; April 24, 2019; May 1, 2019; September 27, 2019; October 11, 2019 –** Meetings were held by Brookfield with the state and federal agencies to discuss the lower Kennebec SPP.
- **December 31, 2019** – Brookfield submitted a draft Biological Assessment and Species Protection Plan to FERC.
- **February 7, 2020** – NMFS filed a letter notifying FERC of the inadequacy of the draft SPP/BA.
- **July 13, 2020** – FERC rejected Brookfield's SPP/BA and encouraged Brookfield to refile the SPP/BA once it had addressed concerns raised by NMFS, the Maine Department of Marine Resources (Maine DMR), and the U.S. Fish and Wildlife Service (USFWS).
- **November 18, 2020 –** Brookfield held a meeting with NMFS to discuss revisions to the lower Kennebec SPP/BA.
- **May 6, 2021; May 13, 2021; May 20, 2021; May 26, 2021** – Meetings were held by Brookfield with NMFS and USFWS to discuss revisions to the lower Kennebec SPP.
- **June 1, 2021** – Brookfield submitted: 1) an SPP/BA for an interim plan for the Shawmut project; and 2) an SPP/BA for the Lockwood, Hydro-Kennebec, and Weston projects.
- **July 1, 2021** – FERC issued its draft EA for the Shawmut Project relicensing.
- **July 9, 2021** – FERC requested formal section 7 consultation for the Shawmut Project relicensing.
- **July 26, 2021 –** FERC requested formal section 7 consultation for the Shawmut Interim Plan and the Lockwood, Hydro-Kennebec, and Weston SPP.
- **August 26, 2021** – NMFS requested additional information before proceeding with formal consultation.
- **September 16, 2021** – Brookfield filed the requested additional information with FERC.
- **December 2, 2021** – FERC indicated that it incorporated the additional information filed by Brookfield into its previously filed BAs and requested "formal consultation under section 7 of the Endangered Species Act (ESA) for the Shawmut, Weston, Lockwood, and Hydro-Kennebec Hydroelectric Projects (Project Nos. 2322-069; 2322-071; 2325-100; 2574-092; 2611-091)."
- **December 2, 2021** – NMFS initiated section 7 consultation on the lower Kennebec SPP, the Shawmut Interim Plan, and the Shawmut relicensing.
- **March 2, 2022 –** NMFS requested from FERC a 60-day extension of the consultation period (from April 16, 2022 to June 15, 2022).
- **March 8, 2022 –** FERC concurred with NMFS' 60-day consultation extension request.
- **May 23, 2022 –** NMFS met with Brookfield to discuss its preliminary analyses, which indicated that effects of these actions on Atlantic salmon and their designated critical habitat were more substantial than had been contemplated in Brookfield and FERC's analyses of project impacts and could result in a jeopardy/adverse modification

conclusion in the ongoing consultation. NMFS indicated that Brookfield should consider modifying its proposal or work with NMFS on the development of Reasonable and Prudent Alternatives.

- **June 9, 2022** -- NMFS participated in a follow-up meeting with Brookfield; NMFS requested from FERC a 30-day extension of the consultation period (from June 16, 2022 to July 15, 2022).
- **June 17-27, 2022 –** NMFS continued to discuss with Brookfield options for proceeding with the consultation, including considerations for the development of any potential reasonable alternatives.
- **July 7-September 1, 2022** – NMFS participates in 13 ESA consultation meetings with Brookfield.
- **July 15, 2022 –** NMFS requested from FERC a 90-day extension of the consultation period (from July 15, 2022 to October 13, 2022).
- **August 8, 2022 –** FERC concurred with NMFS' 90-day extension of the consultation
- **September 21, 2022 –** Brookfield files "supplemental information for the Final Plan, Interim Plan, and License Application" with FERC, a modified SPP proposal (modified proposal) that outlines additional proposed improvements to fishways and project operations at the lower Kennebec Projects.
- **October 5, 2022 –** In a public notice, FERC requests comments on Brookfield's "supplemental information" filing.
- **October 17, 2022 –** NMFS submits a letter to FERC, notifying it that the changes contained in the modified proposal and the underlying new information are significant enough to be considered as a new consultation. NMFS asks whether FERC will request consultation on the modified proposal. NMFS requests additional information before proceeding with consultation.
- **November 1, 2022 –** FERC requests formal consultation on Brookfield's September 21, 2022 modified proposal and in a separate letter requests additional information of Brookfield related to the Shawmut Project.
- **November 4, 2022 –** Brookfield files responses to comments and additional information requested by NMFS and FERC.
- **December 2, 2022 –** NMFS notifies FERC that it has initiated formal section 7 consultation, with an initiation date of 11/4/2021.

1.2 Application of ESA Section 7(a)(2) Standards – Analytical Approach

This section reviews the approach used in this Opinion in order to apply the standards for determining jeopardy and destruction or adverse modification of critical habitat as set forth in section 7(a)(2) of the ESA and as defined by 50 C.F.R. § 402.02 and 50 C.F.R. § 402.14 (the consultation regulations). Additional guidance for this analysis is provided by the Endangered Species Consultation Handbook, March 1998, issued jointly by NMFS and the USFWS and the section 7 regulations as revised in 2019 (84 FR 44976; August 27, 2019). In conducting analyses of actions under section 7 of the ESA, we take the following steps, as directed by the consultation regulations:

- Describes the proposed action and identifies the action area (Section 2);
- Evaluates the current range wide status of the species with respect to biological requirements indicative of survival and recovery and the essential features of designated critical habitat (Section 3);
- Evaluates the relevance of the environmental baseline in the action area to biological requirements and the species' current status, as well as the status of designated critical habitat (Section 4);
- Evaluates the relevance of climate change on environmental baseline and status of the species (Section 5);
- Determines whether the proposed action affects the abundance, reproduction, or distribution of the species, or alters any physical or biological features of designated critical habitat (Section 6);
- Determines and evaluates any cumulative effects within the action area (Section 7); and
- Evaluates whether the effects of the proposed action, taken together with any cumulative effects and the environmental baseline, can be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of the affected species, or is likely to destroy or adversely modify their designated critical habitat (Section 8).

In completing the last step, we determine whether the action under consultation is likely to jeopardize the ESA-listed species or result in the destruction or adverse modification of designated critical habitat. If so, we must identify a reasonable and prudent alternative(s) (RPA) to the action as proposed that avoids jeopardy or adverse modification of critical habitat and meets the other regulatory requirements for an RPA (see 50 C.F.R. § 402.02). In making these determinations, we must rely on the best available scientific and commercial data.

These projects were constructed in the Kennebec River prior to the listing of any endangered species under our jurisdiction and are currently licensed by FERC. While the ESA provides broad authority to protect threatened and endangered species in the U.S., we must consider the action at hand in the context of this section 7 consultation. In this matter, the actions triggering the section 7 consultation are the proposed amendments of four existing FERC licenses to incorporate specific measures to protect ESA-listed species, as well as the issuance of a new operating license at the Shawmut Project. For three of the four projects, the proposed action is not the issuance of a new license by FERC to operate the dams, as they are already licensed to operate. It is, therefore, necessary to draw a distinction in our analysis between certain ongoing effects of the dams that are part of the environmental baseline versus effects of the proposed action. Environmental baseline "refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action" (50 C.F.R. § 402.02). For instance, some effects of the dams are associated with the lawful existence of the physical structures in the river. As we understand that FERC does not have discretionary authority to decommission or remove a dam outside of a relicensing proceeding, some effects (e.g., the effects of the physical presence of the dam including the existing impoundment, sediment loading, water quality)[1] must be considered as part of the environmental baseline. Therefore, only the effects associated with the operation of the facilities consistent with the terms of the proposed license amendments, are effects of those proposed actions. This Opinion also considers the relicensing of the Shawmut Project. As FERC may decide to not issue a new license, and has the authority to order the surrender and decommissioning of the dams (see FERC's 1995 decommissioning and licensing policy statement; 60 FR 339 1995), we consider that all of the effects of the continued existence of the Shawmut dam are consequences of the action subject to consultation under section 7 of the ESA.

The critical habitat analysis determines whether the proposed action will destroy or adversely modify designated critical habitat for ESA-listed species by examining any change in the conservation value of the physical and biological features of that critical habitat. As defined by NMFS and USFWS, destruction or adverse modification "means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features." (81 FR 7214; Feb.11, 2016).

On July 5, 2022, the U.S. District Court for the Northern District of California issued an order vacating the 2019 regulations that were revised or added to 50 CFR part 402 in 2019 ("2019 Regulations," see 84 FR 44976, August 27, 2019) without making a finding on the merits. On September 21, 2022, the U.S. Court of Appeals for the Ninth Circuit granted a temporary stay of the district court's July 5 order. On November 14, 2022, the Northern District of California issued an order granting the government's request for voluntary remand without vacating the 2019 regulations. The District Court issued a slightly amended order two days later on November 16, 2022. As a result, the 2019 regulations remain in effect, and we are applying the 2019 regulations here. For purposes of this consultation and in an abundance of caution, we considered whether the substantive analysis and conclusions articulated in the biological opinion and incidental take statement would be any different under the pre-2019 regulations. We have determined that our analysis and conclusions would not be any different.

2 Project Descriptions and Proposed Actions

As noted above, this consultation considers the effects of five independent federal actions at the four hydro projects in the lower Kennebec River (Figure 1). FERC is proposing to issue a new license for the Shawmut Project for a license term of up to 50 years. In addition, FERC is proposing to amend the licenses for the Weston, Shawmut, Hydro-Kennebec, and Lockwood hydropower projects, pursuant to authorities under the Federal Power Act, to incorporate provisions of a species protection plan. On November 23, 2021, FERC issued a *Notice of Intent to Prepare an Environmental Impact Statement for the Proposed Project Relicense, Interim*

[1] In the context of relicensing, where FERC does have discretionary authority to deny a license, or decommission, or remove a dam, some or all of these effects would be considered effects of the proposed action.

Species Protection Plan, and Final Species Protection Plan for the Shawmut relicensing, Shawmut Interim Plan, and SPP for the Lockwood, Hydro-Kennebec, and Weston Projects. In that notice, FERC stated that it expected to issue a draft Environmental Impact Statement (EIS) in August 2022 and a final EIS in February 2023. On February 15, 2023, FERC issued a revised procedural schedule, which stated that it now expects to issue a draft EIS in August 2023 and final EIS in March 2024. The initial notice did not address if and how this new NEPA analysis could affect the proposed actions. As addressed in our December 7, 2021 letter to FERC, if FERC proposes additional changes to these actions as a result of the NEPA analysis, reinitiation of this consultation may be necessary.

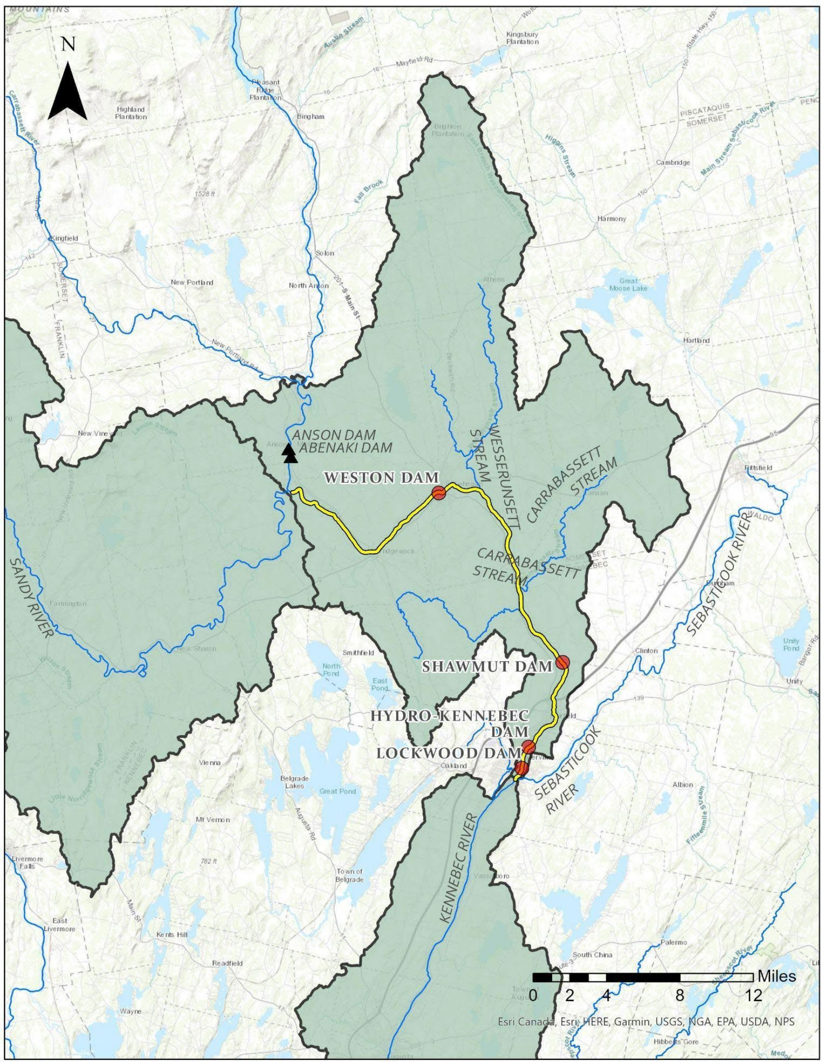

Figure 1. The mainstem of the Kennebec between the Sebasticook River and the upper extent of the Weston impoundment (yellow line) comprises the action area for the proposed actions. The green

watersheds are within designated critical habitat for Atlantic salmon. The Kennebec River downstream of the Lockwood Dam has also been designated as critical habitat for Atlantic sturgeon.

2.1 Lockwood Project

2.1.1 Project Description

The information for the project description is derived from Brookfield's May 31, 2021 Lower Kennebec Species Protection Plan and Draft Biological Assessment. The Lockwood Project is owned by the Merimil Limited Partnership (MLP) and is located at river kilometer 103 and is the first dam on the mainstem of the Kennebec River. The Lockwood Project includes a 1.6 kilometers long (81.5 acre) impoundment, an 875 ft long and approximately 17 ft high dam with two spillway sections and a 160 ft long forebay headworks section, a 450 ft long forebay canal, and two powerhouses. The dam and forebay headworks span the Kennebec River immediately upstream and downstream of the U.S. Route 201 Bridge along a site originally known as Ticonic Falls. The spillway sections impound the river on either side of a small island; the east spillway section begins at the east abutment of the dam and extends about 225 ft in a westerly direction to the small island, while the west spillway extends about 650 ft from the small island in a southwesterly direction to the forebay canal headworks, which in turn extend to the west bank of the river. Each spillway is equipped with 15-inch high wooden flashboards.

The headworks and intake structures are integral to the dam and the powerhouses, respectively. The forebay intake section contains eleven head gates measuring 8.5 ft wide by 12 ft high. From the headworks, the forebay canal directs water to two powerhouses located on the west bank of the Kennebec River: the original 1919 powerhouse contains six vertical Francis units and the 1989 powerhouse contains one horizontal Kaplan unit, which combined have a total authorized capacity of 6.8 MW and a flow of approximately 5,660 cubic feet per second (cfs).

The generating unit trash racks are serviced by a track mounted, hydraulically operated trash rake with trash removal capabilities. The trash racks screening the intakes are 2.0 inch clear spacing in front of Units 1-6 and 3.5 inch clear spacing in front of Unit 7. The project's tailrace returns the flow to the Kennebec River about 1,300 ft. downstream from the east spillway section.

Brookfield indicates that the Lockwood Project is operated in a run-of-river mode. The normal full pond elevation is 52.16 ft above mean sea level (msl) when the flashboards are in place. The Project is normally operated to provide an instantaneous minimum flow of 2,114 cfs or inflow, if less, below the powerhouse to maintain downstream aquatic habitat in the river. Flow in the approximately 1,300 ft long bypassed reach is currently limited to leakage around and through the flashboards, including through three (3 ft long by 8 inches high) engineered orifices cut into the flash boards (estimated at a total of 50 cfs), or as spill over the flashboards when river flow exceeds about 5,600 cfs.

2.1.1.1 Existing Fish Passage Facilities and Operation

Upstream Passage

Upstream passage at Lockwood is currently provided via a main channel fish lift which was commissioned in spring 2006. The facility is located on the west side of the original powerhouse and adjacent to the Unit 7 powerhouse and is designed to pass river herring, American shad, and Atlantic salmon. The fish lift is required to be operated annually from May 1 to October 31, dependent on river conditions. During the river herring, shad, and Atlantic salmon peak migration season (lasting from approximately May through mid-July), the fish lift is operated seven days per week to meet resource agency trap and truck requirements. During that migration season, the fish lift is generally operated from early morning to evening.

The timing and frequency of lifts are a function of the number of migrating fish, water temperature, and river flow; at Lockwood, the lift is operated based on direct camera monitoring of the fishway and V-gate entrance. During the remainder of the season (approximately mid-July through the end of October), lift cycles are less frequent and are specifically for the capture of Atlantic salmon. Pursuant to Maine Department of Marine Resources' (MDMR) Atlantic salmon handling protocol, the fish lift is not operated when the river water temperature exceeds 24.5ºC, in order to prevent injury or mortality of Atlantic salmon that can result from handling and associated stress at these temperatures. However, if this temperature threshold is exceeded while shad are still migrating, the Licensee in consultation with MDMR has the option of continued operation of the fish lift to accommodate shad passage. If a salmon is observed in the hopper during a lift, the hopper can be placed back down into the water allowing the salmon to volitionally swim back downstream.

The lift operates with an attraction flow of approximately 170 cfs, an entrance flow velocity of 4 to 6 ft per second (fps) and a flow velocity over the hopper of 1.0 to 1.5 fps. An auxiliary water system provides the attraction flow upstream of the hopper. The 1,800-gallon hopper discharges water and fish into a 12-ft diameter 2,500-gallon sorting tank. River herring and shad are sorted into one of two ten-foot diameter 1,250-gallon sorting tanks. River herring are then transported and released in habitat upstream in the Kennebec, as well as in other systems. Most shad are trucked and released upstream of Lockwood; whereas others are released below the project at MDMR's direction (BWPH, 2021). Atlantic salmon are removed and held in a 250-gallon isolation tank. Liquid oxygen is supplied to the sorting tanks and isolation tank via carbon micro porous stones to maintain safe dissolved oxygen levels at all times. Two auxiliary water pumps provide a constant flow of ambient river water to all the tanks and for filling of stocking truck tanks. Block ice is used, as necessary, to reduce water temperature in the Atlantic salmon holding tank in preparation for transport to the Sandy River by MDMR staff. Salmon are transported above the currently impassable dams to the habitat in the Sandy River, a major tributary of the Kennebec. Other species of non-anadromous fish captured in the fish lift are returned to the tailrace via a discharge pipe. At the direction of Maine Department of Inland

Fisheries and Wildlife (MDIFW) and MDMR, certain invasive fish species (e.g., carp, white catfish, Northern pike, gizzard shad, etc.) are removed and euthanized.

Downstream Passage

Downstream fish passage is provided at the Lockwood Project via a 7 ft wide by 9 ft deep mechanical overflow gate (fish sluice) located on the outboard side of the power canal just upstream of the Unit 1 trash rack and discharges directly into the river. Maximum flow through the gate is 6% of station capacity or 340 cfs. In 2009, a floating guidance boom was installed in the forebay angled across the forebay from the west wall of the canal downstream to the fish sluice to enhance use of the downstream passage. Following several years of evaluation and modifications made to the original guidance boom, the current design consists of a 300 ft long boom with two 10 ft long plastic cylindrical "Tuff Boom" brand floats per section. From the upstream end, the first 250-ft of boom has 4-ft deep steel punch plate guidance panels (5/16" diameter holes). An additional six feet of Dyneema curtain is attached to the bottom of each panel. The lower 50-ft section of boom has 10 ft deep steel punch plate guidance panels with no Dyneema curtain attached at the bottom. All gaps between the panels are covered by rubber flanges. In addition to the fish sluice gate and associated guidance boom, downstream migrating fish may also use the three submerged orifices (3 ft long by 8 inches high), cut into the flashboards along the spillway. The orifices are designed to provide flow through the ledges and pools in the bypass reach and pass a total of approximately 25 cfs of the required 50 cfs minimum flow at normal full pond, the remainder of which is provided by flashboard leakage. The orifices provide additional downstream passage routes along the spillway even when the project is not spilling over the top of the flashboards.

2.1.2 Proposed Action

FERC is proposing to amend the Lockwood license to incorporate measures consistent with Brookfield's May 31, 2021 SPP, as modified by Brookfield's September 21, 2022 modified proposal, and supplemented by additional information filed by Brookfield on October 20, 2022 and November 4, 2022. These include measures designed to improve upstream and downstream fish passage as described below. Note that the actions under consultation here are FERC's proposal to amend or issue licenses pursuant to the Federal Power Act and ACOE's proposal to permit certain construction activities; these proposed actions are a result of Brookfield's requests for license amendments, new license, and/or permits. For convenience, we may refer to actions being taken or proposed by FERC, ACOE, and/or Brookfield.

2.1.2.1 Upstream Fish Passage

Bypass Fishway Installation

Brookfield and FERC propose to construct a vertical slot volitional fishway in the Lockwood bypass reach. The Lockwood bypass fishway will be built on the east side of the Kennebec River at the head of the bypass reach channel. The vertical slot fishway will measure approximately 530 feet long by approximately 60 feet wide at its widest point. An attraction flow channel will be constructed on the west side of the vertical slot ladder and will be approximately 260 feet long by 10 feet wide. Brookfield proposes to initiate construction within one year after FERC approval and receipt of state and federal permits.

All in-water work will occur within the confines of a 48,450 square foot dewatered cofferdam in the headpond, and an additional 73,720 square foot cofferdam in the tailwater area (Table 1). To allow for fish passage system construction, in-river bedrock will be removed, as well as a portion of the concrete spillway. The fishway and attraction flow channel will be installed within the removed north spillway section along with two 71 foot wide crest gates, and a 92 foot long concrete floodwall, to replace spillway capacity. The two crest gates (approximately 2,860 SF/530 CY of fill) will replace the spillway west of the installed fishway, and the concrete floodwall (approximately 2,030 SF/1,140 CY of fill) will be built to replace the spillway section east of the fishway. Concrete fill (approximately 23,390 SF/10,010 CY) will be placed over the excavated areas where the fishway will be secured.

Table 1. Temporary and permanent fill associated with the construction of the proposed new fishway at the Lockwood Project (ACOE Permit Application).

Project Component	Temporary Fill (SF/LF/CY)	Excavated Fill (SF/CY)	Permanent Fill (SF/CY)	Impact Area
Temporary Dewatered Work Areas	48,450 SF/73,720 SF			Headpond/Tailwater
Upstream Cofferdam	400 LF/3,700 CY			Headpond
Downstream Cofferdam	550 LF/8,140 CY			Tailwater
Wet Road	4,000 SF/300 CY			Headpond
Wet Road	10,060 SF/750 CY			Tailwater
Earth Fill			9,090 SF/2,330 CY	Tailwater
Crane Pad			2,550 SF/950 CY	Tailwater
Bedrock Excavation		5,710 SF/590 CY		Headpond
Fishway Bedrock Excavation		19,570 SF/2,310 CY		Tailrace
Concrete Demolition		3,700 SF/1,340 CY		Dam
Crest Gate Bedrock Excavation		2,860 SF/85 CY		Tailrace
Fishway			5,530 SF/2,350 CY	Headpond
Fishway			17,860 SF/7,660 CY	Tailrace
Concrete Flood Wall			2,030 SF/1,140 CY	Tailrace
Concrete Crest Gate			2,860 SF/530 CY	Dam/Tailrace

In water work windows will be limited to July 15 to September 30 and November 8th to April 9 (Table 2). Once the cofferdams are in place, all work will be in the dry and the cofferdams will be dewatered with the implementation of a Fish Stranding Plan. All excavation and blasting will be done in the dry to the extent possible with sound pressure and sound exposure limits in place pursuant to a Blasting Plan, to be developed in consultation with the agencies.

Table 2. Construction schedule and sequencing for the construction of the Lockwood bypass fishway (ACOE Permit Application). Due to process delays, the actual years of construction may vary from what is presented here, but we anticipate that the months that the different activities have been proposed will remain the same.

Construction Phase	Construction Schedule
Contractor Mobilization and Access Road Construction (upland ground disturbance only; no in water work; 4 months to complete)	October 2021 – January 2021
Construct Temporary In-Water Access and Water Control Structures (target start of installation and work within in water work windows July 15 to September 30 and November 8 to April 9; 6 months to complete)	July 15, 2022 – September 30, 2022 and November 8, 2022 – March 8, 2023
North Spillway Demolition and Bedrock Removal (in the dry; 6 months to complete)	March 2023 – September 2023
Fish Passage, Crest Gates, and Floodwall Construction (in the dry; 14 months to complete)	October 2023 – December 2024
Remove Temporary Access and Water Control Structures, Contractor Demobilization (target removal within in water work windows July 15 to September 30 and November 8 to April 9; 6 months to complete)	January 2025 – April 2025; July 15, 2025 – September 30, 2025
Fishway Commissioning	May 2026

Fishway Operation

FERC is proposing to amend the license to require compliance with the following measures as proposed by the Licensee prior to, during, and after the installation of the bypass fishway:

- Continue to operate the Lockwood fish lift and coordinate trucking activities with MDMR annually during adult Atlantic salmon migration periods (May 1 through October 31) until completion of the bypass reach fishway and pending effectiveness testing.
- To not operate the lift to capture/truck salmon when river water temperature is greater than 24.5°C.
- Coordinate with MDMR to ensure that the trucking component of the fish lift at Lockwood will continue to be operated for Atlantic salmon, American shad, and river herring.
- Undertake measures necessary to keep the Lockwood fish lift in good operating condition. If the fish lift malfunctions or becomes inoperable during the migration period, the fish lift will be repaired and returned to service as soon as it can be safely and reasonably done.
- Maintain records of all fish trapped and/or moved via the fish lift.

- Relocate, if necessary, the upstream eel passage facility in consultation with the agencies.

Once fishways on the lower Kennebec river (i.e., at Lockwood, Hydro-Kennebec, Shawmut, and Weston) have been constructed, the Licensee proposes the following:

- Operate permanent volitional passage in the Lockwood bypass reach as previously approved by the 2016 FERC license amendment during the Atlantic salmon migration period, May 1-October 31. Volitional fish passage will be installed and operational by a target date of May 2024 and one season of shakedown implemented.
- Consult with the agencies and update the Fish Passage Operations and Maintenance Plan for the Project to include the existing fish lift and the bypass reach facility as well as the Fish Stranding Plan and Sturgeon Handling Plan.
- Adaptively manage upstream passage to ensure that fishway performance is consistent with proposed efficacy and delay standards. Additional adaptive upstream measures include the construction of additional fishway entrances and/or fishways in the event that monitoring demonstrates its necessity.

2.1.2.2 Downstream Fish Passage

Brookfield has proposed the following operational and structural modifications to the Lockwood downstream passage facilities. Additionally, the Licensee will continue to operate the existing downstream passage facility at Lockwood. Brookfield will undertake the following measures:

- Continue to operate the Lockwood canal bypass gate and floating guidance boom for utilization by adult and juvenile Atlantic salmon, April 1 through December 31, as river conditions allow. Undertake measures necessary to keep the guidance boom in place and in good operating condition. If the guidance boom becomes dislodged or damaged, repair or replacements to the guidance boom will be made as soon as can be safely and reasonably done.
- Ensure that the canal bypass gate is open and operating to pass the maximum flow through the gate, which is 6% of station unit flow.
- When river flow at the Project exceeds about 5,660 cfs, flow in excess of operating turbine capacity (except for pond fluctuations allowed by the license) will be spilled in accordance with the Project's high-water guidelines unless it is determined through consultation with NMFS that additional spill is needed for downstream passage.
- Within two years of FERC approval:
    - Install a 2-inch trash rack overlay at Unit 7 (Units 1-6 already have 2-inch racks); and
    - Install a uniform acceleration weir at both the downstream fishway and the forebay surface sluice.
- Within one year of license amendment, implement nighttime shutdowns from 8 pm to 8 am for four weeks (up to five weeks) during the smolt migration period, which is generally targeted for the last week of April to the last week of May, with the start date to

be determined in consultation with NMFS and MDMR based on smolt trapping information or a migration model.

- Ensure that downstream fish passage facilities meet performance standard for juvenile salmon of approximately 97% (individual project effectiveness may vary, so long as the cumulative four-project standard of 88.5% is attained).

2.1.2.3 Sturgeon Handling and Protection Plan

The Licensee has developed and will implement a sturgeon handling plan to provide for safe handling of any Atlantic or shortnose sturgeon that may be encountered at the Lockwood Project by personnel during fish lift operations or in the event of stranding during the replacement of flashboards along the spillway. Implementation of this plan promotes the protection of Atlantic and shortnose sturgeon in the event they are encountered at the Project. This plan may be revised in consultation with the agencies when the upstream and downstream passage measures proposed for the Lockwood Project and described in the previous sections are implemented at the Project to ensure continued protection of Atlantic and shortnose sturgeon.

2.2 Hydro-Kennebec Project

2.2.1 Project Description

The information for the project description is derived from Brookfield's May 31, 2021 Lower Kennebec Species Protection Plan and Draft Biological Assessment. The Hydro-Kennebec Project is located at river kilometer 105 on the Kennebec River in the cities of Waterville and Winslow, Maine. Hydro-Kennebec is the second dam upstream on the Kennebec River. The Hydro-Kennebec Project has a total authorized capacity of 15.4 MW. The principal features include a concrete gravity dam with flashboards, forebay, impoundment, and a powerhouse containing two horizontal pit-type Kaplan turbines.

The Project consists of a 555 foot long un-gated concrete gravity spillway and a 200 foot long gated spillway. The dam also includes an 18 foot long east abutment adjacent to the powerhouse.

The un-gated spillway structure is 35 feet high at its maximum section with 6 foot high wooden flashboards, bringing the normal full headpond elevation to 81 feet. The gated spillway section has a permanent crest elevation of 68 feet and is equipped with three hydraulically controlled gates (each 15 feet high by 60 feet wide) to maintain the normal full pond elevation of 81 feet. The impoundment is approximately 2.9 miles long and 250 acres in area.

The powerhouse is located between the middle retaining wall and the left bank and is 131.5 feet long and 62.2 feet wide at its base. The intake has steel trash racks with 3.5-inch clear spacing, supported by concrete piers equipped with steel maintenance gates and a mechanical trash rake. Each of the two four-blade pit-type Kaplan turbine units are capable of operating over a flow range of 1,550 cubic feet per second (cfs) to 3,961 cfs. Unit 2 is located on the bank side of the powerhouse and Unit 1 is located on the river side of the powerhouse. The turbines are approximately 13 feet in diameter and have an operating speed of 115 rpm. The runner speed (115 rpm) is stepped up using a speed increaser to result in a generator speed of 600 rpm. The powerhouse draft tube has roller gates, which are hydraulically operated. Flow from the turbines is directly discharged to the tailrace and into the Kennebec River. The tailrace is separated from the Kennebec River by a narrow section of bedrock stabilized by rock anchors.

2.2.1.1 Existing Fish Passage Facilities and Operation

Upstream Passage

A fish lift was constructed at the Hydro-Kennebec Project in 2016-2017 and became operational in September 2017. The facility was designed to pass Atlantic salmon, American shad, alewives, and blueback herring. The fish lift consists of a tailrace entrance located immediately downstream of the Project powerhouse, a hopper elevator system, exit flume, and upstream exit located adjacent to the Project's abandoned gatehouse. The concrete upstream fish passage entrance is 14.0 ft wide and equipped with an adjustable overshot attraction flow gate. Fish are guided through a curved concrete entrance chamber leading to a 14 ft wide by 20 ft long lower flume. The elevator raises the hopper approximately 45 ft. to discharge fish and water to the 470 ft long exit flume.

A 40 ft wide attraction water intake screen and associated lifting structure (for cleaning) is installed adjacent to the fishway exit with ⅜ inch diameter holes to allow for screening of attraction flow. The fish lift facility is designed to operate under a normal headpond elevation of 81.0 ft. msl and a normal tailwater of elevation 54.0 ft. msl and is designed for river flows between 2,300 cfs and 23,000 cfs.

The Hydro-Kennebec fish lift has a minimum cycle time of approximately 10 minutes and can be operated in either automatic or manual mode. Water flow within the fish lift is adjusted by a series of manually controlled gates and valves. The system is designed to pass a range of attraction flow at the entrance gate of between 240 cfs to 400 cfs. Flow velocity is maintained at approximately 1-1.5 fps in the exit flume, 1-1.5 fps over the hopper, 2-4 fps in the entrance channel, and 4-6 fps at the fishway entrance.

The Hydro-Kennebec fish lift is currently operated in consultation with the MDMR to evacuate Atlantic salmon that are anticipated to have ascended the Lockwood bypass reach spillway during high flow/spill conditions. Until upstream fish passage is completed at all four lower Kennebec River Projects, upstream fish passage on the Kennebec River will continue to be provided via trap and truck operations from Lockwood to the Sandy River upstream.

Downstream Passage

The downstream passage facility at the Hydro-Kennebec Project consists of a floating angled guidance boom that guides fish to a deep-gated surface bypass slot that directs fish into a plunge pool and then to the tailwater area. The floating guidance boom was installed in the Hydro-Kennebec forebay to guide downstream migrating fish to a 4 ft wide by 8 ft deep gated surface weir capable of passing 320 cfs (4% of station flow). The surface weir discharges into a plunge pool which flows out to the tailrace.

The original boom (installed in 2006) was 160 ft long and utilized a 10 ft deep Kevlar curtain to guide the fish. In 2012, the Kevlar curtain was replaced with steel perforated plates (5/16 inch diameter holes) configured as a series of interlocking panels designed to be left in place year round.

The steel plates are 10 ft deep. The plunge pool has been modified several times since 2006 to improve fish survival through the facility. This includes adding depth to the plunge pool in 2007 by installing a weir in the fish bypass to minimize potential for fish injury. The plunge pool was deepened further in 2012 by adding a stop-log structure to the downstream fishway. A confining sill was also installed on the roof of the draft tube extension in the tailrace to keep the discharge jet from spreading over the exposed draft tube roof.

2.2.2 Proposed Action

FERC is proposing to amend the Hydro-Kennebec license to incorporate measures that are consistent with Brookfield's May 31, 2021 proposed SPP, as modified by Brookfield's September 21, 2022 modified proposal, and supplemented by additional information filed by Brookfield on October 20, 2022 and November 4, 2022. These include measures designed to improve upstream and downstream fish passage as described below.

2.2.2.1 Upstream Fish Passage

The Licensee proposes to operate the existing fish lift after upstream fish passage is completed at all four lower Kennebec River Projects. Specifically, the Licensee proposes to:

- Operate the installed Hydro-Kennebec fish lift (designed to allow free-swim passage into the headpond and not configured to trap, sort, or truck fish) during Atlantic salmon migration periods between May 1-October 31.
- Consult with the agencies regarding how the Hydro-Kennebec fish lift will be operated and update the Fish Passage Operations and Maintenance Plan for the Project.

In the period prior to construction and shakedown of upstream fish passage at all four lower Kennebec River Projects, the Licensees propose to:

- Operate the existing lift in coordination with MDMR. The Licensee anticipates that

MDMR will provide guidance for the duration and frequency of lift operation following camera observations of salmon at the fishway entrance, attempt to capture the salmon, and, if caught, turn them over to MDMR to be trucked to the Sandy River.

- When operating to trap and truck salmon, the Licensee will not operate the lift to capture salmon when river water temperatures are greater than 24.5°C.
- Utilize the Lockwood fish lift and coordinate trucking activities with MDMR annually during the Atlantic salmon migration period (May 1 through October 31) to provide interim upstream passage for Atlantic salmon at the Hydro-Kennebec Project.

In the period following construction and shakedown of upstream fish passage at all four lower Kennebec River Projects, the Licensees propose to:

- Adaptively manage upstream passage to ensure that fishway performance is consistent with proposed efficacy and delay standards. Additional adaptive upstream measures could include the construction of additional fishway entrances and/or fishways in the event that monitoring demonstrates its necessity.

2.2.2.2 Downstream Fish Passage

The Licensee proposes the following modifications to improve downstream passage performance:

- Relocate the existing bypass gate, in consultation with the agencies (preliminary conceptual design shown in Figure 6-1 of the BA) within 2 years after FERC approval. The new bypass gate will be designed to pass 5% of station flow and will include a uniform acceleration weir (USFWS 2019).
- Reposition the existing guidance boom so that it extends to the downstream edge of the new gate within 2 years after FERC approval.
- Remove internal weirs and smooth downstream flume within 2 years after FERC approval.
- Operate the downstream bypass and floating guidance boom for utilization by adult and juvenile Atlantic salmon, April 1 through December 31, as river conditions allow. Undertake measures necessary to keep the guidance boom in place and in good operating condition. If the guidance boom becomes dislodged or damaged, repair or replacement will be made as soon as can be safely and reasonably done.
- Install 2-inch clear spaced overlays at the Hydro-Kennebec Project turbine intakes within 2 years after FERC approval.
- Beginning the first downstream passage season following issuance of the Biological Opinion, implement nighttime shutdowns from 8 pm to 8 am for four weeks (up to five weeks) during the smolt migration period, which is generally targeted for the last week of April to the last week of May, with the start date to be determined in consultation with NMFS and MDMR based on smolt trapping information or a migration model.

- Conduct a survey of the bypass reach ledges for perched pools and modify the ledges as necessary to provide opportunities for egress within one year after FERC approval.
- Ensure that downstream fish passage facilities meet a performance standard for juvenile salmon of approximately 97% (individual project effectiveness may vary, so long as the cumulative four-project standard of 88.5% is attained).

2.3 Shawmut Project

2.3.1 Project Description

The information for the project description is derived from Brookfield's January 30, 2020 Shawmut Project Application for New License, FERC's July 1, 2021 Draft Environmental Assessment (DEA), and additional information filed by Brookfield on November 4, 2022._The Shawmut Project is located at river kilometer 113 and is the third dam on the mainstem of the Kennebec River. It includes a 12 mile long (1,310-acre) impoundment, a 1,135 ft long dam with an average height of about 24 ft, headworks structure, enclosed forebay, and two powerhouses with intake structures. The crest of the dam has 380 ft of hinged flashboards 4 ft high serviced by a steel bridge with a gantry crane, a 730 ft long inflatable bladder composed of three sections, each 4.5 ft high when inflated and a 25 ft wide by 8 ft deep sluice equipped with a timber and steel gate.

The headworks and intake structures are integral to the dam and the powerhouses, respectively. The forebay intake section contains eleven headgates and two filler gates. Five of the headgates are installed in openings 10 ft wide by 15.5 ft high and six are installed in openings 10 ft by 12.5 ft. The two filler gate openings are 4 ft by 6 ft. A non-overflow concrete gravity section of the dam connects the west end of the concrete filled forebay gate openings with a concrete cut-off wall which serves as a core wall for an earth dike.

The forebay is located immediately downstream of the headgate structure and is enclosed by two powerhouse structures, the 1924 powerhouse located to the east and the 1982 powerhouse located to the south. An approximately 240 ft long concrete retaining wall is located on the west side of the forebay. Located at the south end of the forebay between the powerhouses is a 10 ft by 7ft Tainter gate. In addition, a 6 ft by 6 ft deep gate and a surface sluice (4 ft wide by 22 inch deep, passing 35 cfs) discharges into a 3 ft deep plunge pool located at the south end of the forebay. In the original powerhouse, the intake section has six open flumes each fitted with two 10.5 ft by 14 ft double-leaf slide gates and a continuous trash rack. In the newer powerhouse, the intake section contains two openings fitted with vertical headgates about 12 ft high by 12 ft wide and operated by hydraulic cylinders. The trash racks are serviced by a track mounted, hydraulically operated trash rake with trash removal capabilities. The trash racks screening the intakes are 1.5 inch clear spacing in front of the Units 1 - 6 Powerhouse and 3.5 inch clear spacing in front of Units 7 and 8 Powerhouse.

The original powerhouse contains six horizontal Francis-design units and the newer powerhouse contains two horizontal propeller units, having a total combined authorized capacity of 8.74 MW and combined station flow of approximately 6,700 cfs. The Project's tailrace channels are excavated riverbed located downstream of the powerhouses. The Licensee states that the Project is typically operated in a run-of-river mode, normally passing a minimum flow of 2,110 cfs, with a normal full pond elevation of about 112.0 ft msl.

2.3.1.1 Existing Fish Passage Facilities and Operation

Upstream Passage

There are currently no upstream fish passage facilities at the Project.

Downstream Passage

Downstream passage for Atlantic salmon at Shawmut is currently provided through a combination of a surface weir (sluice), Tainter gate, and opened hinged flashboards. The sluice is located within the forebay at the right side of the intake structure next to Unit 6. It is 4 ft wide by 22 inches deep and flow can be adjusted by adding or removing stoplogs. With all stoplogs removed, the sluice passes between 30 and 35 cfs which is discharged over the sill into a 3 ft deep plunge pool. The Tainter gate located next to the sluice measures 7 ft high by 10 ft wide and can pass up to 600 cfs.

The Tainter gate is operated for Atlantic salmon smolt and kelt passage from April 1 through June 15 and from November 1 through December 31, as river flow and ice conditions allow. During these periods, the Tainter gate is open to 600 cfs 24 hours a day, 7 days a week. The surface sluice is open from April 1 to December 31, as river and ice conditions allow, continually providing 30 to 35 cfs for downstream passage. Downstream passage is also provided along the Shawmut spillway during periods of excess river flow that results in spill. To provide an additional passage during the Atlantic salmon smolt migration season, the Licensee also drops several sections of flashboards. Currently, four hinged flashboards sections located immediately adjacent to the power canal headworks are opened for the Atlantic salmon smolt migration season, April 1 to June 15, and provide up to approximately 560 cfs of spill flow.

2.3.2 Proposed Action

2.3.2.1 Interim Species Protection Plan

The current FERC license for the Shawmut Project expired on January 31, 2022. On February 10, 2022, FERC issued an annual license for a period effective February 1, 2022 through January 30, 2023, or until the issuance of a new license for the project or other disposition under the FPA, whichever occurs first[2]. The actions proposed by the Licensee under the interim species protection plan (interim plan) would be implemented until the issuance of a new license or other

[2] FERC Accession #: 20220210-3017

disposition under the FPA. FERC has not issued its DEIS or FEIS, and therefore, did not issue a licensing decision for the Shawmut Project prior to January 30, 2023. For this reason, we expect that FERC will issue at least one more annual license.

The information for the interim proposed action is derived from Brookfield's December 31, 2019 Fish Passage Operations and Maintenance Plan and May 31, 2021 Shawmut Interim Plan, FERC's July 1, 2021 Draft Environmental Assessment (DEA), as modified by Brookfield's September 21, 2022 modified proposal, and supplemented by additional information filed by Brookfield on October 20, 2022 and November 4, 2022.

Upstream Fish Passage

No upstream fish passage facilities are anticipated to be constructed and operable during the period defined in the interim plan.

Downstream Fish Passage

The Licensee proposes to operate the existing downstream fish passage facility in accordance with the existing Fish Passage Operation and Maintenance Plan, including the following measures:

- Provide downstream fish passage through the surface sluice (30-35 cfs) and Tainter gate (600 cfs);
- Provide downstream passage via these routes 24 hours a day, 7 days a week, from April 1 through June 15 and November 1 to December 31 for Atlantic salmon;
- Lower 4 sections of hinge boards adjacent to the canal headworks for the Atlantic salmon smolt migration season (April 1 to June 15) to provide approximately 560 cfs of spill flow. Provide this supplemental flow from May 1 to May 31, annually;
- Prepare annual fishway monitoring reports and hold an annual meeting with fishery agencies;
- Notify NMFS of any changes in operation including maintenance activities and debris management at the Project during the term of the interim plan;
- Contact NMFS within 24 hours of any interactions with Atlantic salmon, including non-lethal and lethal takes; and
- In the event of any lethal takes, any dead specimens or body parts must be photographed, measured, and preserved (refrigerate or freeze) until disposal procedures are discussed with NMFS.

2.3.2.2 Relicensing

In a letter dated December 2, 2021, FERC requested formal section 7 consultation under the ESA for the proposed relicensing of the Shawmut Project. FERC indicated that its draft Environmental Assessment (DEA), issued on July 1, 2021, would serve as its Biological Assessment. Therefore, the proposed action we define herein is based upon FERC's staff-recommended measures and mandatory conditions, as described in its July 1, 2021 DEA for the Shawmut Project.

Upstream Fish Passage

The Licensee proposes to construct an upstream fish passage facility at the Shawmut Project. The upstream facility was previously considered in our now-expired 2013 Opinion, and a permit was issued by the ACOE in March of 2020 (Corps permit #: NAE-2019-03035). The upstream anadromous fishways would consist of a new fish lift adjacent to Units 1-6 Powerhouse and a concrete bypass channel through the island separating the two powerhouse tailraces. The concrete bypass channel would enable fish migrating upstream in the Unit 7 and 8 Powerhouse tailrace to move across the island and into the Unit 1 through 6 Powerhouse tailrace where they could access the new fish lift entrance to be passed over the dam.

The description of the new fishways below is based on the description filed with the final plans filed with FERC on December 31, 2019.

The proposed fish passage facility will include a fish lift with integrated attraction water intake and spillway placed downstream of the non-overflow portion of the dam and adjacent to the Units 1 through 6 powerhouse, a short fish ladder connecting the Units 7 and 8 tailrace to the Units 1 through 6 tailrace at the upstream end of the training wall/ island, and modifications to the discharge of the Tainter gate adjacent to the Units 7 and 8 powerhouse.

The lower portion of the fish lift structure will consist of an 81 ft long, 21 ft wide, and 24 ft tall concrete and steel entrance flume. The entrance flume will include a pivoting entrance gate, a set of v-trap gates, approximately 11 ft by 11 ft traveling hopper, a baffle wall, and a v- shaped baffled weir. Set upon the entrance flume will be an approximately 31 ft long, 15 ft wide, and 56.5 ft tall structural steel tower within which the hopper will travel to the upper level; the open steel tower will also contain an access stairway. At the upper level (the top of the non- overflow portion of the dam) will be an exit flume (20-inch diameter pipe), a 600 gallon supplemental water storage tank, and steel grating access platform.

An approximately 93 ft long 16 to 10 ft wide (varying width) spillway will be cut into the non-overflow portion of the dam and extend while turning about 53 degrees to spill adjacent to the fish lift entrance to the flume. At the upstream edge of the spillway a beveled broad crested weir will extend about five feet out into the reservoir. At the downstream edge of the existing dam the floor of the spillway channel will include an intake consisting of a 16 ft long by 16 ft wide wedge wire screen which diverts water from the spillway to the energy dissipation pool.
The attraction water intake and spillway is designed to divert 340 cfs from the upper pond; of this 115 to 225 cfs will be diverted through the wedge wire screen intake to the energy dissipation pool and then the fish lift entrance flume. The remaining 115 to 225 cfs will continue to spill adjacent to the fish lift entrance.

An approximately 77 ft long 10.5 ft wide fish ladder will be placed at the upstream end of the island to provide fish egress from the Unit 7 and 8 tailrace to the Unit 1 through 6 tailrace. The discharge from the Tainter gate located between the two powerhouses will be rerouted to the Unit 7 and 8 tailrace. The fish ladder structure will be comprised of a concrete fishway channel with two baffles, a hinged entrance gate, and isolation gates. The southern side of the channel will share a wall with the modified Tainter gate spillway channel and the northern wall will extend 80 ft downstream along the island as a training wall. An approximately 75 ft long by 8 ft wide channel will be excavated into the bedrock turning about 84 degrees from the Units 1 through 6 tailrace to the fish ladder exit. The excavated rock channel will be at existing grade near the Unit 1 through 6 tailrace and about 5 ft deep at the fish ladder. Access stairs from the roof of the Unit 7 and 8 powerhouse will lead down to a steel grating walkway near the exit of the Tainter gate spillway channel. This walkway will cross over both channels to allow access to the fish ladder.

A new 79 ft long by 10 ft wide concrete spillway channel will extend from the discharge of the existing Tainter gate to the Unit 7&8 tailrace. This channel is located adjacent to the Unit 7 and 8 powerhouse and fish ladder.

The fishway will have an operating range designed for river flows between 2,540 cubic feet per second (cfs) and 20,270 cfs and will maintain an attraction flow of 0.5 feet per second (FPS) in the exit flume and 6 FPS in the fishway entrance.

In addition to the construction of a new fishway, Brookfield has proposed to:

- Operate the new anadromous upstream fish lift and upstream passage flume from May 1 to November 10 to encompass the entire upstream migration period for Atlantic salmon in Maine.
- Develop study plans for monitoring studies to ensure compliance with performance standards. The monitoring studies must begin at the start of the first migratory season after each fishway is operational and continue for up to 3 years or as otherwise required by NMFS.
- After the new fish lift and guidance boom are constructed and tested and Tainter gate and deep gate spillway extensions are completed, prioritize operation of the generating units in the Unit 1 - 6 Powerhouse such that unit 1 is the first on and last off, followed consecutively by units 2 through 6, from May 1 to October 31 to increase attraction to the new fish lift entrance.
- Adaptively manage upstream passage to ensure that fishway performance is consistent with proposed efficacy and delay standards. Additional adaptive upstream measures include the construction of additional fishway entrances and/or fishways in the event that monitoring demonstrates its necessity.

Downstream Fish Passage

- Prioritize operation of Units 1 through 6 from April 1 to December 31 to enhance downstream anadromous fish passage survival.
- Prioritize spill flows to direct spill to avoid ledge outcroppings to the extent possible beginning the first full downstream passage season following issuance of the Biological Opinion.
- Implement nighttime shutdowns of Units 7 and 8 from 8 pm to 8 am for 4 weeks (but with the possibility of extending the shutdowns to 5 weeks) during the smolt migration period, generally targeted for the last week of April to the last week of May, with the start date to be determined in consultation with NMFS and MDMR based on smolt trapping information or migration model and following completion of spillway improvements.
- Install a fish guidance boom in the forebay upstream of the 1982 Powerhouse to direct downstream migrating fish away from the turbines and toward the forebay Tainter and surface sluice gates. The guidance boom would consist of 10 foot deep rigid panels with 0.5-inch perforations and 48% open area within two years after FERC license issuance.
- Installation of the proposed upstream fishway will include an attraction water system (AWS) with a capacity of 340 cfs and a uniform acceleration weir entrance, to provide a dedicated downstream fish passage route.
- Construct a new downstream fish passage flume downstream of the forebay Tainter gate, concurrent with the construction of the upstream fishway.
- Install a fish guidance boom outside the forebay, in front of the existing gate structure, to be designed in consultation with fisheries resource agencies. The guidance boom would consist of 10 foot deep rigid panels with 0.5-inch perforations, would be approximately 330 ft long, and would be designed to provide guidance to the uniform acceleration weir entrance described above, within two years after FERC license issuance.
- Resurface and smooth the spillway concrete below the hingeboards and the log sluice within two years after FERC license issuance.
- Install new trash racks or trash rack overlays on the unit 7-8 powerhouse intake with 2-inch bar spacing within two years after FERC license issuance.
- Install 1-inch overlays at the units 1-6 powerhouse within two years after FERC license issuance.
- Ensure that downstream fish passage facilities meet a minimum performance standard 97% passage effectiveness for juvenile Atlantic salmon and 95% for juvenile alosines.
- Develop study plans for monitoring studies to ensure compliance with performance standards. The monitoring studies must begin at the start of the first migratory season after each fishway is operational and continue for up to 3 years or as otherwise required by NMFS.

2.4 Weston Project

2.4.1 Project Description

The information for the project description is derived from Brookfield's May 31, 2021 Lower Kennebec Species Protection Plan and Draft Biological Assessment and supplemented by Brookfield's September 21, 2022 modified proposal. The Weston Project is located at river mile 82 and is the fourth dam on the mainstem of the Kennebec River. The Weston Project includes a 12.5 mile long (930-acre) impoundment, two dams, and one powerhouse. The two dams are constructed on the north and south channels of the Kennebec River where the river is divided by Weston Island.

The North Channel dam is a concrete gravity and buttress dam. The dam extends from the north bank of the Kennebec River to Weston Island, in a broad V-shape, following the high ledge of a natural falls. The South Channel dam is a concrete gravity and buttress dam that extends between abutment walls from the island to the south river bank. The powerhouse/intake section is integral to the Project dam and includes the headworks and four intake bays, one for each of the four turbine-generator units.

The Licensee indicates that the Weston Project operates in a run-of-river mode, maintaining the impoundment water surface elevation within one foot of the normal full pond elevation, during normal operations. A minimum flow requirement in the existing FERC license requires the Project to release a minimum flow of 1,947 cfs or inflow, whichever is less.

2.4.1.1 Existing Fish Passage Facilities and Operation

<u>Upstream Passage</u>

There are currently no upstream fish passage facilities at the Weston Project.

<u>Downstream Passage</u>

Downstream passage at the Weston Project is provided through a sluice gate and associated concrete flume located on the South Channel dam near the Unit 4 intake. The sluice is 20.8 ft high and 70 ft long and discharges into a deep plunge pool. The gate is capable of discharging up to 2,250 cfs at full pond (approximately 38% of station unit flow). Brookfield's modified proposal clarified that the log sluice is prioritized as the first conveyance of inflows in excess of station capacity. On average, the capacity of the powerhouse is exceeded approximately 55% of the time from April 15 to June 15, resulting in supplemental log sluice flows. The log sluice is operated at its full capacity approximately 45% of the time, on average, during the downstream fish passage season. In 2011, the Licensee enhanced the downstream passage facility by installing a 300 ft long floating guidance boom in front of the intakes with suspended 10 ft deep sections of 5/16 inch metal punch plate screens leading to the sluice gate.

On the North Channel side of the Weston Project, there are two Tainter gates, an inflatable rubber (Obermeyer) dam section, and stanchion gate sections. Currently, additional passage opportunities are provided at the North Channel side via spillage in times of high flows. Brookfield's modified proposal clarified that under current operations, the right Tainter is generally operated first as the left Tainter cannot be operated remotely. If operations staff are onsite for manual operation of the left Tainter, the flows are distributed evenly among the two gates. Otherwise, the left Obermeyer section may be operated remotely to pass inflows in excess of the right Tainter. These operations are followed by the left Tainter, if not already operational, and then the right Obermeyer section.

2.4.2 Proposed Action

FERC is proposing to amend the Weston license to incorporate measures that are consistent with Brookfield's May 31, 2021 proposed SPP, as modified by Brookfield's September 21, 2022 modified proposal, and supplemented by additional information filed by Brookfield on October 20, 2022 and November 4, 2022. These include measures designed to improve upstream and downstream fish passage as described below.

2.4.2.1 Upstream Fish Passage

The Licensee proposes to construct an upstream fish passage facility, beginning one year after FERC approval and receipt of state and federal permits. The upstream facility was previously considered in our now-expired 2013 Opinion. The proposed fish passage facility will include a fish lift with an integrated attraction water system (AWS) spillway. The proposed fish lift and AWS spillway are to be located between the powerhouse and log sluice on the south channel dam. Construction of the facility will take place in the waterway and will include temporary fill, permanent fill, and permanent excavation below the Ordinary High Water line (OHW) of the Kennebec River.

According to Brookfield's July 13, 2021, application to the ACOE, the fish lift and AWS spillway will be located between the powerhouse and the log sluice on the south channel dam. The total system will be approximately 30 feet wide by 70 feet high. An approximate 15 foot long section of the south channel dam will be removed down to elevation 144 feet to make space for installation of the AWS spillway. Minor bedrock excavation will additionally be required for installation of the fishway entrance.

The fish lift structure itself with have a 10-foot entrance width where the fish will swim into and stay in a hopper with a volume of 490 cubic feet. The fish lift facility will provide a total attraction flow of up to 304 cubic feet per second (cfs) and will have a cycle time of 15 minutes. The attraction flow will be provided via the isolation gate with a wedge wire screen that has 0.25-inch slot widths. Migrating fish will swim into the hopper, which will lift fish from an elevation of 123 feet to an elevation of 145 feet where they will swim out the approximately 215-foot long by 20-inch smooth fiberglass pipe to an elevation of 159 feet and exit into the headpond at elevation 156 feet to continue their migration upstream. The exit pipe has a maximum of 5% slope. Flows through the exit pipe will not be continuous. A total of 490 cubic feet (3,665 gallons) of water will be passed through the exit pipe over approximately 30 seconds, with instantaneous flows ranging from 10 to 40 cfs. An additional 600 gallons will discharge through the exit pipe for approximately 30 seconds from an auxiliary tank following the hopper discharge.

To allow for fish passage system construction, in-river bedrock removal will occur and a small portion of the south concrete spillway will be removed. The fish lift and attraction flow channel will be installed downstream of the spillway. A temporary contractor designed bulkhead cofferdam will be constructed on the downstream side of the access road and around the fish lift construction area in the tailrace. A small temporary contractor designed bulkhead cofferdam will also be constructed in the headpond, upstream of the fish lift work area. All work will occur in the dry and within cofferdam areas. Turbidity curtain systems will be placed around the cofferdams. Dewatering pumps will be used to pump water out of the work area. These pumps will utilize crushed stone and filter fabric to ensure sediment laden waters are not pumped back into the river system. For safety during cofferdam construction, the Project impoundment will be lowered 1.5 feet. The impoundment drawdown will not exceed a rate of approximately 1 inch per hour. When downstream flow regulation is necessary to raise the impoundment level after construction of the cofferdam, Brookfield will follow a 90/10 refill protocol rate: passing 90% of inflow and allowing 10% of inflow to refill the impoundment.

Once the cofferdam structures are set up and the work area is dry, some bedrock and a small portion of the existing South Channel Dam will need to be removed to prepare the area for the installation of the fish lift. Estimated fill quantities are indicated in Table 3. In-river bedrock excavation will occur in the proposed fishway footprint. This area will be excavated to various slopes and elevations, in order to prepare the bedrock surface for the fish lift. Bedrock material will be removed from the river. Blasting is not anticipated to be utilized for the removal of bedrock for this project. A portion of the south channel dam concrete spillway will be removed, in order for the fishway exit pipe to be installed. Excavated materials may be temporarily stored on site before being transported off site and disposed of in accordance with local, state, and federal regulations.

Table 3. Estimated excavation and fill quantities into waters of the United States anticipated due to the construction of a new fish lift at the Weston Project in Skowhegan, Maine.

Project Component	Temporary Fill (SF/LF/CY)	Excavated Fill (SF/CY)	Permanent Impact (SF/CY)	Impact Area
Access Road	11,100 ft^2 / 830 y^3			Tailrace
Bedrock Removal		2,740 ft^2 / 800 y^3		Tailrace
Concrete Spillway Section Removal		360 ft^2 / 170 y^3		Dam
Cofferdam	480 Length Feet / 4,910 y^3			Tailrace
Fish Lift			3,440 ft^2 / 2,320 y^3	Tailrace

In water work windows will be limited to July 15 to September 30 and November 8th to April 9 (Table 4). Once the cofferdams are in place, all work will be in the dry and the cofferdams will be dewatered with the implementation of a Fish Stranding Plan, to be developed in consultation with the agencies. All excavation and blasting will be done in the dry to the extent possible with sound pressure and sound exposure limits in place pursuant to a Blasting Plan, to be developed in consultation with the agencies.

Once all the fishways have been constructed, Brookfield will adaptively manage upstream passage to ensure that fishway performance is consistent with proposed efficacy and delay standards. Additional adaptive upstream measures include the construction of additional fishway entrances and/or fishways in the event that monitoring demonstrates its necessity.

Table 4. Construction schedule and sequencing for the construction of the Lockwood bypass fishway (ACOE Permit Application).

Construction Phase	Construction Schedule
Contractor Mobilization and Access Road Construction (upland ground disturbance only; no in water work; less than 1 month to complete)	June 2022
Construct Temporary In-Water Access and Water Control Structures (target start of installation and work within in water work windows: July 15 to September 30 and November 8 to April 9; 6 months to complete)	July 15, 2022 – September 30, 2022 and November 8, 2022 – March 8, 2023
Demolition and Bedrock Removal (in the dry; 2 months to complete)	April 2023 – June 2023
Fish Lift Construction (in the dry; 9 months)	July 2023 – April 2024
Remove Temporary Access and Water Control Structures, Contractor Demobilization (target removal within in water work windows: July 15 to September 30 and November 8 to April 9; 6 months to complete)	July 15, 2024 – September 30, 2024 and November 8, 2024 – March 8, 2025
Fishway Commissioning	May 2025

2.4.2.2 Downstream Fish Passage

The Licensee proposes the following measures:

- Continue to operate the existing (and modified) bypass and floating guidance boom for utilization by adult and juvenile Atlantic salmon from April 1 through December 31, as river conditions allow. Undertake measures necessary to keep it in place and in good operating condition. If the guidance boom becomes dislodged or damaged, the Licensee will repair or replace it as soon as can be safely and reasonably done.
- Operate the bypass/sluice gate under the following parameters:
    - From April 1 to June 15: As ice conditions allow, provide between 8-45% of station flow, 24 hours/day, 7 days/week.
    - From June 16 to September 14: Following construction and commissioning of the upstream fish passage facility or in the event that MDMR trucking operations result in stocking alosine above the Weston Project, the bypass log sluice will be

operated at a minimum of 6% of station flow (approximately 3.0 ft at normal full pond elevation of 156 ft) (up to a maximum capacity of 2,500 cfs or 45% of station flow) 24 hours/day, 7 days/week, as river conditions allow. In the interim, the log sluice bypass does not have a minimum setting specifically for downstream fish passage but passes water in excess of station capacity to its maximum capacity of 2,500 cfs.
    - From September 15 to October 31: Operate at a minimum of 6% of station flow for 8 hours per night, 7 days/week.
    - From November 1 to December 31: As ice conditions allow, 6% of station flow; 24 hours a day, 7 days a week.
- Modify the existing downstream bypass to increase survival. The preliminary proposal includes the construction of a lip at the downstream end of the sluice to provide energy dissipation, resurfacing the flume, and sealing gaps. Detailed components of the improvements to be made will be developed in consultation with the agencies. Downstream bypass improvements will be undertaken concurrent with the construction of the upstream fish lift.
- Within two years after FERC approval, automate the left side Tainter gate and change the prioritization of the gates to: 1) the right Obermeyer (up to a max capacity of 4,450 cfs), which would be operated as first on and last off; 2) the left Obermeyer (up to a max capacity of 4,450 cfs). At flows above the capacity of the powerhouse, the top half of the center stanchions would be tripped followed by the left Tainter gate (up to a max capacity of 5,000 cfs) and the right Tainter gate (up to a maximum capacity of 5,000 cfs). The North Channel bypass reach ledges would be expected to be partially if not fully inundated at the cumulative flows in excess of 23,000 cfs such that effects from opening the right Tainter gate would be significantly reduced compared with existing operations. The remaining top gates of the north channel and south channel will be operated last.
- Installation of the proposed upstream fishway will include an attraction water system (AWS) with a capacity of 304 cfs and a uniform acceleration weir entrance, to provide a dedicated downstream fish passage route.
- Installation of 2-inch clear spaced overlays at the powerhouse intake, for the protection of kelts within two years following FERC approval.
- Conduct a balloon tag study to confirm the appropriate gate prioritization to maximize survival on spill within one year following FERC approval.
- Ensure that downstream fish passage facilities meet a performance standard for juvenile salmon of approximately 97% (individual project effectiveness may vary, so long as the cumulative four-project standard of 88.5% is attained).

2.5 Performance Standards, Adaptive Management, and Mitigation

2.5.1 Upstream Passage

New upstream fishways will be constructed at the Lockwood, Shawmut, and Weston Projects. Consistent with the proposal, construction of the upstream fishways will begin within one year following FERC approval (i.e. issuance of license amendment or new license) and receipt of any necessary state and federal permits. We are unable to predict the date that FERC will issue license amendments or new licenses, but expect that any FERC approvals will follow the issuance of its final EIS, expected in March 2024. Therefore, we anticipate that at the latest, construction of the facilities would commence in 2025, be completed by 2027, and would be available to pass fish for any study evaluations by 2028, following a year for shakedown.

Qualitative Assessments

The Licensees are proposing to conduct up to two years of qualitative studies to evaluate the effectiveness of the upstream passage through all four Projects once all the new fishways are operational. The studies the Licensees are proposing will utilize up to 20 adult Atlantic salmon each year, originating from the Kennebec River (i.e., examined to exclude hatchery smolt origin, tagged, marked, or fin-clipped salmon from other rivers), captured at the Lockwood or Hydro-Kennebec fish lifts. The Licensees indicate that the purpose of this effort is to help identify any issues associated with near and far field attraction, conveyance flows, and the need for ongoing operation of the existing fish lift.

Passage Effectiveness

The Licensees propose a performance standard to evaluate the upstream passage effectiveness of the fishways at all four dams after they become operational. Specifically, the Licensees propose that the performance standard for upstream passage for the four projects would be considered to be met when a cumulative (“end-of-pipe”) passage rate of at least 84.9% is achieved. That is, the Licensees are proposing to manage passage such that at least 84.9% of salmon that were stocked as juveniles upstream of the dams will pass all four dams as adults to access habitat upstream of the Weston dam. For the purposes of defining the proposed action, we consider that FERC will determine the Licensees in compliance with the licenses when this standard is achieved. The Licensees propose to conduct quantitative studies in consultation with the agencies using 200 fish of Kennebec River origin (i.e., fish naturally produced or stocked within the Kennebec River) to estimate end-of-pipe passage efficiency and assess migratory delay. The adult upstream passage studies would commence in the first full season after the last of the proposed upstream fishways is completed in 2024 and one year of shakedown has occurred. To ensure that sufficient returning adult salmon are available to conduct quantitative upstream passage studies, Brookfield proposes to provide funding or other agreed support to offset the costs of production of smolts to be stocked upstream of the Weston project with the purpose of producing approximately 200 motivated prespawn adults to evaluate the effectiveness of the proposed new fishways; provided, however, that such stocking efforts shall not (i) exceed 250,000 smolts per year, (ii) be required to continue beyond the earlier of 6 years from commencement of stocking or the expiration of the incidental take statement, nor (iii) begin prior to 2 years before expected completion of all upstream passage facilities. The licensees propose to develop a study plan in coordination with, and approval from, NMFS, within a year of the issuance of the license amendments.

Delay

The Licensees propose a goal for timely upstream passage of Atlantic salmon adults through the projects wherein the standard for delay of upstream passage would be considered met when Atlantic salmon adults migrate through all four projects with a cumulative upstream passage time of no more than 192 hours. As above, we anticipate that FERC will determine the Licensee in compliance with the project licenses when this standard is achieved.

Adaptive Management

If it is determined that either the upstream or downstream performance standard for Atlantic salmon is not being achieved, the Licensees propose to implement the Adaptive Management Plan, described in Section 9.5 of the SPP with a commitment to the same for the Shawmut Project as part of relicense. The Licensees do not propose discrete measures for the adaptive management of upstream passage at the projects. Rather, the Licensees state that if testing determines that the performance standard has not been achieved, they will consult with the agencies to determine the need for any additional operational and/or structural measures to meet the performance standards. Brookfield proposes annual reports and agency meetings to discuss study results, along with potential opportunities to make minor adjustments to fishway operations that might improve passage. These meetings may also be used to adjust ongoing fish passage monitoring studies, and to modify study plans, as appropriate, for the upcoming study season. The Licensees have outlined a general adaptive management scheme, presented in Table 5. However, we note that where indicated in the project-specific proposed action sections above, Brookfield's September 21, 2022 modified proposal now includes the immediate implementation of many of the adaptive measures listed below, which are derived from the SPP. If the Licensees cannot demonstrate achievement of the proposed cumulative performance/delay standard within three years following fishways construction and a shakedown year, Brookfield proposes to develop and implement, in consultation with NMFS, additional operational or infrastructure measures, as reasonable and practicable, that are likely to meet or exceed the upstream performance standard. Provided that information demonstrates necessity, Brookfield's proposal does not limit the scope of adaptive measures necessary to achieve the performance standards. Thus the proposed adaptive management scheme could include modifications up to and including additional fishways.

Table 5. Adaptive management tools and measures for Atlantic salmon proposed by Brookfield.

Observed Effect	Adaptive Management Considerations	Adaptive Management Tools/Options
Upstream Passage		

Observed Effect	Adaptive Management Considerations	Adaptive Management Tools/Options
Cumulative Performance Standard Not Achieved	Identify Project fishway modifications(s) with best opportunity to improve upstream passage	• Field observations • Engineering review • Monitoring study results
	Evaluate fishway entrance conditions or source of fishway hesitancy/seeking behavior	• Field observations • Computational Fluid Dynamics (CFD) modeling • Sound study
	Potential modifications to fishway operations to improve effectiveness	• Operational timing • Modify fishway flows • Modify attraction flows • Unit prioritization • Lift frequency
	Potential modifications to fishway entrance to improve performance	• Engineering review • Gate reconfiguration • Flume modifications
	Potential modifications to fishway design to improve	• Modify attraction flow • Second entrance/Relocate

Observed Effect	Adaptive Management Considerations	Adaptive Management Tools/Options
	performance	entrance
Downstream Passage		
Cumulative Performance Standard Not Achieved	Identify Project fishway modification(s) with best opportunity to improve downstream passage	• Field observations • Engineering review • Monitoring study results
	Potential modifications to increase bypass utilization	• Increase conveyance flow • Second entrance • Relocated entrance • Alden-style weir
	Potential options for increasing bypass survival	• Flume modifications • Gate modifications
	Potential options for increasing spill route utilization	• Unit turn-down • Partial unit shutdown • Unit shutdown • Dedicated spill

Observed Effect	Adaptive Management Considerations	Adaptive Management Tools/Options
	Potential options for reducing turbine entrainment/passage	• New/additional guidance boom • Tighter rack spacing • Rack overlay • Unit turn-down
	Potential options for increasing turbine survival	• Unit prioritization • Unit turn-down • Partial unit shutdown • Unit shutdown

2.5.2 Downstream Passage

Brookfield proposes the construction and implementation of downstream measures at all four lower Kennebec River Projects, including, but not limited to seasonal turbine shutdowns, the installation of turbine intake screens, the installation of floating guidance booms, and dam resurfacing and downstream fish passage improvements. We expect that all downstream measures not related to the construction of the proposed upstream fishways will be fully implemented/operational within three years following FERC's issuance of license amendments (Lockwood, Hydro-Kennebec, and Weston) or issuance of a subsequent license (Shawmut).

Passage Effectiveness

The Licensees propose a performance standard to evaluate the downstream passage effectiveness of all four dams. Specifically, the Licensees propose the downstream smolt performance standard for the four Projects will be considered to be met when a cumulative ("end-of-pipe") station survival of at least 88.5% is achieved, based on the cumulative calculation of an average individual whole station survival rate of 97% per project. Achievement of the standard would be based on an average of three years of smolt passage performance data, wherein the individual whole station survival estimates are cumulatively calculated from Weston through Lockwood, as tested following the implementation of the downstream fish passage facilities and measures proposed for Lockwood, Hydro-Kennebec, Shawmut, and Weston Projects. For the purposes of defining the proposed action, we consider that FERC will determine the Licensees in compliance with the project licenses when this standard is achieved. Full implementation of all downstream measures will be contingent upon the construction of the proposed upstream fishways, as the upstream fishway designs include structures dedicated for safe downstream fish passage. Therefore, we expect that evaluations of the downstream effectiveness of all four dams could proceed in 2028, consistent with the expected implementation date of the upstream fishways, as described above.

Although not specified, we assume that Brookfield is proposing to conduct these studies using the same study design as was used in the 2012-2015 studies. That is, they are proposing to conduct a radio telemetry study with receivers located in the same locations as in those earlier studies. As described in section 4, the placement of receivers matters as it has significant bearing on whether the studies are capturing all of the mortality that is attributable to passage at the dams.

<u>Injury Assessments</u>

The Licensees propose to conduct a study or (studies) on the potential of dam passage injury to contribute to hydrosystem delayed mortality at the Lockwood, Hydro-Kennebec, and Weston Projects.

<u>Delay</u>

The Licensee proposes a goal for timely upstream passage of Atlantic salmon smolts through the projects. Achievement of the downstream salmon smolt timing goal would be based on a three-year average equal to or greater than 97% of individuals passing through all four projects with a cumulative project residence time of no more than 96 hours, where residence time for each individual test smolt would be calculated as the duration of time from first detection at the point 200 meters upstream of each dam to a point downstream of each dam. As above, we anticipate that FERC will determine the Licensees in compliance with the project licenses when this standard is achieved.

<u>Adaptive Management</u>

The Licensees do not propose discrete measures for the adaptive management of upstream passage at the projects, although they have outlined a general adaptive management scheme, presented in Table 5. They indicate that after all facilities and measures have been fully implemented, if testing determines that the performance standard has not been achieved, they will work with the agencies to identify additional operational and/or structural measures that will be necessary for the performance standards to be met or that may be necessary to reduce adverse effects to the species. Brookfield proposes annual reports and agency meetings to discuss study results, along with potential opportunities to make modifications to fishway operations to improve passage and may also be used to adjust ongoing fish passage monitoring studies, and to modify study plans, as appropriate, for the upcoming study season.

2.5.3 Mitigation Plan

Brookfield proposes to develop a mitigation plan in consultation with NMFS that will be implemented until the performance standards have been achieved. The plan will include funding of habitat restoration focusing on restoring access to, and suitability of, high value, climate resilient, spawning and rearing habitat for Atlantic salmon within the Kennebec River watershed and Merrymeeting Bay SHRU. Following the filing of the mitigation plan, Brookfield proposes to contribute $300,000 ($75,000 per Project) in the aggregate annually for the first 10 years (with a review in year 10 to determine attainment of the upstream and downstream performance standard) for the purpose of funding habitat enhancement projects to be determined in consultation with NMFS in the Kennebec River and Merrymeeting Bay SHRU[3]. Should attainment of the performance standards for upstream and downstream passage be attained within the 10-year timeframe, funding would cease or be potentially reduced from the year of attainment to the expiration of the SPP.

2.6 Action Area

The action area is defined as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area (project area) involved in the proposed action" (50 C.F.R. § 402.02). Operation of the Lockwood, Hydro-Kennebec, Shawmut, and Weston Projects under the terms of the amended licenses, as well as the new license at Shawmut, affects a portion of the Kennebec River. In addition to the immediate footprint of the projects, the action area encompasses the impounded habitat upriver of each dam, as well as the area downriver of each project affected by project flow modifications. We therefore, define the action area for this consultation by adding what would be defined as the action area for each of the four projects; as such, the action area for this consultation extends from the upper extent of the Weston Dam impoundment (approximately 20 kilometers upstream of the dam) to the confluence with the Sebasticook River, approximately 0.75 kilometers downstream of the Lockwood Project (shown on Figure 1 above). The action area only includes mainstem habitat as we do not anticipate that tributary habitat will be affected by dam operations or the implementation of fish passage measures at the Projects.

3 Status of the Species and Critical Habitat Rangewide

We have determined that the actions being considered in this Opinion may affect the endangered or threatened species and critical habitat under our jurisdiction listed in Table 6. Note that

[3] Brookfield did not propose a date for the filing of the final mitigation plan. In section 10.2.3, we include a Term and Condition (#7) requiring the filing of the mitigation plan within one year of the issuance of this Opinion.

Atlantic and shortnose sturgeon and critical habitat designated for the Gulf of Maine DPS of Atlantic sturgeon occur only in the portion of the action area below the Lockwood Dam.

Table 6. ESA-listed species and critical habitat in the action area.

ESA-Listed Species	**Scientific Name**	**Distinct Population Segment (DPS)**	**Federal Register (FR) Citation**	**Recovery Plan**
Atlantic salmon	*Salmo salar*	Gulf of Maine	74 FR 29344	Final Recovery plan: (USFWS & NMFS, 2019)
Atlantic Sturgeon	*Acipenser oxyrinchus oxyrinchus*	Gulf of Maine	77 FR 5880	N/A[4]
Shortnose Sturgeon	*Acipenser brevirostrum*	Range-wide	32 FR 4001	NMFS 1998
Designated Critical Habitat (species)	**Scientific Name**	**Distinct Population Segment (DPS)**	**Federal Register (FR) Citation**	**Recovery or River Unit**
Atlantic salmon	*Salmo salar*	Gulf of Maine	74 FR 29300	Merrymeeting Bay Salmon Habitat Recovery Unit
Atlantic Sturgeon	*Acipenser oxyrinchus oxyrinchus*	Gulf of Maine	2 R 39160	

3.1 Atlantic salmon (Gulf of Maine DPS)

The Gulf of Maine (GOM) DPS of anadromous Atlantic salmon was initially listed by USFWS and NMFS (collectively, the Services) as an endangered species on November 17, 2000 (65 FR

[4] A Recovery Outline for the 5 distinct populations of Atlantic sturgeon was published by NMFS in 2018. It is available at: https://media.fisheries.noaa.gov/dam-migration/ats_recovery_outline.pdf (last accessed Oct 12, 2021).

69459) (Figure 2). A subsequent rule issued by the Services expanded the geographic range for the GOM DPS of Atlantic salmon (June 19, 2009; 74 FR 29344). The GOM DPS of Atlantic salmon is defined as all anadromous Atlantic salmon whose freshwater range occurs in the watersheds from the Androscoggin River northward along the Maine coast to the Dennys River, and wherever these fish occur in the estuarine and marine environment. The marine range of the GOM DPS extends from the Gulf of Maine, throughout the Northwest Atlantic Ocean, to the coast of Greenland. Included in the GOM DPS are all associated conservation hatchery populations used to supplement these natural populations; currently, such conservation hatchery populations are maintained at Green Lake National Fish Hatchery (GLNFH) and Craig Brook National Fish Hatcheries (CBNFH), both operated by the USFWS, as well as private watershed-based facilities (Downeast Salmon Federation's East Machias and Pleasant River facilities). Excluded from the GOM DPS are landlocked Atlantic salmon and those salmon raised in commercial hatcheries for the aquaculture industry.

Coincident with the June 19, 2009 endangered listing, NMFS designated critical habitat for the GOM DPS of Atlantic salmon (74 FR 29300).

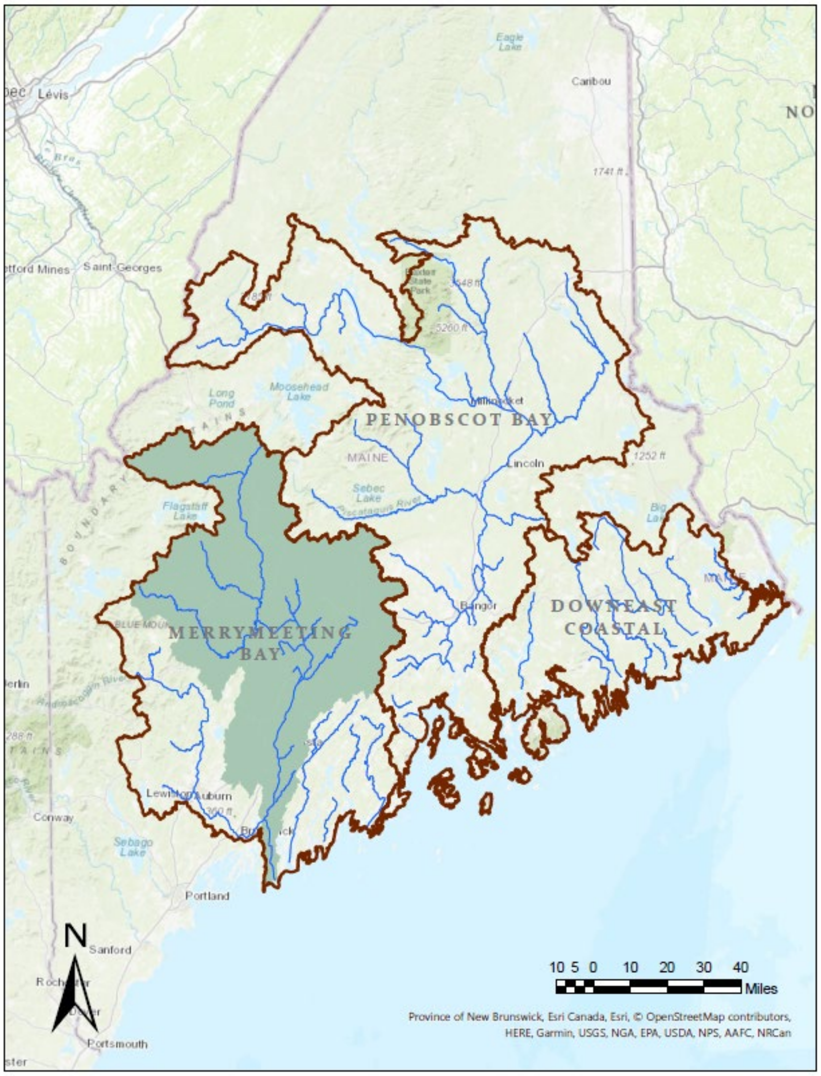

Figure 2. The GOM DPS for Atlantic salmon with the three recovery units identified. The Kennebec River is shown in green.

3.1.1 Survival and Recovery of the GOM DPS

The USFWS and NMFS issued a recovery plan ("Recovery Plan") for Atlantic salmon on February 12, 2019 (USFWS & NMFS, 2019). The Recovery Plan presents a recovery strategy based on the biological and ecological needs of the species as well as current threats and conservation accomplishments that affect its long-term viability. The Recovery Plan is based on two premises: first, that recovery must focus on rivers and estuaries located in the GOM DPS until the Services have a better understanding of the threats in the marine environment, and second, that survival of Atlantic salmon in the GOM DPS will be dependent on conservation hatcheries through much of the recovery process. In addition, the scientific foundation for the plan includes conservation biology principles regarding population viability, an understanding of freshwater habitat viability, and threats abatement needs.

We have divided the GOM DPS into three Salmon Habitat Recovery Units (SHRUs) (74 FR 29300, June 19, 2009). The three SHRUs are the Downeast Coastal SHRU, Penobscot Bay SHRU, and Merrymeeting Bay SHRU. The SHRU delineations were designed to: 1) ensure that a recovered Atlantic salmon population has widespread geographic distribution to help maintain genetic variability; and 2) provide protection from demographic and environmental variation. A widespread distribution of salmon across the three SHRUs will provide a greater probability of population sustainability in the future, which will be needed to achieve recovery of the GOM DPS.

As described in the Recovery Plan, reclassification of the GOM DPS from endangered to threatened will be considered when all of following criteria are met:

- Abundance: The DPS has total annual returns of at least 1,500 naturally reared adults (i.e., originating from spawning in the wild, or from hatchery stocked eggs, fry or parr), with at least two of the three SHRUs having a minimum annual escapement of 500 naturally reared adults;
- Productivity: Among the SHRUs that have met or exceeded the abundance criterion, the population has a positive mean growth rate greater than 1.0 in the 10-year (two-generation) period preceding reclassification; and,
- Habitat: In each of the SHRUs where the abundance and productivity criterion have been met, there is a minimum of 7,500 units[5] of accessible and suitable spawning and rearing habitats capable of supporting the offspring of 1,500 naturally reared adults.

As described in the Recovery Plan, the delisting criteria are:

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

[5] One habitat unit equals 100 square meters.

In 2020, NMFS and USFWS completed a 5-year review that evaluated whether any of these reclassification criteria had been achieved. The review concluded that the demographic risks to Atlantic salmon are still high, that the number of naturally reared or wild adults is still less than 100 per SHRU, and that the primary threats have not been sufficiently abated. As such, the review indicated that none of the above criteria had been achieved; and therefore did not recommend any change to the classification of the GOM DPS of Atlantic salmon (NMFS & USFWS, 2020).

3.1.2 Atlantic Salmon Life History

Atlantic salmon spend most of their adult life in the ocean and return to freshwater to reproduce. Atlantic salmon have a complex life history that includes territorial rearing in rivers to extensive feeding migrations on the high seas (Figure 3). During their life cycle, Atlantic salmon go through several distinct phases that are identified by specific changes in behavior, physiology, morphology, and habitat requirements.

Spawning

Adult Atlantic salmon return to rivers in Maine from the Atlantic Ocean and migrate to their natal streams to spawn. Although spawning does not occur until late fall, the majority of Atlantic salmon in Maine enter freshwater between May and mid-July; however, individuals may enter at any time between early spring and late summer (E. Baum, 1997). Early migration is an adaptive trait that ensures adults have sufficient time to reach spawning areas (Bjornn & Reiser, 1991). Salmon that return in early spring spend nearly five months in the river before spawning, often seeking cool water refuge (e.g., deep pools, springs, and mouths of smaller tributaries) during the summer months.

From mid-October to mid-November, adult females select sites in rivers and streams for spawning. Spawning sites are positioned within flowing water, particularly where upwelling of groundwater occurs, allowing for percolation of water through the gravel (Danie et al., 1984). These sites are most often positioned at the head of a riffle (Beland et al., 1982), the tail of a pool, or the upstream edge of a gravel bar where water depth is decreasing and water velocity is increasing (McLaughlin & Knight, 1987). The female salmon creates an egg pit (i.e., redd) by digging into the substrate with her tail and then deposits eggs while male salmon release sperm to fertilize the eggs. After spawning, the female continues digging upstream of the last deposition site, burying the fertilized eggs with clean gravel. Females produce a total of 1,500 to 1,800 eggs per kilogram of body weight, yielding an average of 7,500 eggs per two sea-winter (SW) female (an adult female that has spent two winters at sea before returning to spawn) (Baum & Meister, 1971).

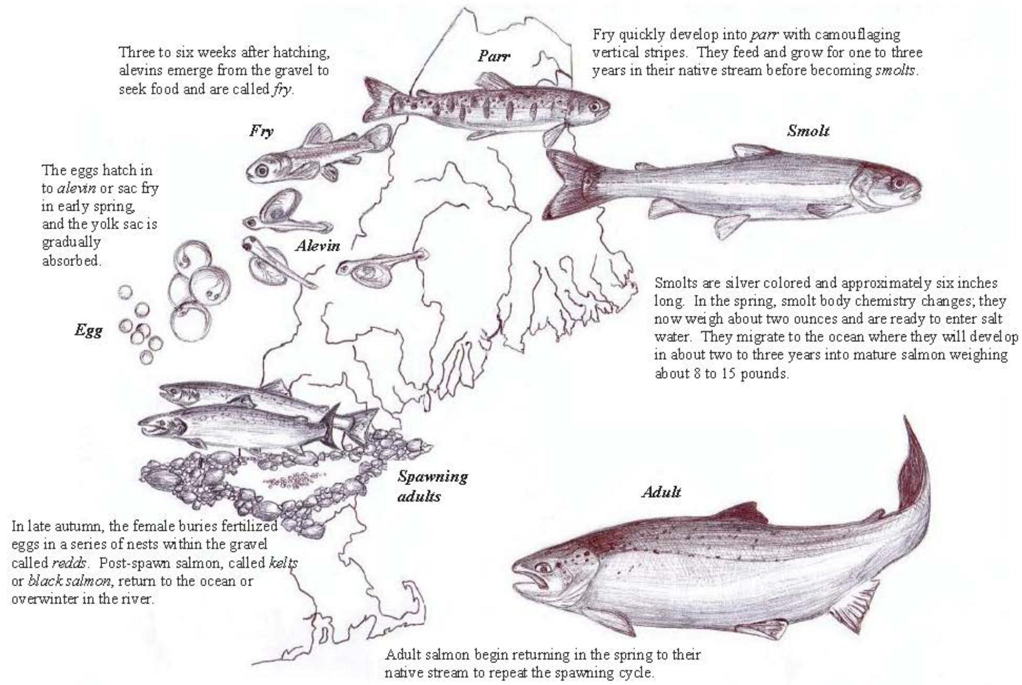

Figure 3. Life Cycle of the Atlantic salmon (diagrams courtesy of Katrina Mueller)

Postspawn Adult Salmon (Kelts)

Atlantic salmon are iteroparous, meaning they are able to spawn more than once. Repeat spawners may comprise a significant proportion of a self-sustaining Atlantic salmon population, with estimates reaching upwards of 60% for some populations (Lawrence et al., 2016). Repeat spawners provide considerable benefits to Atlantic salmon populations as repeat spawning females are considerably larger than first time spawners. Larger fish have greater fecundity and larger egg size, resulting in increased fitness of their progeny (Beacham & Murray, 1993; Fleming, 1996). Repeat spawners also increase genetic diversity because they add additional year classes to the spawning population (Niemelä et al., 2006; Saunders & Schom, 1985). Consequently, a salmon population with a higher proportion of repeat spawners is widely considered to be more resilient and better able to compensate for the many threats posed through their life-cycle (Babin et al., 2021; Baktoft et al., 2020; Lawrence et al., 2016; Maynard et al., 2018; Schindler et al., 2010). In years when marine survival is particularly low, a higher proportion of repeat-spawners can partially offset the overall reduction in returns given their higher fecundity. As such, it has been estimated that a high proportion of repeat spawners may reduce the probability of population decline by 27% or greater (Lawrence et al., 2016). Lawrence et al. (2016) has estimated that a salmon population in a river with four dams is 16% less likely to face decline if it has kelt stage as part of its life history[6].

[6] Assuming a 90% per dam passage survival probability.

It is thought that only a small proportion of adult salmon that survive spawning will migrate back to the ocean in the fall, whereas the majority (>80%) overwinter in the river and then out-migrate in the subsequent spring (Maynard et al., 2018; Babin et al., 2021). Though initial survival after spawning may be upwards of 80 percent for first time spawners (Maynard et al., 2018), in-river mortality among overwintering postspawn adults can be quite high (~50% or greater), particularly in males (up to 100%) (Babin et al., 2021; Maynard et al., 2018). This mortality is a result of depleted energy reserves after a lengthy migration when salmon are not feeding. Although this is a natural part of salmon life-history, the presence of dams can significantly increase postspawn mortality due to the additional depletion of reserves associated with substantial migratory delay at multiple dams during their spawning run (Baktoft et al., 2020; Rubenstein et al., 2022).

Since 1970, repeat spawners have represented just over 1% (on average) of the US adult returns (Maynard et al., 2018). The low proportion is likely due to a number of factors such as poor marine survival, and the presence of dams on all major river systems. Dams lead to energy depletion in prespawn adults, which can lead to increased prespawn and postspawn mortality (Rubenstein, 2021). The Kennebec River, which hosts four mainstem dams downstream of the Sandy River, only had a single repeat spawning adult documented between 2011 and 2020 (USASAC, 2021), which constitutes less than 0.5% of the run over that time period.

Out-migrating postspawn salmon are subjected to similar challenges as out-migrating smolts when it comes to passing dams. Postspawn adults may experience both direct mortality (e.g., turbine strikes) and indirect mortality as a result of injury or delay (Baktoft et al., 2020). As with prespawn adults, postspawn adults are exposed to delay at dams as they migrate back out to the ocean. Delay of kelts at hydro-dams has been shown to reduce their remaining energy reserves by as much as 4 to 5 percent, which may lead to reduced postspawn survival (Baktoft et al., 2020). Babin et al. (2021) found that kelt movement slowed in dam reservoirs as kelts either entered searching mode or underwent multiple reversals, resulting in lower migration success. Jonnson et al. (1997) found that even minor additional energy expenditures by kelts resulted in considerable reduction in postspawn survival (Jonsson et al., 1997).

Eggs

The fertilized eggs develop in the redd for a period of 175 to 195 days, hatching in late March or April (Danie et al., 1984).

Alevins and Fry

Newly hatched salmon, referred to as alevin or sac fry, remain in the redd for approximately 6 weeks after hatching and are nourished by their yolk sacs (Gustafson-Greenwood & Moring, 1991). In 3 to 6 weeks, they consume most of their yolk sac, travel to the surface to gulp air to fill their swim bladders, and begin to swim freely; at this point they are called fry. Survival from the egg to fry stage in Maine is estimated to range from 15 to 35% (Jordan & Beland, 1981).

Parr

When fry reach approximately 4 cm in length, the young salmon are termed parr (Danie et al., 1984). Most parr remain in the river for two to three years before undergoing smoltification, the process in which parr go through physiological changes in order to transition from a freshwater environment to a saltwater marine environment. Some male parr may not go through smoltification and will become sexually mature and participate in spawning with sea-run adult females. These males are referred to as precocious parr.

Smolts

During the smoltification process, the body becomes streamlined and silvery with a pronounced fork in the tail. Naturally reared smolts (i.e., smolts that were produced through spawning in the wild, or that were stocked as eggs or fry) in Maine range in size from 13 to 17 cm, and most smolts enter the sea during May to begin their first ocean migration (USASAC, 2004). Researchers have identified a "smolt window" or period of time in which smolts must reach estuarine waters or suffer irreversible negative effects (McCormick et al., 1998). Late migrants lose physiological smolt characteristics due to high water temperatures during spring migration. Most smolts migrate rapidly if unimpeded (Hyvärinen et al., 2006; Lacroix & McCurdy, 1996; Lacroix & Knox, 2005; Lacroix et al., 2004).

Atlantic salmon from the USFWS conservation hatchery program are stocked throughout the GOM DPS. Therefore, salmon smolts migrating to the ocean may be a result of either spawning in the wild or the stocking of hatchery reared salmon; generally eggs, fry, parr, or smolts. A proportion of salmon stocked as smolts may hold over in the vicinity of their stocking location, rather than migrating to sea, as they are not physiologically ready for the transition to saltwater. Available information indicates that approximately 5-10% of stocked smolts may hold over, and that it could vary based on whether the fish are graded (i.e., sorted based on size) prior to stocking (Kocik, J. and J. Hawkes, NOAA's Northeast Fisheries Science Center, personal communication, October 6, 2021). These juvenile salmon that hold over, technically parr, likely move to rearing habitat in the mainstem or in nearby tributaries prior to migrating to the ocean the following year.

Predation

Smallmouth bass and chain pickerel are each significant predators of juvenile Atlantic salmon within the range of the GOM DPS (Fay et al., 2006). Smallmouth bass are a warm-water species whose range now extends through north-central Maine and well into New Brunswick (Jackson, 2002). Smallmouth bass are important predators of smolts in mainstem habitats, although bioenergetics modeling indicates that bass predation is insignificant at 5°C and increases with increasing water temperature during the smolt migration (van den Ende, 1993).

Chain pickerel are known to feed upon smolts within the range of the GOM DPS and also feed upon fry and parr (van den Ende, 1993). Chain pickerel feed actively in temperatures below 10°C (van den Ende, 1993). Smolts were, by far, the most common item in the diet of chain pickerel observed by Barr (Barr, 1962) and van den Ende (1993). However, van den Ende (1993) concluded that "daily consumption was consistently lower for chain pickerel than that of smallmouth bass" apparently due to the much lower abundance of chain pickerel.

Many species of birds prey upon Atlantic salmon throughout their life cycle (Fay et al., 2006). Blackwell et al. (1997) reported that salmon smolts were the most frequently occurring food item in cormorant sampled at mainstem dam foraging sites (Blackwell et al., 1997). Given their piscivorous diets, common mergansers, belted kingfishers, cormorants, and loons likely prey upon Atlantic salmon in the Kennebec River.

Post-smolts

Smolts are termed post-smolts after ocean entry to the end of the first winter at sea (Allan & Ritter, 1977). Post-smolts generally travel out of coastal systems on the ebb tide and may be delayed by flood tides (Hyvärinen et al., 2006; Lacroix & McCurdy, 1996; Lacroix & Knox, 2005; Lacroix et al., 2004). Lacroix and McCurdy (1996), however, found that post-smolts exhibit active, directed swimming in areas with strong tidal currents. Studies in the Bay of Fundy and Passamaquoddy Bay suggest some aggregation and common migration corridors related to surface currents (Hyvärinen et al., 2006; Lacroix & McCurdy, 1996; Lacroix et al., 2004). Post-smolt distribution may reflect water temperatures (Reddin & Shearer, 1987) and/or the major surface-current vectors (Lacroix & Knox, 2005). Post-smolts travel mainly at the surface of the water column (Renkawitz et al., 2012) and may form shoals, possibly of fish from the same river (Shelton et al*.,* 1997). Post-smolts grow quickly, achieving lengths of 30-35 cm by October (Baum, 1997). Smolts can experience high mortality during the transition to saline environments for reasons that are not well understood (Kocik et al., 2009; Thorstad et al., 2012).

During the late summer and autumn of the first year, North American post-smolts are concentrated in the Labrador Sea and off the west coast of Greenland, with the highest concentrations between 56° N. and 58°N. (Reddin, 1985; Reddin & Friedland, 1993; Reddin & Short, 1991; Renkawitz et al., 2021). Atlantic salmon located off Greenland are primarily composed of non-maturing first sea winter (1SW) fish, which are likely to return to their natal river to spawn after their second sea winter (2SW) plus a smaller component of previous spawners who have returned to the sea prior to their next spawning event; these fish are from rivers in North America and Europe (Reddin et al., 1988). The following spring, 1SW and older fish are generally located in the Gulf of St. Lawrence, off the coast of Newfoundland, and on the eastern edge of the Grand Banks (Dutil & Coutu, 1988; Friedland et al., 1999; Reddin & Friedland, 1993; Ritter, 1997).

Adults

Some salmon may remain at sea for one or two years before they are ready to return to the rivers to spawn. After their second winter at sea, the salmon likely over-winter in the area of the Grand Banks before returning to their natal rivers to spawn (Reddin & Shearer, 1987).

The average size of Atlantic salmon is 71-76 cm (28-30 inches) long and 3.6-5.4 kg (8-15 pounds) after two to three years at sea. Although uncommon, adults can grow to be as large as 30 pounds (13.6 kg). The natural lifespan of Atlantic salmon ranges from two to eight years (Fay et al., 2006).

3.1.3 Status and Trends of the GOM DPS of Atlantic salmon

The historic distribution and abundance of Atlantic salmon in Maine has been described extensively (E. T. Baum, 1997; Beland, 1984). In short, substantial populations of Atlantic salmon existed in nearly every river in Maine that was large enough to maintain a spawning population. The upstream extent of the species' distribution extended far into the headwaters of even the largest rivers (Saunders et al., 2006).

Today, the spatial distribution of the GOM DPS of Atlantic salmon is limited directly by dams that obstruct passage and indirectly by low abundance levels. Within the range of the GOM DPS, the Kennebec, Androscoggin, Union, Narraguagus, and Penobscot rivers contain dams that severely limit passage of salmon to significant amounts of spawning and rearing habitat. Indirectly, the spatial distribution of the GOM DPS of Atlantic salmon is also limited by low abundance (i.e., lack of potential donor or source populations) as well as the species' strong and inherent homing tendencies (Pess et al., 2014).

The reproduction and abundance of Atlantic salmon within the range of the GOM DPS have been generally declining since the 1800s (Fay et al., 2006). A comprehensive time series of adult returns to the GOM DPS dating back to 1967 exists (Figure 4; Fay et al., 2006; USASAC, 2021). Contemporary abundance levels of Atlantic salmon within the GOM DPS are several orders of magnitude lower than historical abundance estimates. For example, Foster and Atkins (Foster & Atkins, 1867) estimated that as many as 216,000 adult salmon may have returned to the Kennebec River alone before the river was dammed, whereas estimates of abundance for the entire GOM DPS have rarely exceeded 5,000 individuals in any given year since 1967 (Fay et al., 2006; USASAC, 2021).

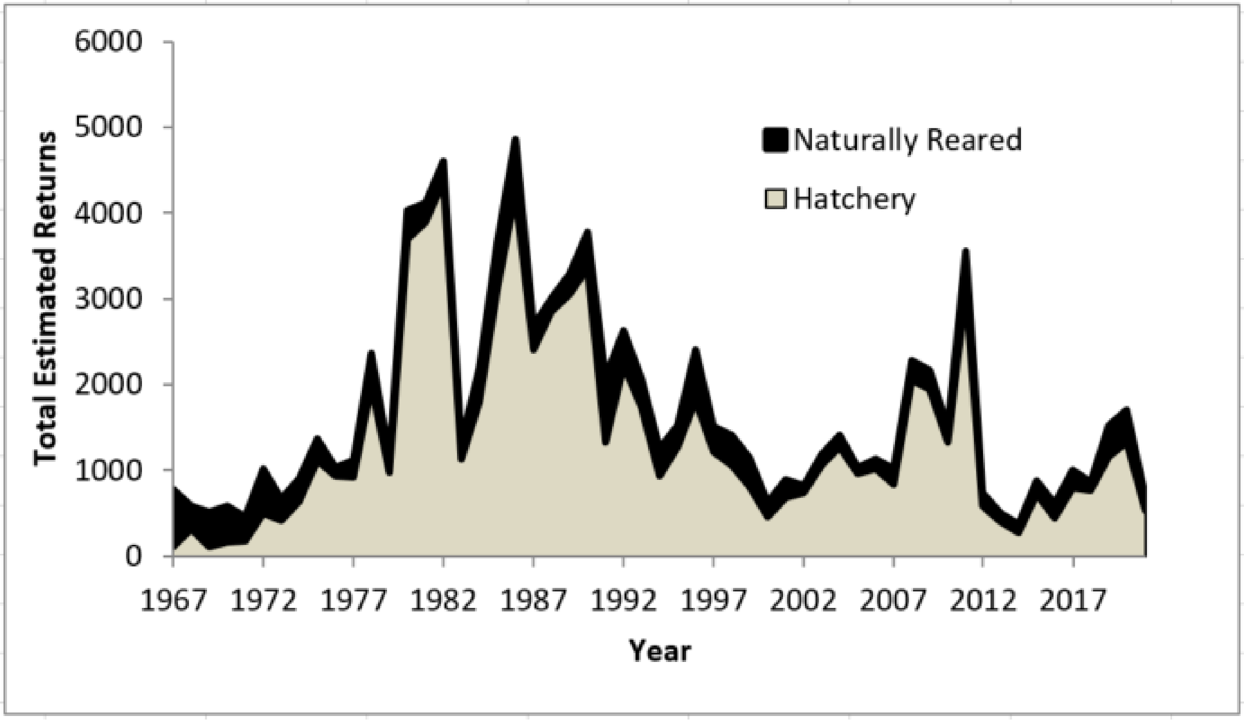

Figure 4. Summary of natural vs. hatchery adult salmon returns to the GOM DPS Rivers between 1967 and 2021.

After a period of population growth between the 1970s and the early 1980s, adult returns of salmon in the GOM DPS have been declining since the early 1990s, stabilizing at very low levels during the 2000s. The population growth observed in the 1970s is likely attributable to favorable marine survival and increases in hatchery capacity, particularly from the USFWS Green Lake National Fish Hatchery (GLNFH) (constructed in 1974). Marine survival remained relatively high throughout the 1980s, and salmon populations in the GOM DPS remained relatively stable until the early 1990s. In the early 1990s, marine survival rates decreased, leading to the declining trend in adult abundance that persists today.

The pattern of low marine survival is not unique to the GOM DPS of Atlantic salmon. Chaput et al. (2005) first raised the potential for a “regime shift” in marine survival for Atlantic salmon throughout North America resulting in decreased productivity and abundance. The effects of this regime shift appear to be particularly acute at the southern edge of the range with many researchers implicating the effects of climate change as a key driver in the ongoing reductions in marine survival of Atlantic salmon (Mills et al., 2013). Marine survival, growth, and maturation are affected in complex ways by warming conditions in the ocean (Friedland, 1998; Friedland & Todd, 2012) and a warming ocean is generally problematic for Atlantic salmon (Friedland & Todd, 2012) except in the northernmost portions of the range (Jonsson & Jonsson, 2009). Reductions in energy content of prey resources in the marine environment may also be linked to recent changes in climate and reduced marine survival (Renkawitz et al., 2015), but considerable uncertainty remains. While the reasons for the decline in marine survival of Atlantic salmon are not well understood at this time, a growing consensus has emerged: abundant healthy wild smolts should be free to emigrate from rivers to the ocean if populations are to sustain the contemporary challenges imposed by the marine environment (Thorstad et al., 2021).

Since 1967 when numbers of adult returns were first recorded, the vast majority of adult returns have been the result of smolt stocking; only a small portion of returning adults were naturally reared (Figure 4). Natural reproduction of the species contributes approximately 20% of Atlantic salmon returns to the GOM DPS (CMS, 2022). The term "naturally reared" includes fish originating from both natural spawning and from stocked hatchery eggs and fry (USASAC, 2012). Adults that result from the stocking of eggs and fry are included as naturally reared because hatchery eggs and fry are not marked, and therefore cannot be visually distinguished from fish produced through natural spawning. While the Penobscot hosts the largest run in the GOM DPS by far (10-year average of 83% of the total returns), only 22% of that run consists of naturally reared fish (CMS, 2022). This compares to 53% and 78% of the run in the Downeast Coastal and Merrymeeting Bay SHRUs, respectively. The run in the Kennebec River, which occurs in the Merrymeeting Bay SHRU, consists of 94% naturally reared returns (as a result of egg planting in the Sandy River). The distinction between hatchery and naturally reared adult salmon is critical in understanding the potential for the achievement of the recovery criteria as laid out in the Final Recovery Plan (USFWS & NMFS 2019). Only naturally reared and wild salmon are considered when determining achievement of the downlisting and delisting criteria. Hatchery returns do not count towards the criteria themselves; however, if they return and successfully spawn in the wild their progeny would be counted toward the criteria. Therefore, in the context of reaching downlisting and delisting goals, a more meaningful metric than the total adult returns to the GOM DPS is the abundance of naturally reared or wild returns (Figure 5).

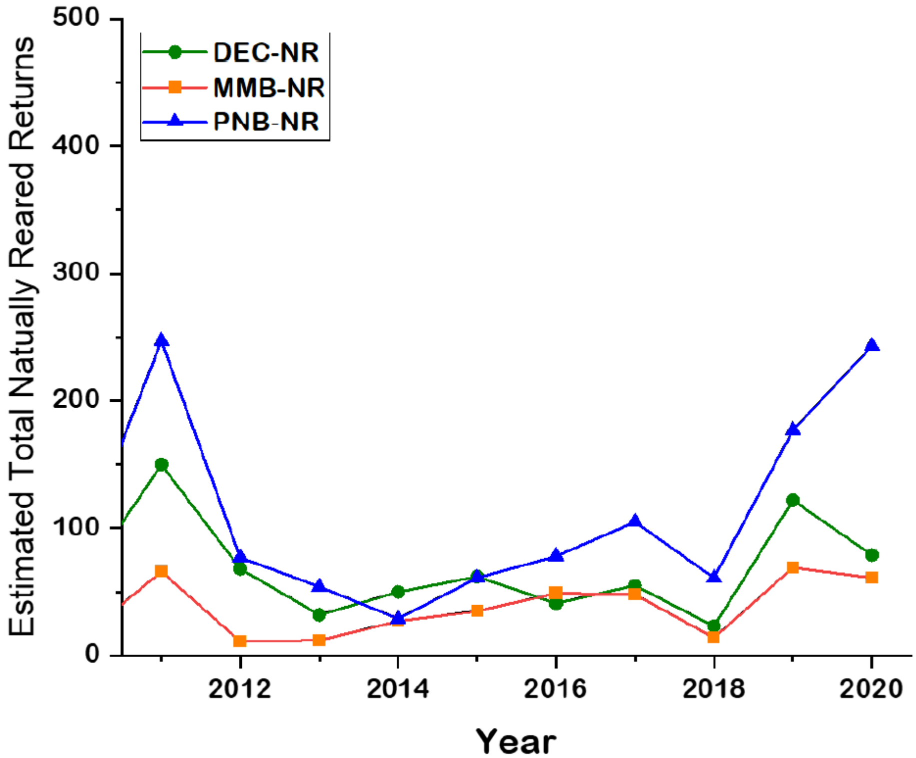

Figure 5. Time series of the last decade of naturally reared adult returns to the Merrymeeting Bay (Orange), Penobscot Bay (Blue), and Downeast Coastal (Green) SHRUs. Note: naturally reared interim target of 500 natural spawners is maximum axis value (USASAC, 2021).

Although the *proportion* of naturally reared salmon is significantly higher in the Downeast and Merrymeeting Bay SHRUs, the more extensive stocking effort in the Penobscot SHRU leads to a higher number of naturally reared adults compared to the other SHRUs. Of the naturally reared or wild adults returning to the GOM DPS, on average 51%, 30%, and 19% return to the Penobscot Bay, Downeast, and Merrymeeting Bay SHRUs, respectively. It should be emphasized that this distribution is dependent on current stocking effort (lifestage and abundance), and by itself should not be construed to mean that any one SHRU is inherently more important or suitable in regards to its contribution to recovery.

3.1.4 Summary of Rangewide Status of Atlantic salmon

The GOM DPS of Atlantic salmon currently exhibits critically low spawner abundance, poor marine survival, and is confronted with a variety of additional threats. The abundance of GOM DPS Atlantic salmon has been low and either stable or declining over the past several decades. The proportion of fish that are of natural origin is small and displays little sign of growth. The most recent five year review for the species concluded that:

> The demographic risks to Atlantic salmon remain high. The three SHRUs have 10-year

> average abundance of less than 100 natural spawners per SHRU. Of the eight locally adapted populations that remain in the GOM DPS, seven are supported by conservation hatcheries that act to buffer extinction risk. The eighth, the Ducktrap River, is at very high risk of extirpation. With naturally reared populations being very low, the geometric mean population growth rates have been, as can be expected, highly variable. Given the high degree of variability in the population growth rates and the very low population abundances of naturally reared fish, we will need to continue to monitor population trajectories very carefully. (NMFS and USFWS, 2020)

The spatial distribution of the GOM DPS has been severely reduced relative to historical distribution patterns due to the construction of dams. The conservation hatchery program assists in slowing the decline and helps stabilize populations at low levels, but has not contributed to an increase in the overall abundance of salmon and has not been able to halt the decline of the naturally reared component of the GOM DPS. Although the hatchery program is critical, it alone cannot recover the species. Recovery of the GOM DPS must be accomplished through increases in naturally reared salmon, which will only occur if the ongoing threats to the species (as defined in the 2019 Recovery Plan) are abated. This can be accomplished by improving connectivity at dams and road stream crossings, and through projects that improve freshwater habitat productivity.

3.1.5 Atlantic salmon Critical Habitat

Coincident with the June 19, 2009 endangered listing, we designated critical habitat for the GOM DPS of Atlantic salmon (74 FR 29300; June 19, 2009) (Figure 7). The final rule was revised on August 10, 2009. In this revision, designated critical habitat for the expanded GOM DPS of Atlantic salmon was reduced to exclude trust and fee holdings of the Penobscot Indian Nation and a table was corrected (74 FR 39003; August 10, 2009). That designation defines critical habitat as "specific areas within the geographical area occupied by the species at the time of listing, on which are found those physical or biological features that are essential to the conservation of the listed species and that may require special management considerations or protection."

3.1.5.1 Physical and Biological Features of Atlantic salmon Critical Habitat

Designation of critical habitat is based on the known physical and biological features within the occupied areas of a listed species that are deemed essential to the conservation of the species. For the GOM DPS, the physical and biological features (PBFs; also known as primary constituent elements) essential for the conservation of Atlantic salmon are: 1) sites for spawning and rearing, and, 2) sites for migration (excluding marine migration[7]) (Table 7). Although each habitat does have distinct features, spawning and rearing habitats were not separated into distinct

[7] Although successful marine migration is essential to Atlantic salmon, we were not able to identify the essential features of marine migration and feeding habitat or their specific locations at the time critical habitat was designated.

PBFs in the critical habitat designation. The reason for this is that the GIS-based habitat prediction model approach that was used to designate critical habitat (74 FR 29300; June 19, 2009) cannot consistently distinguish between spawning and rearing habitat across the entire range of the GOM DPS.

Table 7. The physical and biological features for Atlantic salmon critical habitat.

SR1	Deep, oxygenated pools and cover (*e.g.*, boulders, woody debris, vegetation, etc.), near freshwater spawning sites, necessary to support adult migrants during the summer while they await spawning in the fall.
SR2	Freshwater spawning sites that contain clean, permeable gravel and cobble substrate with oxygenated water and cool water temperatures to support spawning activity, egg incubation, and larval development.
SR3	Freshwater spawning and rearing sites with clean, permeable gravel and cobble substrate with oxygenated water and cool water temperatures to support emergence, territorial development, and feeding activities of Atlantic salmon fry.
SR4	Freshwater rearing sites with space to accommodate growth and survival of Atlantic salmon parr.
SR5	Freshwater rearing sites with a combination of river, stream, and lake habitats that accommodate parr's ability to occupy many niches and maximize parr production.
SR6	Freshwater rearing sites with cool, oxygenated water to support growth and survival of Atlantic salmon parr.
SR7	Freshwater rearing sites with diverse food resources to support growth and survival of Atlantic salmon parr.
M1	Freshwater and estuary migratory sites free from physical and biological barriers that delay or prevent access of adult salmon seeking spawning grounds needed to support recovered populations.
M2	Freshwater and estuary migration sites with pool, lake, and instream habitat that provide cool, oxygenated water and cover items (*e.g.*, boulders, woody debris, and vegetation) to serve as temporary holding and resting areas during upstream migration of adult salmon.
M3	Freshwater and estuary migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation.
M4	Freshwater and estuary migration sites free from physical and biological barriers that delay or prevent emigration of smolts to the marine environment.

M5 Freshwater and estuary migration sites with sufficiently cool water temperatures and water flows that coincide with diurnal cues to stimulate smolt migration.

M6 Freshwater migration sites with water chemistry needed to support seawater adaptation of smolts.

Habitat areas designated as critical habitat must contain one or more physical and biological features within the acceptable range of values required to support the biological processes for which the species uses that habitat (Table 8). Critical habitat includes all perennial rivers, streams, and estuaries and lakes connected to the marine environment within the range of the GOM DPS, except for those areas that have been specifically excluded as critical habitat. Critical habitat includes the stream channels within the designated stream reach and includes a lateral extent as defined by the ordinary high-water line or the bankfull elevation in the absence of a defined high-water line. In estuaries, critical habitat is defined by the perimeter of the water body as displayed on standard 1:24,000 scale topographic maps or the elevation of extreme high water, whichever is greater. Critical habitat was designated in areas (HUC-10 watersheds) occupied by the species at the time of listing. As described in the designation, for each SHRU, we determined that there were sufficient habitat units within the currently occupied habitat to achieve recovery objectives in the future; therefore, no unoccupied habitat (at the HUC-10 watershed scale) was designated as critical habitat.

Table 8. The factors that determine the suitability of habitat for the different life stages of Atlantic salmon, as well as the acceptable range of values required to support these biological processes.

	Spawning Habitat		**Rearing Habitat**	**Migration Habitat**	
	Spawning	*Embryo/Fry Development*	*Parr Development*	*Adults*	*Juveniles*
	Oct 1-Dec 14	Oct 1-Apr 14	All Year	Apr 15-Dec 14	Apr 15-Jun 14
Depth	17-76 cm	5-15 cm	10-30 cm		
Velocity	8-83 cm/sec	4-15 cm/sec	< 120 cm/sec	30-125 cm/sec	
Temperature	7-10°C	< 10°C	7-22.5°C	<23°C	5-11°C
pH	>5.0	> 4.5			>5.5
DO		saturation, or 7-8 mg/L	>2.9 mg/L	>4.5 mg/L	
Substrate	Cobble/Gravel	Cobble/Gravel	Gravel/Boulders		
Cover	Pools, large boulders, woody debris				
Fisheries	Many native fish species; few non-native fish species				
Food			Macroinvertebrates and small fish		

We have determined that the action area contains spawning and rearing PBFs 1-7 (SR 1-7) and the migratory PBFs 1-6 (M 1-6). We discuss the other features and their current status in the action area in the Environmental Baseline (Section 4).

3.1.6 Factors Affecting Atlantic salmon and Critical Habitat

Atlantic salmon face a number of threats to their survival, which are fully described in the Recovery Plan (USFWS & NMFS, 2019) with additional information provided in the 2020 5-Year Review. As described in the listing rule and the Recovery Plan, we consider the following to be the most significant threats to the GOM DPS of Atlantic salmon:

- Lack of access to spawning and rearing habitat due to dams and road-stream crossings
- Reduced habitat complexity
- Continued low marine survival rates for U.S. stocks of Atlantic salmon
- Degraded water quality
- Water withdrawal
- Incidental capture of adults and parr by recreational anglers
- Poaching of adults
- Intercept fishery
- Introduced fish species that compete or prey on Atlantic salmon
- Diseases
- Predation
- Inadequate regulatory mechanisms related to dams
- Aquaculture practices, which pose ecological and genetic risks
- Climate change
- Depleted diadromous fish communities
- Recovery hatchery program (potential for artificial selection/domestication)
- Sedimentation of spawning and rearing habitat.

These conclusions were reaffirmed in the 2020 5-Year Review (NMFS and USFWS, 2020).

Many actions have been implemented to protect and restore the GOM DPS of Atlantic salmon. These activities include hatchery supplementation, dam removal, fishway construction, upgrading road crossings, protecting riparian corridors along rivers, reducing the impact of irrigation water withdrawals, limiting effects of recreational and commercial fishing, reducing the effects of finfish aquaculture, outreach and education activities, and research focused on better understanding the threats to Atlantic salmon and developing effective restoration strategies. As noted in the 2020 5-Year Review, while progress has been made to reduce or better understand many of those threats, each of these threats continues to contribute to the endangerment of the species (NMFS & USFWS, 2020).

The final rule designating critical habitat for the GOM DPS identifies a number of activities that have and will likely continue to affect the biological and physical features of spawning, rearing, and migration habitat for Atlantic salmon. These include agriculture, forestry, changing land-use and development, hatcheries and stocking, roads and road-crossings and other instream activities (such as alternative energy development), mining, dams, dredging, and aquaculture. Most of these activities have or still do occur, at least to some extent, throughout the Gulf of Maine.

3.1.7 Status and Trends of Atlantic Salmon in the Merrymeeting Bay SHRU

A summary of the status of the species range wide and designated critical habitat in its entirety was provided above. This section will focus on the status of Atlantic salmon and designated critical habitat in the Merrymeeting Bay SHRU.

The number of returning adults to the Merrymeeting Bay SHRU is small but has been increasing steadily in recent years as stocking effort in the Kennebec increased (Figure 7). Over the last 10 years, the total number of prespawn Atlantic salmon returning to the three rivers where counts are made in the Merrymeeting Bay SHRU (Kennebec, Androscoggin, Sheepscot) ranged between 18 and 87 annually; with an average return of 46 individuals (derived from data in USASAC (2022) and CMS (2022)). Of the prespawn adult salmon that return to the Merrymeeting Bay SHRU to spawn, approximately 63% (10 year average) return to the Kennebec River; 5% return to the Androscoggin River, and 32% return to the Sheepscot River.

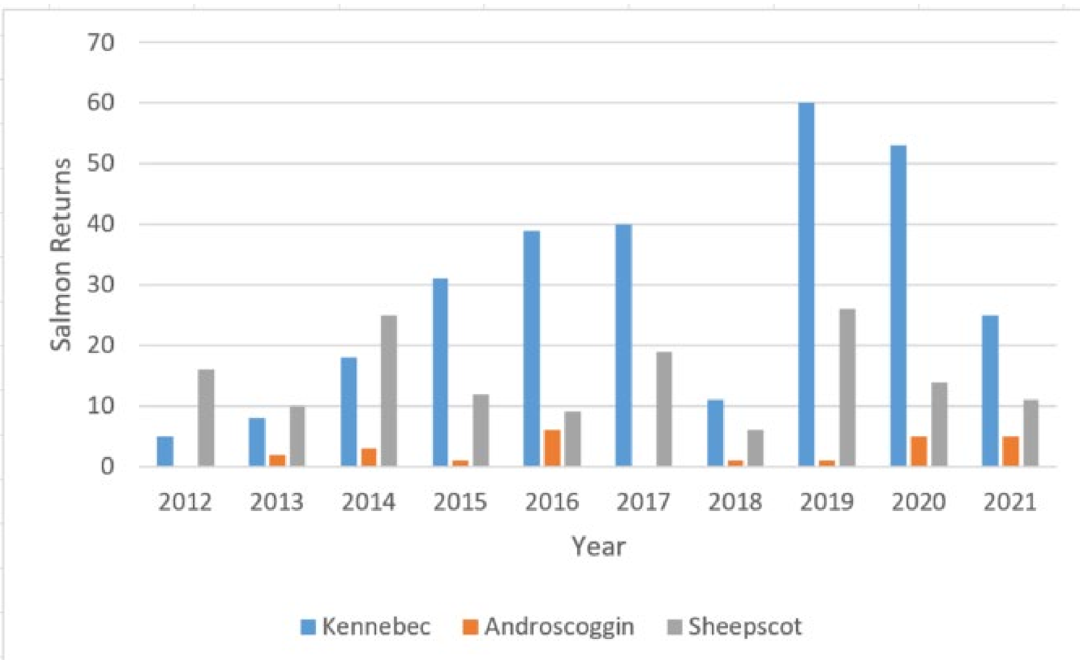

Figure 6. Adult Atlantic salmon returns to the rivers in the Merrymeeting Bay SHRU between 2012 and 2021 (derived from data in USASAC (2022) and CMS (2022)).

Although relatively small, the Sheepscot River hosts one of the eight remaining river-specific stocks of Atlantic salmon. These are the only remaining locally adapted populations of wild Atlantic salmon in the GOM DPS. The river specific stocks for the Androscoggin and Kennebec were extirpated largely due to habitat loss and the construction of dams. Both rivers are now stocked with salmon from the Penobscot population. The Sheepscot stock is the only river-specific population remaining in the Merrymeeting Bay SHRU and is the southernmost population in the GOM DPS.

Smolts

Out-migrating Atlantic salmon smolts in the Merrymeeting Bay rivers are the result of wild production following natural spawning and juvenile rearing, or from stocking eggs, fry, parr, and smolts (Fay et al., 2006). The majority of the salmon run in the SHRU is the result of egg stocking in the Sandy River (a large tributary to the Kennebec), but egg, fry, and parr stocking also occurs elsewhere in the SHRU (Table 9). Between 2010 and 2020, the only smolts that were stocked in the SHRU were tagged study fish that Brookfield put in the river to test the efficiency of their downstream fishways. In 2020 and 2021, MDMR began implementing a multi-year plan to stock smolts in the mainstem Kennebec River with the stocking of almost 90,000 smolts in 2020, and 100,000 in 2021(USASAC, 2022). Stocking in the Androscoggin has been limited to a small educational stocking effort conducted by the Fish Friends (i.e., Salmon in Schools) program. Over the last 10 years stocking from this effort has ranged between zero and 2,000 fry per year in the Androscoggin. No stocking occurred in the river between 2016 and 2019, but in 2020, Fish Friends reported the stocking of 2,000 salmon fry (USASAC, 2021).

Table 9. Stocking history by life stage in the Merrymeeting Bay SHRU between 2012-2021 (derived from data in USASAC (2021) and CMS (2022)).

Lifestage	Kennebec	Androscoggin	Sheepscot
Egg	7,651,290	0	1,780,632
Fry	14,000	9,000	236,277
Parr	0	0	139,061
Smolt	189,682	500	0

Areas designated as critical habitat within each SHRU are described in terms of habitat units. One habitat unit represents 100 m^2 of salmon spawning or rearing habitat. The quantity of habitat units in each SHRU was estimated using a GIS-based salmon habitat model (Wright et al., 2008). Using this model, we estimate that approximately one-third of habitat units within the Merrymeeting Bay SHRU are within the designated critical habitat for Atlantic salmon. Approximately 90,000 of those habitat units occur within critical habitat in the Kennebec River; this constitutes roughly three-quarters of the critical habitat in the SHRU. The remaining 32,000 habitat units within critical habitat are divided between the other four rivers within the SHRU (Figure 7). In addition to abundance, the model also identifies the proportion of each modeled reach that is expected to be suitable for juvenile rearing. The Maine Stream Habitat Viewer[8] categorized these proportions into three classes with the first, second, and third classes predicted

[8] Maine Stream Habitat Viewer. Atlantic salmon Modeled Rearing Habitat. Layer maintained by US Fish and Wildlife Service Gulf of Maine Coastal Program. https://webapps2.cgis-solutions.com/MaineStreamViewer/

to contain >50%, 27-50%, and <26% rearing habitat, respectively. As areas that contain a higher proportion of rearing habitat are more likely to produce juvenile salmon, class 1 habitats are expected to be the most suitable for rearing and class 3 habitats expected to be least suitable[9]. Using the model and the established classification, we describe how the suitability and abundance of rearing habitat compares between the five rivers in the SHRU (Figure 7). Of the over 55,000 class 1 habitat units in the critical habitat within the Merrymeeting Bay SHRU, 78% occur within the Kennebec River, with the remaining 22% divided among the other four rivers.

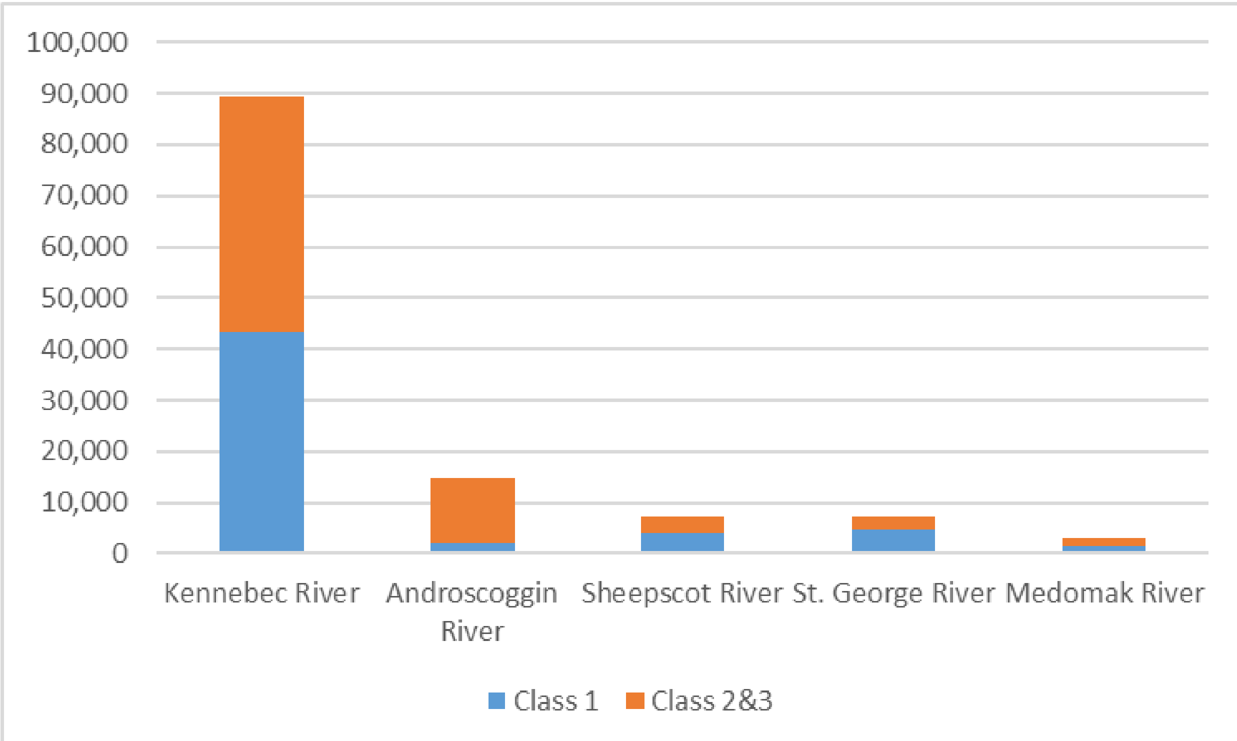

Figure 7. The abundance and suitability of modeled rearing habitat units in designated critical habitat within the Merrymeeting Bay SHRU for Atlantic salmon (based on Wright et al. (2008)).

Dams significantly affect Atlantic salmon in the Merrymeeting Bay SHRU through habitat alteration, fish passage delays, and entrainment and impingement of juveniles and kelts. There are approximately 200 dams in the Merrymeeting Bay SHRU watershed; 80 of which occur within critical habitat. For comparison, the Penobscot Bay SHRU and the Downeast Coastal SHRU have approximately 110 and 65 dams, respectively.

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[9] In the context of the Wright et al. (2008) model, what we refer to as suitability is actually a measure of habitat abundance or density within a stream reach, rather than a measure of quality. A segment of river modeled as class 1 would be expected to have a higher proportion of productive habitat than one modeled as class 3. However, this does not suggest that a unit of habitat in a class 1 reach would necessarily produce more salmon parr than a unit of habitat in a class 3 reach (i.e., quality).

The Merrymeeting Bay SHRU contains a large number of FERC licensed and exempt dams that block or hinder access for diadromous fish species. These dams are concentrated on the Kennebec and Androscoggin Rivers; no FERC licensed dams exist on the smaller rivers in the basin. Of the 37 FERC licensed or exempt dams in the Merrymeeting Bay SHRU, 14 are within critical habitat. For comparison, the Penobscot Bay SHRU and the Downeast Coastal SHRU have approximately 26 and 3 FERC licensed or exempt dams located in critical habitat, respectively. Few of the dams in the Merrymeeting Bay SHRU have fishways for diadromous fish. On the Androscoggin River, only the first three dams (i.e., Brunswick, Pejepscot, and Worumbo) currently have fishways. On the Kennebec River, the first and second dams (i.e., Lockwood and Hydro-Kennebec) have fish passage facilities. Rather than a swim-through fishway, the Lockwood dam has a trap that allows for the capture of a portion of prespawn Atlantic salmon, which are then driven by truck to the Sandy River. As salmon are trucked upstream from Lockwood, the new fish lift at Hydro-Kennebec is currently inaccessible to salmon.

The current number of accessible habitat units suitable for rearing in the Merrymeeting Bay SHRU is approximately 12,423 (i.e., 10% of the habitat in the critical habitat) (CMS, 2021). Accessible habitat, in the context of the recovery criteria, is habitat that the majority of Atlantic salmon can freely swim to safely and effectively with minimal human intervention. As such, habitat above dams that have inadequate passage effectiveness is not considered accessible. Similarly, habitat that is only accessible because salmon are trapped at a dam and transported to the habitat upstream through extensive human intervention is not considered accessible. Therefore, the estimate of accessible habitat does not include habitat above the Lockwood dam (because salmon can only access upstream habitat when transported by humans) or the first Androscoggin dam (where fishway effectiveness has not been evaluated). Most of the accessible high quality (i.e., class 1) rearing habitat in the SHRU is located in the Sheepscot River (3,985 units), St. George River (4,617 units) and the Kennebec River downstream of the Lockwood Dam (5,337 units). This is a relatively small amount when compared to the 39,389 units located upstream of Lockwood on the Kennebec; 30,000 of which occur in the Sandy River tributary. There is also mapped accessible spawning habitat in the lower Kennebec, St. George, and Sheepscot[10] that provides opportunity for spawning and rearing for adults that do not pass successfully upstream of the Lockwood Dam.

<u>Summary</u>

Adult returns for the Merrymeeting Bay recovery unit remain well below the biological criteria established for each SHRU in the 2019 Recovery Plan (USFWS & NMFS, 2019). The Recovery Plan identifies a self-sustaining annual escapement target of 2,000 wild origin adults for each SHRU before delisting of the species under the ESA can proceed. Similarly, the Plan indicates that an escapement of 500 naturally reared adults returning to two of the three SHRUs would be

[10] Maine Stream Habitat Viewer. Atlantic salmon Surveyed Spawning Habitat. Layer maintained by MDMR. https://webapps2.cgis-solutions.com/MaineStreamViewer/

required to downlist the species from endangered to threatened. The abundance of Atlantic salmon in the SHRU remains low. The 10-year (2012-2021) average number of naturally-reared or wild adults returning to the Merrymeeting Bay SHRU is 36 (CMS, 2022). This constitutes 7.2% of the total needed for downlisting (reclassification to threatened), and 1.8% of what is needed for delisting. The conservation hatchery program has assisted in slowing the decline and helping to stabilize populations at low levels, but has not contributed to an increase in the overall abundance of salmon and has not been able to significantly increase the naturally reared component of the GOM DPS.

In 2020, NMFS and USFWS completed a 5-year review that evaluated whether the reclassification criteria had been achieved for the GOM DPS of Atlantic salmon (NMFS & USFWS, 2020). The review concluded that the demographic risks to Atlantic salmon are still high, that the number of naturally reared or wild adults is still less than 100 per SHRU, and that the primary threats have not been sufficiently abated. A number of activities within the Merrymeeting Bay SHRU will continue to impact the biological and physical features of spawning, rearing, and migration habitat for Atlantic salmon. In freshwater, the primary threat to the species and to the functioning of critical habitat is the lack of abundant accessible spawning and rearing habitat, which is attributable to ineffective fish passage at dams, and at road-stream crossings.

3.2 Shortnose Sturgeon

Shortnose sturgeon occur in the portion of the action area below the Lockwood dam. Shortnose sturgeon are fish that occur in rivers and estuaries along the East Coast of the U.S. and Canada (SSSRT, 2010). They have a head covered in bony plates, as well as protective armor called scutes extending from the base of the skull to the caudal peduncle. Other distinctive features include a subterminal, protractile tube-like mouth, and chemosensory barbels for benthic foraging (SSSRT, 2010). Sturgeon have been present in North America since the Upper Cretaceous period, more than 66 million years ago. The information below is a summary of available information on the species. More thorough discussions can be found in the cited references as well as the Shortnose Sturgeon Status Review Team's (SSSRT) Biological Assessment (2010).

3.2.1 Life History and General Habitat Use

There are differences in life history, behavior, and habitat use across the range of the species. Current research indicates that these differences are adaptations to unique features of the rivers where these populations occur. For example, there are differences in larval dispersal patterns in the Connecticut River (MA) and Savannah River (GA) (Parker, 2007). There are also morphological and behavioral differences. Growth and maturation occurs more quickly in southern rivers but fish in northern rivers grow larger and live longer. We provide general life history attributes in Table 10.

Table 10. Shortnose sturgeon general life history for the species throughout its range

Stage	Size (mm)	Duration	Behaviors/Habitat Used
Egg	3-4	13 days postspawn	stationary on bottom; Cobble and rock, fresh, fast flowing water (0.4-0.8 m/s)
Yolk Sac Larvae	7-15	8-12 days post hatch	Photonegative; swim up and drift behavior; form aggregations with other YSL; Cobble and rock, stay at bottom near spawning site
Post Yolk Sac Larvae	15 - 57	12-40 days post hatch	Free swimming; feeding; Silt bottom, deep channel; fresh water
Young of Year	57 – 140 (north); 57-300 (south)	From 40 days post-hatch to one year	Deep, muddy areas upstream of the salt wedge
Juvenile	140 to 450-550 (north); 300 to 450-550 (south)	1 year to maturation	Increasing salinity tolerance with age; same habitat patterns as adults
Adult	450-1100 average; (max recorded 1400)	Post-maturation	Freshwater to estuary with some individuals making nearshore coastal migrations

Shortnose sturgeon live on average for 30-40 years (Dadswell et al., 1984). Males mature at approximately 5-10 years and females mature between age 7 and 13, with later maturation occurring in more northern populations (Dadswell et al., 1984). Females typically spawn for the first time 5 years post-maturation (age 12-18; Dadswell, 1979; Dadswell et al., 1984) and then spawn every 3-5 years (Dadswell, 1979; Dadswell et al., 1984;). Males spawn for the first time approximately 1-2 years after maturity with spawning typically occurring every 1-2 years (Kieffer and Kynard, 1996; NMFS, 1998; Dadswell et al., 1984). Shortnose sturgeon are iteroparous (spawning more than once during their life) and females release eggs in multiple "batches" during a 24 to 36-hour period (total of 30,000-200,000 eggs). Multiple males are likely to fertilize the eggs of a single female.

Cues for spawning are thought to include water temperature, day length and river flow (Kynard et al,, 2012, Kynard et al. 2016). Shortnose sturgeon spawn in freshwater reaches of their natal rivers when water temperatures reach 9–15°C in the spring (Dadswell, 1979; Taubert, 1980a and b; Kynard, 1997). Spawning occurs over gravel, rubble, and/or cobble substrate (Dadswell, 1979, Taubert, 1980a and b; Buckley and Kynard, 1985b; Kynard, 1997) in areas with average bottom velocities between 0.4 and 0.8 m/s. Depths at spawning sites are variable, ranging from

1.2 - 27 m (multiple references in SSSRT (2010)). Eggs are small and demersal and stick to the rocky substrate where spawning occurs.

Shortnose sturgeon occur in waters between 0-34°C (Dadswell et al., 1984; Heidt & Gilbert, 1978); with temperatures above 28°C considered to be stressful. Depths used are highly variable, ranging from shallow mudflats while foraging to deep channels up to 30 m (Dadswell et al., 1984; Dadswell, 1979). Salinity tolerance increases with age; while young of the year must remain in freshwater, adults have been documented in the ocean with salinities of up 30 parts-per-thousand (ppt) (Holland and Yeverton, 1973; Saunders and Smith, 1978). Dissolved oxygen affects distribution, with preference for DO levels at or above 5mg/l and adverse effects anticipated for prolonged exposure to DO less than 3.2mg/L (Secor and Niklitschek 2001).

Shortnose sturgeon feed on benthic insects, crustaceans, mollusks, and polychaetes (Dadswell et al., 1984). Both juvenile and adult shortnose sturgeon primarily forage over sandy-mud bottoms, which support benthic invertebrates (Carlson and Simpson, 1987; Kynard, 1997). Shortnose sturgeon have also been observed feeding off plant surfaces (Dadswell et al., 1984).

Following spawning, adult shortnose sturgeon disperse quickly down river to summer foraging grounds areas and remain in areas downstream of their spawning grounds throughout the remainder of the year (Buckley and Kynard, 1985a, Dadswell et al., 1984; Buckley and Kynard, 1985b; O'Herron et al., 1993).

In northern rivers, shortnose aggregate during the winter months in discrete, deep (3-10m) freshwater areas with minimal movement and foraging (Kynard et al., 2012; Buckley and Kynard, 1985a; Dadswell, 1979, Li et al., 2007; Dovel et al., 1992; Bain et al., 1998a and b). In the winter, adults in southern rivers spend much of their time in the slower moving waters downstream near the salt-wedge and forage widely throughout the estuary (Collins and Smith, 1993, Weber et al., 1998). Prespawning sturgeon in some northern and southern systems migrate into an area in the upper tidal portion of the river in the fall and complete their migration in the spring (Rogers and Weber, 1995). Older juveniles typically occur in the same overwintering areas as adults while young of the year remain in freshwater (Jenkins et al., 1993; Jarvis et al. 2001).

Listing History

Shortnose sturgeon were listed as endangered in 1967 (32 FR 4001), and the species remained on the endangered species list with the enactment of the ESA in 1973. Shortnose sturgeon are thought to have been abundant in nearly every large East Coast river prior to the 1880s (see McDonald, 1887; Smith and Clugston, 1997). Pollution and overfishing, including bycatch in the shad fishery, were listed as principal reasons for the species' decline. The species remains listed as endangered throughout its range. While the 1998 Recovery Plan refers to Distinct Population Segments (DPS), the process to designate DPSs for this species has not been undertaken. The SSSRT published a Biological Assessment for shortnose sturgeon in 2010. The report summarized the status of shortnose sturgeon within each river and identified stressors that continue to affect the abundance and stability of these populations.

Current Status

There is no current total population estimate for shortnose sturgeon rangewide. Information on populations and metapopulations is presented below. In general, populations in the Northeast are larger and more stable than those in the Southeast (SSSRT, 2010). Population size throughout the species' range is considered to be stable; however, most riverine populations are below the historic population sizes and most likely are below the carrying capacity of the river (Kynard, 1996).

Population Structure

There are 19 documented populations of shortnose sturgeon ranging from the St. Johns River, Florida (possibly extirpated from this system) to the Saint John River in New Brunswick, Canada. There is a large gap in the middle of the species range with individuals present in the Chesapeake Bay separated from populations in the Carolinas by a distance of more than 400 km. Currently, there are significantly more shortnose sturgeon in the northern portion of the range.

Developments in genetic research as well as differences in life history support the grouping of shortnose sturgeon into five genetically distinct groups, all of which have unique geographic adaptations (see Grunwald et al., 2008; Grunwald et al., 2002; King et al., 2001; Waldman et al., 2002b; Walsh et al., 2001; Wirgin et al., 2009; Wirgin et al., 2002; SSSRT, 2010). These groups are: 1) Gulf of Maine; 2) Connecticut and Housatonic Rivers; 3) Hudson River; 4) Delaware River and Chesapeake Bay; and 5) Southeast. The Gulf of Maine, Delaware/Chesapeake Bay and Southeast groups function as metapopulations[11]. The other two groups (Connecticut/Housatonic and the Hudson River) function as independent populations.

While there is migration within each metapopulation (i.e., between rivers in the Gulf of Maine and between rivers in the Southeast) and occasional migration between populations (e.g., Connecticut and Hudson), interbreeding between river populations is limited to very few individuals per generation; this results in morphological and genetic variation between most river populations (see Walsh et al., 2001; Grunwald et al., 2002; Waldman et al., 2002; Wirgin et al., 2005). Indirect gene flow estimates from mtDNA indicate an effective migration rate of less than two individuals per generation. This means that while individual shortnose sturgeon may move between rivers, very few sturgeon are spawning outside their natal river; it is important to remember that the result of physical movement of individuals is rarely genetic exchange.

[11] A metapopulation is a group of populations in which distinct populations occupy separate patches of habitat separated by unoccupied areas (Levins 1969). Low rates of connectivity through dispersal, with little to no effective movement, allow individual populations to remain distinct as the rate of migration between local populations is low enough not to have an impact on local dynamics or evolutionary lineages (Hastings and Harrison 1994). This interbreeding between populations, while limited, is consistent, and distinguishes metapopulations from other patchy populations.

Summary of Status of Northeast Rivers

In NMFS' Greater Atlantic Region, shortnose sturgeon are known to spawn in the Kennebec, Androscoggin, Merrimack, Connecticut, Hudson, and Delaware Rivers. Shortnose sturgeon are also known to occur in the Penobscot and Potomac Rivers; although it is unclear if spawning is currently occurring in those systems.

Gulf of Maine Metapopulation

Tagging and telemetry studies indicate that shortnose sturgeon are present in the Penobscot, Kennebec, Androscoggin, Sheepscot, and Saco Rivers. Individuals have also been documented in smaller coastal rivers; however, the duration of presence has been limited to hours or days and the smaller coastal rivers are thought to be only used occasionally (Zydlewski et al., 2011).

Since the removal of the Veazie and Great Works Dams (2013 and 2012, respectively), in the Penobscot River, shortnose sturgeon range from the Bay to the Milford Dam. Shortnose sturgeon now are presumed to have access to their full historical range. Adult and large juvenile sturgeon have been documented to use the river. While potential spawning sites have been identified, no spawning has been documented. Foraging and overwintering are known to occur in the river. Nearly all prespawn females and males detected in the Penobscot River have been documented to return to the Kennebec or Androscoggin Rivers. Robust design analysis with closed periods in the summer and late fall estimated seasonal adult abundance ranging from 636-1285 (weighted mean), with a low estimate of 602 (95% CI: 409.6-910.8) and a high of 1306 (95% CI: 795.6-2176.4) (Fernandes, 2008; Fernandes et al., 2010; Dionne, 2010 in Maine DMR (2010)).

Kennebec/Androscoggin/Sheepscot Rivers

The estimated size of the adult population (>50cm TL) in this system, based on a tagging and recapture study conducted between 1977 and 1981, was 7,200 (95% CI = 5,000 - 10,800; Squiers et al. 1982). A population study conducted 1998-2000 estimated population size at 9,488 (95% CI = 6,942 -13,358; Squiers 2003) suggesting that the population exhibited significant growth between the late 1970s and late 1990s. Spawning is known to occur in the Androscoggin and Kennebec Rivers (Wippelhauser and Squiers 2015, Wippelhauser et al. 2015). In both rivers, there are hydroelectric facilities located at the base of natural falls thought to be the natural upstream limit of the species. As such, these dams (Lockwood Dam on the Kennebec and Brunswick Dam on the Androscoggin) are not considered to limit the movements of sturgeon in these rivers. The Sheepscot River is used for foraging during the summer months.

Altenritter et al. (2017) found that a large proportion of female shortnose sturgeon tagged in the Penobscot River migrated to the Kennebec River during probable spawning windows. They also found that shortnose sturgeon in the Penobscot River were larger and had a higher condition factor than shortnose sturgeon in the Kennebec River. Based on this, they speculated that "increased abundance and resource limitation in the Kennebec River may be constraining growth and promoting migration to the Penobscot River by individuals with sufficient initial size and condition." These individuals then return to spawn in the Kennebec River at larger size that could potentially result in increased reproductive potential compared to nonmigratory females. Thus, migrants could experience an adaptive reproductive advantage relative to nonmigratory individuals. Further, Altenritter et al. (2017) noted that although migrants to the Penobscot River may be a small proportion of the Kennebec River population, they could disproportionately contribute to regional recruitment and facilitate population resilience to disturbance.

Merrimack River

The historic range in the Merrimack extended to Amoskeag Falls (Manchester, NH, river kilometer 116; Piotrowski (2002)); currently shortnose sturgeon cannot move past the Essex Dam in Lawrence, MA (river kilometer 46). A current population estimate for the Merrimack River is not available. Based on a study conducted 1987-1991, the adult population was estimated at 32 adults (20–79; 95% confidence interval; B. Kynard and M. Kieffer unpublished information). However, recent gill-net sampling efforts conducted by Kieffer indicate a dramatic increase in the number of adults in the Merrimack River. Sampling conducted in the winter of 2009 resulted in the capture of 170 adults. Preliminary estimates suggest that there may be approximately 2,000 adults using the Merrimack River annually. Spawning, foraging and overwintering all occur in the Merrimack River.

Tagging and tracking studies demonstrate movement of shortnose sturgeon between rivers within the Gulf of Maine, with the longest distance traveled between the Penobscot and Merrimack rivers (Altenritter et al., 2017, Wippelhauser et al., 2017). Genetic studies indicate that a small, but statistically insignificant amount of genetic exchange likely occurs between the Merrimack River and these rivers in Maine (King et al., 2013). The Merrimack River population is genetically distinct from the Kennebec-Androscoggin-Penobscot population (SSSRT, 2010). In the fall of 2014, a shortnose sturgeon tagged in the Connecticut River in 2001 was captured in the Merrimack River. To date, genetic analysis has not been completed and we do not yet know the river of origin of this fish.

Connecticut River

The Holyoke Dam divides the Connecticut River shortnose population; upstream and downstream fishway improvements were implemented for the 2016 fish passage season. Passage between 1975 and 1999 was an average of four fish per year and no shortnose sturgeon passed upstream of the dam between 2000 and 2015. From 2016 - 2020, 287 shortnose sturgeon have passed upstream of the dam, at an average rate of 57 per year. The number of sturgeon passing downstream of the Dam is less well known due to difficulties in monitoring downstream passage. However, the 2016 fishway improvements have been shown to significantly reduce the potential for serious injury or mortality. Despite this separation, the populations are not genetically distinct (Kynard, 1997, Wirgin et al., 2005, Kynard et al., 2012). The most recent estimate of the number of shortnose sturgeon upstream of the dam, based on captures and tagging from 1990-2005 is approximately 328 adults (CI = 188–1,264 adults; B. Kynard, USGS, unpubl. Data in SSSRT 2010); this compares to a previous Peterson mark-recapture estimate of 370–714 adults (Taubert, 1980a). Using four mark-recapture methodologies, the long-term population estimate (1989-2002) for the lower Connecticut River ranges from 1,042-1,580 (Savoy, 2004). Comparing 1989-1994 to 1996-2002, the population exhibits growth on the order of 65-138%. The population in the Connecticut River is thought to be stable, but at a small size.

As described in SSSRT (2010), shortnose sturgeon in the Connecticut River inhabit a reach downstream of the Turners Falls Dam (Turners Falls, MA; river kilometer 198) to Long Island Sound. Construction of the Turners Falls Dam was completed in 1798 and built on a natural falls-rapids. Turners Falls is believed to be the historic upstream boundary of shortnose sturgeon in the Connecticut River; however, there have been anecdotal sightings of sturgeon upstream of the dam and in the summer of 2017 an angler reported a catch of a shortnose sturgeon upstream of the Turners Falls Dam. This information suggests that occasional shortnose sturgeon are present upstream to the dam; however, we have no information on how shortnose sturgeon accessed this reach or how many sturgeon may be present in this area, if any.

While limited spawning is thought to occur below the Holyoke Dam, until recently successful spawning (i.e., capture of viable eggs and larvae) has only been documented upstream of the Holyoke Dam. Abundance of prespawning adults was estimated each spring between 1994 and 2001 at a mean of 142.5 spawning adults (CI =14–360 spawning adults) (Kynard et al., 2012). Overwintering and foraging occur in both the upper and lower portions of the river. Occasionally, sturgeon have been captured in tributaries to the Connecticut River including the Deerfield River and Westfield River. Additionally, a sturgeon tagged in the Connecticut River was recaptured in the Housatonic River (T. Savoy, CT DEP, pers. comm.). Three individuals tagged in the Hudson were captured in the CT, with one remaining in the river for at least one year (Savoy, 2004). In spring 2021, the CT DEEP captured a number of shortnose sturgeon eggs on egg mats below the Holyoke Dam. Young of year shortnose sturgeon were also observed by divers monitoring for listed mussels at a construction site in Springfield, MA. These observations suggest that occasional spawning may occur below the dam; however, we do not have sufficient information to determine how frequently such an occurrence may happen.

Hudson River

The Hudson River population of shortnose sturgeon is the largest in the United States. Studies indicated an extensive increase in abundance from the late 1970s (13,844 adults (Dovel et al., 1992), to the late 1990s (56,708 adults (95% CI 50,862 to 64,072; Bain et al., 1998). This increase is thought to be the result of high recruitment (31,000 – 52,000 yearlings) from 1986-1992 (Woodland and Secor, 2007). Woodland and Secor examined environmental conditions throughout this 20-year period and determined that years in which water temperatures drop quickly in the fall and flow increases rapidly in the fall (particularly October), are followed by high levels of recruitment in the spring. This suggests that these environmental factors may index a suite of environmental cues that initiate the final stages of gonadal development in spawning adults. The population in the Hudson River exhibits substantial recruitment and is considered to be stable at high levels.

Delaware River-Chesapeake Bay Metapopulation

Shortnose sturgeon range from Delaware Bay up to at least Scudders Falls (river kilometer 223); there are no dams within the species' range on this river. The population is considered stable (comparing 1981-1984 to 1999-2003) at around 12,000 adults (Hastings et al., 1987 and ERC, 2006b). Spawning occurs primarily between Scudders Falls and the Trenton rapids. Overwintering and foraging also occur in the river. Shortnose sturgeon have been documented to use the Chesapeake-Delaware Canal to move from the Chesapeake Bay to the Delaware River.

In Chesapeake Bay, shortnose sturgeon have most often been found in Maryland waters of the mainstem bay and tidal tributaries such as the Susquehanna, Potomac, and Rappahannock Rivers (Kynard et al., 2016; SSSRT, 2010). Spells (1998), Skjeveland et al. (2000), and Welsh et al. (2002) all reported one capture each of adult shortnose sturgeon in the Rappahannock River. Recent documented use of Virginia waters of Chesapeake Bay is currently limited to two individual shortnose sturgeon: one captured in 2016 (Balazik, 2017) and a second sturgeon (a confirmed gravid female) caught in 2018 in the James River (Balazik, pers. comm. 2018). Spawning has not been documented in any tributary to the Bay although suitable spawning habitat and two prespawn females with late stage eggs have been documented in the Potomac River. Current information indicates that shortnose sturgeon are present year round in the Potomac River with foraging and overwintering taking place there. Shortnose sturgeon captured in the Chesapeake Bay are not genetically distinct from the Delaware River population.

Southeast Metapopulation

There are no shortnose sturgeon between Maryland waters of the Chesapeake Bay and the Carolinas. Shortnose sturgeon are only thought to occur in the Cape Fear River and Yadkin-Pee Dee River in North Carolina and are thought to be present in very small numbers.

The Altamaha River supports the largest known population in the Southeast with successful self-sustaining recruitment. The most recent population estimate for this river was 6,320 individuals (95% CI = 4,387-9,249; DeVries, 2006). The population contains more juveniles than expected. Comparisons to previous population estimates suggest that the population is increasing; however, there is high mortality between the juvenile and adult stages in this river. This mortality is thought to result from incidental capture in the shad fishery, which occurs at the same time as the spawning period (DeVries, 2006).

The only available estimate for the Cooper River is of 300 spawning adults at the Pinoplis Dam spawning site (based on 1996-1998 sampling; Cooke et al., 2004). This is likely an underestimate of the total number of adults as it would not include non-spawning adults. Estimates for the Ogeechee River were 266 (95%CI=236-300) in 1993 (Weber, 1996; Weber et al., 1998); a more recent estimate (sampling from 1999-2004; Fleming et al., 2003) indicates a population size of 147 (95% CI = 104-249). While the more recent estimate is lower, it is not significantly different from the previous estimate. Available information indicates the Ogeechee River population may be experiencing juvenile mortality rates greater than other southeastern rivers.

Spawning is also occurring in the Savannah River, the Congaree River, and the Yadkin-Pee Dee River. There are no population estimates available for these rivers. Occurrence in other southern rivers is limited, with capture in most other rivers limited to fewer than five individuals. They are thought to be extremely rare or possibly extirpated from the St. Johns River in Florida as only a single specimen was found by the Florida Fish and Wildlife Conservation Commission during extensive sampling of the river in 2002/2003. In these river systems, shortnose sturgeon occur in nearshore marine, estuarine, and riverine habitat.

3.2.2 Threats

Because sturgeon are long-lived and slow growing, stock productivity is relatively low; this can make the species vulnerable to rapid decline and slow recovery (Musick, 1999). In well studied rivers (e.g., Hudson, upper Connecticut), researchers have documented significant year to year recruitment variability (up to 10 fold over 20 years in the Hudson and years with no recruitment in the CT). However, this pattern is not unexpected given the life history characteristics of the species and natural variability in hydrogeologic cues relied on for spawning.

The small amount of effective movement between populations means recolonization of currently extirpated river populations is expected to be very slow and any future recolonization of any rivers that experience significant losses of individuals would also be expected to be very slow. Despite the significant decline in population sizes over the last century, gene diversity in shortnose sturgeon is moderately high in both mtDNA (Quattro et al., 2002; Wirgin et al., 2005; Wirgin et al., 2000) and nDNA (King et al., 2001) genomes.

A population of sturgeon can go extinct as a consequence of demographic stochasticity (fluctuations in population size due to random demographic events); the smaller the metapopulation (or population), the more prone it is to extinction. Anthropogenic impacts acting on top of demographic stochasticity further increase the risk of extinction.

All shortnose sturgeon populations are highly sensitive to increases in juvenile mortality that would result in reductions in the number of adult spawners (Anders et al., 2002; Gross et al., 2002; Secor, 2002). Populations of shortnose sturgeon that do not have reliable natural recruitment are at increased risk of experiencing population decline leading to extinction (Secor et al*.,* 2002). Elasticity studies of shortnose sturgeon indicate that the highest potential for increased population size and stability comes from YOY and juveniles as compared to adults (Gross et al., 2002); that is, increasing the number of YOY and juveniles has a more significant long term impact to the population than does increasing the number of adults or the fecundity of adults.

The Shortnose Sturgeon Recovery Plan (NMFS, 1998) and the Shortnose Sturgeon Status Review Team's Biological Assessment of shortnose sturgeon (2010) identify habitat degradation or loss and direct mortality as principal threats to the species' survival. Natural and anthropogenic factors continue to threaten the recovery of shortnose sturgeon and include: poaching, bycatch in riverine fisheries, habitat alteration resulting from the presence of dams, in-water and shoreline construction, including dredging; degraded water quality which can impact habitat suitability and result in physiological effects to individuals including impacts on reproductive success; direct mortality resulting from dredging as well as impingement and entrainment at water intakes; and, loss of historical range due to the presence of dams. Shortnose sturgeon are also occasionally killed as a result of research activities. The total number of sturgeon affected by these various threats is not known. Climate change, particularly shifts in seasonal temperature regimes and changes in the location of the salt wedge, may impact shortnose sturgeon in the future (more information on Climate Change is presented in Section 5.0). More information on threats experienced in the action area is presented in the Environmental Baseline section of this Opinion.

3.2.3 Survival and Recovery

The 1998 Recovery Plan (NMFS, 1998) outlines the steps necessary for recovery and indicates that each population may be a candidate for downlisting (i.e., to threatened) when it reaches a minimum population size that is large enough to prevent extinction and will make the loss of genetic diversity unlikely; the minimum population size for each population has not yet been determined. The Recovery Outline contains three major tasks: (1) establish delisting criteria; (2) protect shortnose sturgeon populations and habitats; and, (3) rehabilitate habitats and population segments. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. In many rivers, particularly in the Southeast, habitat is compromised and continues to impact the ability of sturgeon populations to recover. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. The loss of any population or metapopulation would result in the loss of biodiversity and would create (or widen) a gap in the species' range.

3.2.4 Summary of Status

Shortnose sturgeon remain listed as endangered throughout their range, with populations in the Northeast being larger and generally more stable than populations in the Southeast. All populations are affected by mortality incidental to other activities, including dredging, power plant intakes and shad fisheries where those still occur, and impacts to habitat and water quality that affect the ability of sturgeon to use habitats and impacts individuals that are present in those habitats. While the species is overall considered to be stable (i.e., its trend has not changed recently, and we are not aware of any new or emerging threats that would change the trend in the future), we lack information on abundance and population dynamics in many rivers. We also do not fully understand the extent of coastal movements and the importance of habitat in non-natal rivers to migrant fish. While the species has high levels of genetic diversity, the lack of effective movement between populations increases the vulnerability of the species, should there be a significant reduction in the number of individuals in any one population or metapopulation as recolonization is expected to be very slow. All populations, regardless of size, are faced with threats that result in the mortality of individuals and/or affect the suitability of habitat and may restrict the further growth of the population. Additionally, there are several factors that combine to make the species particularly sensitive to existing and future threats; these factors include: the small size of many populations, existing gaps in the range, late maturation, the sensitivity of adults to very specific spawning cues which can result in years with no recruitment, and the impact of losses of young of the year and juveniles to population persistence and stability.

3.3 Atlantic sturgeon

Atlantic sturgeon occur in the portion of the action area below the Lockwood Dam. An estuarine-dependent anadromous species, Atlantic sturgeon occupy ocean and estuarine waters, including sounds, bays, and tidal-affected rivers from Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida (ASSRT, 2007) (Figure 8). The marine range of U.S. Atlantic sturgeon extends from Labrador, Canada, to Cape Canaveral, Florida. As Atlantic sturgeon travel long distances in these waters, all five DPSs of Atlantic sturgeon have the potential to be anywhere in this marine range. On February 6, 2012, NMFS listed five DPSs of Atlantic sturgeon under the ESA: Gulf of Maine (GOM), New York Bight (NYB), Chesapeake Bay (CB), Carolina, and South Atlantic (77 FR 5880 and 77 FR 5914). The Gulf of Maine DPS is listed as threatened, and the New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs are listed as endangered. As described below, only individuals from the Gulf of Maine DPS are expected to occur in the action area. Critical habitat for all five DPSs was designated in 2017 (82 FR 39160); the designation for the Gulf of Maine DPS includes the Kennebec River critical habitat unit as described further below.

Determination of DPS Composition in the Action Area

As explained above, the range of all five DPSs overlaps and extends from Canada through Cape Canaveral, Florida (Figure 8). The distribution of Atlantic sturgeon is influenced by geography, with Atlantic sturgeon from a particular DPS becoming less common the further from the river of origin one moves. Areas that are geographically close are expected to have a similar composition of individuals. We have considered the best available information to determine from which DPSs individuals in the action area are likely to have originated.

There is currently no mixed stock analysis[12] for the action area specifically; however, genetic analyses and telemetry studies indicate that within the Gulf of Maine nearly all Atlantic sturgeon originate from the Gulf of Maine DPS and that within the action area we would only expect Atlantic sturgeon originating from the Gulf of Maine DPS. Wippelhauser et al. (2017) tagged Atlantic sturgeon in four Gulf of Maine rivers and tracked their movements between 2006 and 2014; they found that only 7% of the Atlantic sturgeon tagged in the four study rivers moved outside of the Gulf of Maine during the study period. Kazyak et al. (2021) examined genetic results of captured Atlantic sturgeon in three geographic regions (North of Cape Cod, Mid-Atlantic, and south of Cape Hatteras) to determine stock compositions in each of the three areas. They report that all individuals from the north region were from the Gulf of Maine DPS (87.8%) or Canadian River (12.2%). The authors state there was no indication that Atlantic sturgeon from other stocks were present in the samples from the north region, nor did they detect any differences in stock composition between individuals collected in riverine/estuarine habitats and offshore. Wirgin et al. (2012) determined that stocks in the Bay of Fundy were primarily from the St. John River (>60%) and the Kennebec River (34-36%). Together, these studies support the conclusion that Atlantic sturgeon in the Gulf of Maine are likely to originate from Canadian rivers or the Gulf of Maine DPS.

The only Atlantic sturgeon we expect to occur in the action area are adults, eggs, and larvae. In the Kennebec River, non-spawning Atlantic sturgeon spend the majority of their time downstream of rkm 45 (Wippelhauser et al., 2017), which is downstream of the action area. Because the best available information suggests that Atlantic sturgeon only spawn in their natal river, we expect all Atlantic sturgeon in the action area to be from the Gulf of Maine DPS.

[12] A mixed stock analysis uses genetic studies to estimate the proportional contributions of individuals from different stocks in a particular geographic area or population.

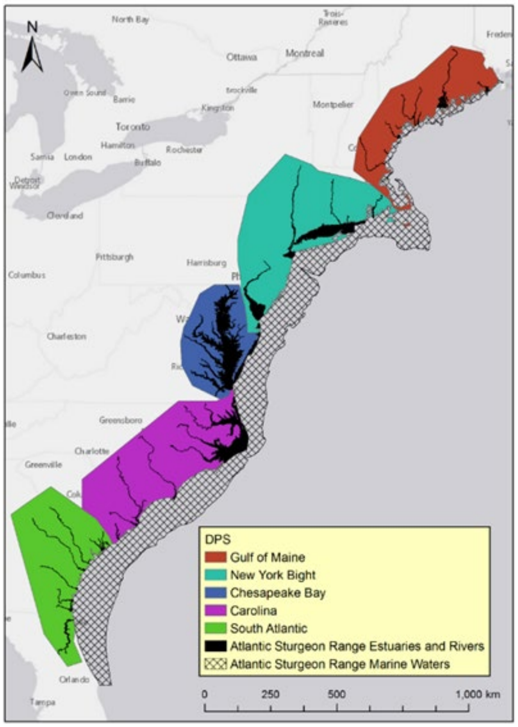

Figure 8**.** U.S. range of Atlantic sturgeon DPSs

Information available from the 2007 Atlantic sturgeon status review (ASSRT, 2007), 2017 ASMFC benchmark stock assessment (ASMFC, 2017), final listing rules (77 FR 5880 and 77 FR 5914; February 6, 2012), and material supporting the designation of Atlantic sturgeon critical habitat (NMFS, 2017a), as well as the 5-Year Reviews for the Gulf of Maine, New York Bight, and Chesapeake Bay DPSs (NMFS, 2022a, b, c) were used to summarize the life history, population dynamics, and status of the species.

3.3.1 Atlantic Sturgeon Life History

Atlantic sturgeon size at sexual maturity varies with latitude with individuals reaching maturity in the Saint Lawrence River at 22 to 34 years (Scott and Crossman, 1973). Atlantic sturgeon spawn in freshwater but spend most of their adult life in the marine environment. Spawning adults generally migrate upriver in May through July in Canadian systems (Bain, 1997; Caron et al., 2002; Murawski and Pacheco, 1977; Smith, 1985; Smith and Clugston, 1997). Atlantic sturgeon spawning is believed to occur in flowing water between the salt front and fall line of large rivers at depths of three to 27 meters (Bain et al., 2000; Borodin, 1925; Crance, 1987; Leland, 1968; Scott and Crossman, 1973). Atlantic sturgeon likely do not spawn every year; spawning intervals range from one to five years for males (Caron et al., 2002; Collins et al., 2000; Smith, 1985) and two to five years for females (Stevenson and Secor, 2000; Van Eenennaam et al., 1996; Vladykov and Greeley, 1963).

The life stages of Atlantic sturgeon can be divided up into six general categories as described in Table 11 below.

Table 11. Descriptions of Atlantic sturgeon life history stages.

Age Class	**Size**	**Description**
Egg	~2 to 3 mm diameter	Fertilized or unfertilized
Yolk Sac Larvae	~6 to 14 mm TL	Negative phototaxis, nourished by yolk sac (endogenous feeding)
Post Yolk Sac Larvae	~14 to 37 mm TL	Positive phototaxis, free swimming, actively feeding (exogenous feeding)
Young of Year (YOY)	0.3 grams <41 cm TL	Fish that are > 3 months and < one year; capable of capturing and consuming live food
Juveniles	>41 cm and <76 cm TL	Fish that are at least age 1 and are not sexually mature and do not make coastal migrations.
Subadults	>76cm and <150cm TL	Fish that are not sexually mature but make coastal migrations
Adults	>150 cm TL	Sexually mature fish

Sturgeon eggs are highly adhesive and are deposited on the bottom substrate, usually on hard surfaces (Gilbert, 1989; Smith and Clugston, 1997) between the salt front and fall line of large rivers (Bain et al., 2000; Borodin, 1925; Crance, 1987; Scott and Crossman 1973). Following spawning in northern rivers, males may remain in the river or lower estuary until the fall; females typically exit the rivers within four to six weeks (Savoy and Pacileo, 2003). Hatching occurs approximately 94 to 140 hours after egg deposition at temperatures of 20 and 18 degrees Celsius, respectively (Theodore et al., 1980).

Hatchlings (called free embryos) have a yolk sac that provides nourishment (endogenous feeding) during the first stage of larval development. Hatchlings are assumed to undertake a demersal existence, seek cover in the bottom substrate and yolk sac larvae (i.e., free embryos less than 4 weeks old, with total lengths (TL) less than 30 mm; Van Eenennaam et al., 1996) are assumed to inhabit the same riverine or estuarine areas where they were spawned (Kynard and Horgan 2002; Bain et al. 2000). The free embryo exhaust the yolk sac and become (post yolk sac) larvae after about eight days (Kynard and Horgan, 2002). Post yolk sac larvae drift downstream where they eventually settle, become demersal, and start foraging in freshwater reaches above the salt front (Kynard and Horgan, 2002).

Studies suggest that age-0 (i.e., young-of-year), age-1, and age-2 juvenile Atlantic sturgeon occur in low salinity waters of the natal estuary (Hilton et al., 2016) while older fish are more salt tolerant and occur in higher salinity waters as well as low salinity waters (Hilton et al., 2016; Collins et al., 2000). Atlantic sturgeon remain in the natal estuary for months to years before emigrating to open ocean as subadults (ASSRT, 2007; Dadswell, 2006; Dovel and Berggren, 1983; Hilton et al., 2016). Juvenile Atlantic sturgeon feed on aquatic insects, insect larvae, and other benthic invertebrates (ASSRT, 2007; Guilbard et al., 2007; Bigelow and Schroeder, 1953).

Upon reaching the subadult phase, individuals move to coastal and estuarine habitats (Dovel and Berggren, 1983; Murawski and Pacheco, 1977; Smith, 1985; Stevenson, 1997). Tagging and genetic data indicate that subadult and adult Atlantic sturgeon travel widely once they emigrate from rivers. Despite extensive mixing in coastal waters, Atlantic sturgeon exhibit high fidelity to their natal rivers (Grunwald et al., 2008; King et al., 2001; Waldman et al., 2002). Because of high natal river fidelity, it appears that most rivers support independent populations (Grunwald et al., 2008; King et al., 2001; Waldman and Wirgin, 1998; Wirgin et al., 2002; Wirgin et al., 2000). Atlantic sturgeon feed primarily on polychaetes, isopods, American sand lances and amphipods in the marine environment, while in fresh water they feed on oligochaetes, gammarids, mollusks, insects, and chironomids (Guilbard et al., 2007; Johnson et al., 1997; Moser and Ross, 1995; Novak et al., 2017; Savoy, 2007).

Based on fishery-independent, fishery dependent, tracking, and tagging data, Atlantic sturgeon appear to primarily occur inshore of the 50 meter depth contour (Stein et al., 2004a; Stein et al., 2004b; Laney et al., 2007; Dunton et al., 2010; Erickson et al., 2011; Dunton et al., 2015; Waldman et al., 2013; O'Leary et al., 2014; Wirgin et al., 2015a; Wirgin et al., 2015b). However, they are not restricted to these depths and excursions into deeper (e.g., 75 m) continental shelf waters have been documented (Timoshkin, 1968; Collins and Smith, 1997; Colette, 2002; Stein et al., 2004a; Dunton et al., 2010; Erickson et al., 2011). Data from fishery-independent surveys and tagging and tracking studies also indicate that some Atlantic sturgeon may undertake seasonal movements along the coast (Erickson et al., 2011; Dunton et al., 2010; Wippelhauser et al., 2012; Oliver et al., 2013; Post, 2014; Hilton et al., 2016). For instance, studies found that satellite-tagged adult sturgeon from the Hudson River concentrated in the southern part of the Mid-Atlantic Bight, at depths greater than 20 m, during winter and spring; while, in the summer and fall, Atlantic sturgeon concentrations shifted to the northern portion of the Mid-Atlantic Bight at depths less than 20 meters (Erickson et al., 2011).

In the marine range, several marine aggregation areas occur adjacent to estuaries and/or coastal features formed by bay mouths and inlets along the U.S. eastern seaboard (i.e., waters off North Carolina, Chesapeake Bay; Delaware Bay; New York Bight; Massachusetts Bay; Long Island Sound; and Connecticut and Kennebec River Estuaries). Depths in these areas are generally no greater than 25 meters (Bain et al., 2000; Stein et al., 2004a; Laney et al., 2007; Dunton et al., 2010; Erickson et al., 2011; Oliver et al., 2013; Waldman et al., 2013; O'Leary et al., 2014; Wippelhauser et al., 2012; Wippelhauser et al., 2015; Savoy and Pacileo, 2003). Although additional studies are still needed to clarify why Atlantic sturgeon aggregate at these sites, there is some indication that they may serve as thermal refuge, wintering sites, or marine foraging areas (Stein et al., 2004a; Dunton et al., 2010; Erickson et al., 2011).

Water temperature plays a primary role in triggering the timing of spawning migrations (Hilton et al., 2016). Spawning migrations generally occur during February-March in southern systems, April-May in Mid-Atlantic systems, and May-July in Canadian systems (Hilton et al., 2016). Male sturgeon begin upstream spawning migrations when waters reach approximately 6° C (43° F) (Hilton et al., 2016), and remain on the spawning grounds throughout the spawning season (Bain, 1997). Females begin spawning migrations when temperatures are closer to 12° C to 13° C (54° to 55° F) (Dovel and Berggren, 1983; Smith, 1985), make rapid spawning migrations upstream, and quickly depart following spawning (Bain, 1997). Females may leave the estuary and travel to other coastal estuaries until outmigration to marine waters in the fall (Smith et al., 1982; Dovel and Berggren, 1983; Smith, 1985; Bain, 1997; Bain et al., 2000; Greene et al., 2009; Balazik et al., 2012; Breece et al., 2013; NMFS, 2017; Hatin et al., 2002). Following spawning, males move downriver to the lower estuary and remain there until outmigration in the fall (Smith et al., 1982; Dovel and Berggren, 1983; Smith, 1985; Bain, 1997; Bain et al., 2000; Hatin et al., 2002; Greene et al., 2009; Balazik et al., 2012; Breece et al., 2013; Ingram et al., 2019).

Population Dynamics

A population estimate was derived from the NEAMAP trawl surveys.[13] For this Opinion, we are relying on the population estimates derived from the NEAMAP swept area biomass assuming a

[13] Since fall 2007, NEAMAP trawl surveys (spring and fall) have been conducted from Cape Cod, Massachusetts to Cape Hatteras, North Carolina in nearshore waters at depths up to 60 ft. (18.3 m). Each survey employs a spatially stratified random design with a total of 35 strata and 150 stations.

50% catchability (i.e., net efficiency x availability) rate. We consider that the NEAMAP surveys sample an area utilized by Atlantic sturgeon but do not sample all the locations and times where Atlantic sturgeon are present. We also consider that the trawl net captures some, but likely not all, of the Atlantic sturgeon present in the sampling area. Therefore, we assume that net efficiency and the fraction of the population exposed to the NEAMAP surveys in combination result in a 50% catchability (NMFS, 2013). The 50% catchability assumption reasonably accounts for the robust, yet not complete, sampling of the Atlantic sturgeon oceanic temporal and spatial ranges and the documented high rates of encounter with NEAMAP survey gear. As these estimates are derived directly from empirical data with fewer assumptions than have been required to model Atlantic sturgeon populations to date, we believe these estimates continue to serve as the best available information. Based on the above approach, the overall abundance of Atlantic sturgeon in U.S. Atlantic waters is estimated to be 67,776 fish (see Table 16 in Kocik et al. 2013). Based on genetic frequencies of occurrence in the sampled area, this overall population estimate was subsequently partitioned by DPS (Table 12). Given the proportion of adults to sub-adults in the NMFS NEFSC observer data (approximate ratio of 1:3), we have also estimated the number of adults and sub-adults originating from each DPS. However, this cannot be considered an estimate of the total number of sub-adults because it only considers those sub-adults that are of a size that are present and vulnerable to capture in commercial trawl and gillnet gear in the marine environment.

It is important to note, the NEAMAP-based estimates do not include young-of-the-year (YOY) fish and juveniles in the rivers; however, those segments of the Atlantic sturgeon populations are at minimal risk from the proposed actions since they are rare to absent within the action area. The NEAMAP surveys are conducted in waters that include the preferred depth ranges of sub-adult and adult Atlantic sturgeon and take place during seasons that coincide with known Atlantic sturgeon coastal migration patterns in the ocean. However, the estimated number of sub-adults in marine waters is a minimum count because it only considers those sub-adults that are captured in a portion of the action area and are present in the marine environment, which is only a fraction of the total number of sub-adults. In regards to adult Atlantic sturgeon, the estimated population in marine waters is also a minimum count as the NEAMAP surveys sample only a portion of the action area, and therefore a portion of the Atlantic sturgeon's range.

Table 12. Calculated population estimates based upon the NEAMAP survey swept area model, assuming 50% efficiency

DPS	Estimated Ocean Population Abundance	Estimated Ocean Population of Adults	Estimated Ocean Population of Sub-adults (of size vulnerable to capture in fisheries)
GOM	7,455	1,864	5,591

NYB	34,566	8,642	25,925
CB	8,811	2,203	6,608
Carolina	1,356	339	1,017
SA	14,911	3,728	11,183
Canada	678	170	509

Precise estimates of population growth rate (intrinsic rates) are unknown for the five listed DPSs of Atlantic sturgeon due to a lack of long-term abundance data. The Commission's 2017 stock assessment referenced a population viability assessment (PVA) that was done to determine population growth rates for the five DPSs based on a few long-term survey programs, but most results were statistically insignificant or utilized a model for which the available did not or poorly fit. In any event, the population growth rates reported from that PVA ranged from -1.8% to 4.9% (ASMFC, 2017).

The genetic diversity of Atlantic sturgeon throughout its range has been well-documented (ASSRT, 2007; Bowen & Avise, 1990; O'Leary et al., 2014; Ong et al., 1996; Waldman et al., 1996; Waldman & Wirgin, 1998). Overall, these studies have consistently found populations to be genetically diverse, and the majority can be readily differentiated. Relatively low rates of gene flow reported in population genetic studies (Fritts et al., 2016; Savoy et al., 2017; Wirgin et al., 2002) indicate that Atlantic sturgeon return to their natal river to spawn, despite extensive mixing in coastal waters.

Status

Atlantic sturgeon were once present in 38 river systems and, of these, spawned in 35 (ASSRT, 2007). They are currently present in 36 rivers and are expected to be present in additional rivers that provide sufficient forage base, depth, and access (ASSRT, 2007). The benchmark stock assessment evaluated evidence for spawning tributaries and sub-populations of U.S. Atlantic sturgeon in 39 rivers. They confirmed (eggs, embryo, larvae, or YOY observed) spawning in 10 rivers, considered spawning highly likely (adults expressing gametes, discrete genetic composition) in nine rivers, and suspected (adults observed in upper reaches of tributaries, historical accounts, presence of resident juveniles) spawning in six rivers. Spawning in the remaining rivers was unknown (ten) or suspected historical (four) (ASMFC, 2017). The decline in abundance of Atlantic sturgeon has been attributed primarily to the large U.S. commercial fishery, which existed for the Atlantic sturgeon through the mid-1990s. Based on management recommendations in the ISFMP, adopted by the Commission in 1990, commercial harvest in Atlantic coastal states was severely restricted and ultimately eliminated from most coastal states (ASMFC, 1998a). In 1998, the Commission placed a 20-40 year moratorium on all Atlantic sturgeon fisheries until the spawning stocked could be restored to a level where 20 subsequent year classes of adult females were protected (ASMFC, 1998a, 1998b). In 1999, NMFS closed the U.S. EEZ to Atlantic sturgeon retention, pursuant to the ACA (64 FR 9449; February 26, 1999). However, many state fisheries for sturgeon were closed prior to this.

The most significant threats to Atlantic sturgeon are incidental catch, dams that block access to spawning habitat in southern rivers, poor water quality, dredging of spawning areas, water withdrawals from rivers, and vessel strikes. A first-of-its-kind climate vulnerability assessment, conducted on 82 fish and invertebrate species in the Northeast U.S. Shelf, concluded that Atlantic sturgeon from all five DPSs were among the most vulnerable species to global climate change (Hare et al., 2016).

The ASMFC completed an Atlantic sturgeon benchmark stock assessment in 2017 that considered the status of each DPS individually, as well as all five DPSs collectively as a single unit (ASMFC, 2017). The assessment concluded all five DPSs of Atlantic sturgeon, as well as each individual DPS remain depleted relative to historic abundance. The assessment also concluded that the population of all five DPSs together appears to be recovering slowly since implementation of a complete moratorium on directed fishing and retention in 1998. However, there were only two individual DPSs, the New York Bight DPS and Carolina DPS, for which there was a relatively high probability that abundance of the DPS has increased since the implementation of the 1998 fishing moratorium. There was considerable uncertainty expressed in the stock assessment and in its peer review report. For example, new information suggests that these conclusions about the New York Bight DPS primarily reflect the status and trend of only the DPS's Hudson River spawning population. In addition, there was a relatively high probability that mortality for animals of the Gulf of Maine DPS and the Carolina DPS exceeded the mortality threshold used for the assessment. Yet, the stock assessment notes that it was not clear if: (1) the percent probability for the trend in abundance for the Gulf of Maine DPS is a reflection of the actual trend in abundance or of the underlying data quality for the DPS; and (2) the percent probability that the Gulf of Maine DPS exceeds the mortality threshold actually reflects lower survival or was due to increased tagging model uncertainty owing to low sample sizes and potential emigration. Therefore, while Atlantic sturgeon populations may be showing signs of slow recovery since the 1998 and 1999 moratoriums when all five DPSs are considered collectively, these trends are not necessarily reflected with individual DPSs and there is considerable uncertainty related to population trends (ASMFC, 2017).

3.3.2 Gulf of Maine DPS of Atlantic Sturgeon

The Gulf of Maine DPS includes the following: all anadromous Atlantic sturgeons that are spawned in the watersheds from the Maine/Canadian border and, extending southward, all watersheds draining into the Gulf of Maine as far south as Chatham, MA. Within this range, Atlantic sturgeon historically spawned in the Androscoggin, Kennebec, Merrimack, Penobscot, and Sheepscot Rivers (ASSRT, 2007). Spawning habitat is available and accessible in the Penobscot, Androscoggin, Kennebec, Merrimack, and Piscataqua (inclusive of the Cocheco and

Salmon Falls rivers) rivers. As described more fully in section 3.3.4, spawning occurs in the Kennebec River. During the study period of 2009-2011, eight sturgeon, including one male in spawning condition, were also captured in the Androscoggin River estuary, which suggests that spawning may be occurring in the Androscoggin River as well (Wippelhauser et al., 2017). However, additional evidence, such as capture of a spawning female, sturgeon eggs or larvae, is not yet available to confirm that spawning for the Gulf of Maine DPS is occurring in the Androscoggin River (NMFS, 2018).

Bigelow and Schroeder (1953) surmised that Atlantic sturgeon likely spawned in Gulf of Maine Rivers in May-July. More recent captures of Atlantic sturgeon in spawning condition within the Kennebec River suggest that spawning more likely occurs in June-July (ASMFC, 1998; NMFS and USFWS, 1998; Wippelhauser et al., 2017). Evidence for the timing and location of Atlantic sturgeon spawning in the Kennebec River includes: (1) the capture of five adult male Atlantic sturgeon in spawning condition (*i.e.*, expressing milt) in July 1994 below the (former) Edwards Dam; (2) capture of 31 adult Atlantic sturgeon from June 15, 1980, through July 26, 1980, in a small commercial fishery directed at Atlantic sturgeon from the South Gardiner area (above Merrymeeting Bay) that included at least four ripe males and one ripe female captured on July 26, 1980; (3) capture of nine adults during a gillnet survey conducted from 1977-1981, the majority of which were captured in July in the area from Merrymeeting Bay and upriver as far as Gardiner, ME (ASMFC, 2007; NMFS and U.S. FWS, 1998); and (4) the capture of three Atlantic sturgeon larvae between rkm 72 and rkm 75 in July 2011 (Wippelhauser et al., 2017). The low salinity values for waters above Merrymeeting Bay are consistent with values found in rivers where successful Atlantic sturgeon spawning is known to occur.

At this time, there is no evidence of recent spawning in the remaining rivers in the Gulf of Maine DPS. Atlantic sturgeons that are spawned elsewhere continue to use habitats within all of these rivers as part of their overall marine range (ASSRT, 2007). The movement of subadult and adult sturgeon between rivers, including to and from the Kennebec River and the Penobscot River, demonstrates that coastal and marine migrations are key elements of Atlantic sturgeon life history for the Gulf of Maine DPS (ASSRT, 2007; Fernandes et al., 2010; Wippelhauser et al. 2017).

Several threats play a role in shaping the current status of Gulf of Maine DPS Atlantic sturgeon. Historical records provide evidence of commercial fisheries for Atlantic sturgeon in the Kennebec and Androscoggin Rivers dating back to the 17th century (Squiers and Smith, 1979). In 1849, 160 tons of sturgeon was caught in the Kennebec River by local fishermen (Squiers and Smith, 1979). Following the 1880s, the sturgeon fishery was almost non-existent due to a collapse of the sturgeon stocks. All directed Atlantic sturgeon fishing as well as retention of Atlantic sturgeon bycatch has been prohibited since 1998. Nevertheless, mortalities associated with bycatch in fisheries occurring in state and federal waters still occurs. In the marine range, Gulf of Maine DPS Atlantic sturgeon are incidentally captured in federal and state-managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (ASMFC, 2007; Stein et al., 2004a). Subadults and adults are killed as a result of bycatch in fisheries authorized under Northeast Fishery Management Plans (FMPs). At this time, we are not able to quantify the impacts from this and other threats or estimate the number of individuals killed as a result of anthropogenic threats. Habitat disturbance and direct mortality from anthropogenic sources are the primary concerns.

Riverine habitat may be impacted by dredging and other in-water activities, disturbing spawning habitat and also altering the benthic forage base. Many rivers in the Gulf of Maine DPS have navigation channels that are maintained by dredging. Dredging outside of Federal channels and in-water construction occurs throughout the Gulf of Maine DPS. While some dredging projects operate with observers present to document fish mortalities, many do not. To date, we have not received any reports of Atlantic sturgeon killed during dredging projects in the Gulf of Maine region; however, as noted above, not all projects are monitored for interactions with fish. At this time, we do not have any information to quantify the number of Atlantic sturgeon killed or disturbed during dredging or in-water construction projects. We are also not able to quantify any effects to habitat.

Connectivity is disrupted by the presence of dams on some rivers in the Gulf of Maine region, including the Penobscot and Merrimack Rivers. While there are also dams on the Kennebec, Androscoggin, and Saco Rivers, these dams are near the site of natural falls and likely represent the maximum upstream extent of sturgeon occurrence even if the dams were not present. Because no Atlantic sturgeon are known to occur upstream of any hydroelectric projects in the Gulf of Maine region, passage over hydroelectric dams or through hydroelectric turbines is not a source of injury or mortality in this area. While not expected to be killed or injured during passage at the dam, the extent that Atlantic sturgeon are affected by the existence of dams and their operations in the Gulf of Maine region is currently unknown. The tracking of spawning condition Atlantic sturgeon downstream of the Brunswick Dam in the Androscoggin River suggests however, that Atlantic sturgeon spawning may be occurring in the vicinity of at least that project and therefore, may be affected by project operations. Until it was breached in July 2013, the range of Atlantic sturgeon in the Penobscot River was limited by the presence of the Veazie Dam. Since the removal of the Veazie Dam and the Great Works Dam, sturgeon can now travel as far upstream as the Milford Dam. Atlantic sturgeon primarily occur within the mesohaline reach of the river, particularly in areas with high densities of sturgeon prey which means that the Penobscot River is likely an important foraging area for Atlantic sturgeon belonging to the Gulf of Maine DPS (Altenritter et al., 2017). There is no current evidence that spawning is occurring in the Penobscot River. Acoustic tag detections suggest that the adults that forage in the Penobscot River travel to the Kennebec River to spawn (Altenritter et al., 2017). The Essex Dam on the Merrimack River blocks access to approximately 58 percent of historically accessible habitat in this river. Atlantic sturgeon occur in the Merrimack River but spawning has not been documented. Like the Penobscot, it is unknown how the Essex Dam affects the likelihood of spawning occurring in this river.

Gulf of Maine DPS Atlantic sturgeon may also be affected by degraded water quality. In general, water quality has improved in the Gulf of Maine over the past decades (EPA, 2008; Lichter et al., 2006). Many rivers in Maine, including the Kennebec River, were heavily polluted in the past from industrial discharges from pulp and paper mills. While water quality has improved and most discharges are limited through regulations, many pollutants persist in the benthic environment. This can be particularly problematic if pollutants are present on spawning and nursery grounds, as developing eggs and larvae are particularly susceptible to exposure to contaminants.

The threat of vessel strike appears to be less for Atlantic sturgeon belonging to the Gulf of Maine DPS compared to the New York Bight or Chesapeake Bay DPSs based on the number of Atlantic sturgeon vessel struck carcasses that are found in Gulf of Maine rivers, and given the differences in vessel activity in the respective natal rivers. Nevertheless, some strikes do occur within the Gulf of Maine and sturgeon belonging to the Gulf of Maine can also be struck in other areas of their range including higher salinity waters of the Hudson River Estuary, Delaware River Estuary, and Chesapeake Bay.

We described in the listing rule that potential changes in water quality as a result of global climate change (temperature, salinity, dissolved oxygen, contaminants, etc.) in rivers and coastal waters inhabited by Atlantic sturgeon will likely affect riverine populations, and we expected these effects to be more severe for southern portions of the U.S. range. However, new information shows that the Gulf of Maine is one of the fastest warming areas of the world as a result of global climate change (Brickman et al., 2021; Pershing et al., 2015). Markin and Secor (2020) further demonstrate the effects of temperature on the growth rate of juvenile Atlantic sturgeon, and informs how global climate change may impact growth and survival of Atlantic sturgeon across their range. Their study showed that all juvenile Atlantic sturgeon had increased growth rate with increased water temperature regardless of their genetic origins. However, based on modeling and water temperature data from 2008 to 2013, they also determined that there is an optimal water temperature range, above and below which juveniles experience a slower growth rate, and they further considered how changes in growth rate related to warming water temperatures associated with global climate change might affect juvenile survival given the season (e.g., spring or fall) in which spawning currently occurs.

There are no abundance estimates for the Gulf of Maine DPS or for the Kennebec River spawning population. Wippelhauser and Squiers (2015) reviewed the results of studies conducted in the Kennebec River System from 1977-2001. In total, 371 Atlantic sturgeon were captured, but the abundance of adult Atlantic sturgeon in the Kennebec spawning population could not be estimated because too few tagged fish were recaptured (i.e., 9 of 249 sturgeon).

Another method for assessing the number of spawning adults is through determinations of effective population size, which measures how many adults contributed to producing the next generation based on genetic determinations of parentage from the offspring. Effective population size is always less than the total abundance of a population because it is only a measure of parentage, and it is expected to be less than the total number of adults in a population because not all adults successfully reproduce. Measures of effective population size are also used to inform whether a population is at risk for loss of genetic diversity and inbreeding. The effective population size of the Gulf of Maine DPS was assessed in two studies based on sampling of adult Atlantic sturgeon captured in the Kennebec River in multiple years. The studies yielded very similar results which were an effective population size of: 63.4 (95% CI=47.3-91.1) (ASMFC 2017) and 67 (95% CI=52.0–89.1) (Waldman et al. 2019).

Summary of the Gulf of Maine DPS of Atlantic Sturgeon

Spawning for the Gulf of Maine DPS is known to occur in the Kennebec River and may occur in the Androscoggin. Spawning may be occurring in other rivers, such as the Penobscot, but has not been confirmed. In the Stock Assessment, the Commission concluded that the abundance of the Gulf of Maine DPS is "depleted" relative to historical levels and there is a 51 percent probability that abundance of the Gulf of Maine DPS has increased since implementation of the 1998 fishing moratorium (ASMFC, 2017). The Commission also noted that the Gulf of Maine is particularly data poor among all five DPSs. Atlantic sturgeon continue to be present in the Kennebec River; in addition, they are captured in directed research projects in the Penobscot River, and are observed in rivers where they were unknown to occur or had not been observed to occur for many years (e.g., the Saco, Presumpscot, and Charles rivers). The Saco River supports a large aggregation of Atlantic sturgeon that forage on sand lance in Saco Bay and within the first few kilometers (km) of the Saco River, primarily from May through October. Detections of acoustically-tagged sturgeon indicate that both adult and subadult Atlantic sturgeon use the area for foraging and come back to the area year after year (Little, 2013; Novak et al., 2017). Some sturgeon also overwinter in Saco Bay (Hylton et al., 2018; Little, 2013) which suggests that the river provides important wintering habitat as well, particularly for subadults. However, none of the new information indicates recolonization of the Saco River for spawning. It remains questionable whether sturgeon larvae could survive in the Saco River even if spawning were to occur because of the presence of the Cataract Dam at rkm 10 of the river (Little, 2013) which limits access to the freshwater reach. Some sturgeon that spawn in the Kennebec have subsequently been detected foraging in the Saco River and Bay (Novak et al., 2017; Wippelhauser et al., 2017).

Some of the impacts from the threats that contributed to the decline of the Gulf of Maine DPS have been removed (e.g., directed fishing), or reduced as a result of improvements in water quality and removal of dams (e.g., the Edwards Dam on the Kennebec River in 1999). There are strict regulations on the use of fishing gear in Maine state waters that incidentally catch sturgeon. In addition, there have been reductions in fishing effort in state and federal waters, which most likely would result in a reduction in bycatch mortality of Atlantic sturgeon. A significant amount of fishing in the Gulf of Maine is conducted using trawl gear, which is known to have a much lower mortality rate for Atlantic sturgeon caught in the gear compared to sink gillnet gear (ASMFC, 2007). Atlantic sturgeon from the Gulf of Maine DPS are not commonly taken as bycatch in areas south of Chatham, Massachusetts, with only 8 percent (e.g., 7 of 84 fish) of interactions observed in the New York region being assigned to the Gulf of Maine DPS (Wirgin and King, 2011). Tagging results also indicate that Gulf of Maine DPS fish tend to remain within the waters of the Gulf of Maine and only occasionally venture to points south. However, data on Atlantic sturgeon incidentally caught in trawls and intertidal fish weirs fished in the Minas Basin area of the Bay of Fundy (Canada) indicate that approximately 35 percent originated from the Gulf of Maine DPS (Wirgin et al., 2012). Thus, a significant number of the GOM DPS fish appear to migrate north into Canadian waters where they may be subjected to a variety of threats including bycatch. Dadswell et al. (2016) describes characteristics of the seasonal aggregation of sturgeon in the Bay of Fundy. Dadswell et al. does not identify the natal origin of each of the 1,453 Atlantic sturgeon captured and sampled for their study. However, based on Wirgin et al. (2012) and Stewart et al. (2017), NMFS considers the results of Dadswell et al. as representative of the movement of the Gulf of Maine DPS of Atlantic sturgeon. Dadswell et al. determined subadult and adult Atlantic sturgeon occur seasonally (approximately May to September) in the Bay of Fundy for foraging, and many return in consecutive years. Fork length (FL) of the 1,453 sampled sturgeon ranged from 45.8 to 267 cm, but the majority (72.5 percent) were less than 150 cm FL. The age of the sturgeon (i.e., 4 to 54 years old) is also indicative of the two different life stages. Detailed seasonal movements of sturgeon to and from the Bay of Fundy are described in Beardsall et al. (2016).

As noted previously, studies have shown that in order to rebuild, Atlantic sturgeon can only sustain low levels of bycatch and other anthropogenic mortality (Boreman, 1997; Brown and Murphy, 2010; ASMFC, 2007; Kahnle et al., 2007). We have determined that the Gulf of Maine DPS is at risk of becoming endangered in the foreseeable future throughout all of its range (i.e., is a threatened species) based on the following: (1) significant declines in population sizes and the protracted period during which sturgeon populations have been depressed; (2) the limited amount of current spawning; and, (3) the impacts and threats that have and will continue to affect recovery.

In 2018, we announced the initiation of a 5-year review for the Gulf of Maine DPS. We reviewed and considered new information for the Gulf of Maine DPS that has become available since this DPS was listed as threatened in February 2012. We completed the 5-year review for the Gulf of Maine DPS in February 2022. Based on the best scientific and commercial data available at the time of the review, we concluded that no change to the listing status is warranted.

3.3.3 Atlantic Sturgeon Recovery Goals

A Recovery Plan has not been completed for any DPS of Atlantic sturgeon. In 2018, NMFS published a Recovery Outline to serve as an initial recovery-planning document. In this, the recovery vision is stated, “subpopulations of all five Atlantic sturgeon DPSs must be present across the historical range. These subpopulations must be of sufficient size and genetic diversity to support successful reproduction and recovery from mortality events. The recruitment of juveniles to the sub-adult and adult life stages must also increase and that increased recruitment must be maintained over many years. Recovery of these DPSs will require conservation of the riverine and marine habitats used for spawning, development, foraging, and growth by abating threats to ensure a high probability of survival into the future." The Outline also includes steps that are expected to serve as an initial recovery action plan. These include protecting extant subpopulations and the species' habitat through reduction of threats; gathering information through research and monitoring on current distribution and abundance; and addressing vessel strikes in rivers, the effects of climate change and bycatch.

3.3.4 Critical Habitat Designated for the GOM DPS of Atlantic Sturgeon

On August 17, 2017, we issued a final rule to designate critical habitat for the threatened Gulf of Maine DPS of Atlantic sturgeon, the endangered New York Bight DPS of Atlantic sturgeon, the endangered Chesapeake Bay DPS of Atlantic sturgeon, the endangered Carolina DPS of Atlantic sturgeon, and the endangered South Atlantic DPS of Atlantic sturgeon (82 FR 39160).
The rule was effective on September 18, 2017. The action area overlaps with the Kennebec River critical habitat unit designated for the Gulf of Maine DPS.

The conservation objective identified in the final rule is to increase the abundance of each DPS by facilitating increased successful reproduction and recruitment to the marine environment. We designated five critical habitat units to achieve this objective for the Gulf of Maine DPS: (1) Penobscot River mainstem from the Milford Dam downstream for 53 river kilometers to where the mainstem river discharges at its mouth into Penobscot Bay; (2) Kennebec River mainstem from the Ticonic Falls/Lockwood Dam downstream for 103 river kilometers to where the mainstem river discharges at its mouth into the Atlantic Ocean; (3) Androscoggin River mainstem from the Brunswick Dam downstream for 10 river kilometers to where the mainstem river discharges at its mouth into Merrymeeting Bay; (4) Piscataqua River from its confluence with the Salmon Falls and Cocheco rivers downstream for 19 river kilometers to where the mainstem river discharges at its mouth into the Atlantic Ocean as well as the waters of the Cocheco River from its confluence with the Piscataqua River and upstream 5 river kilometers to the Cocheco Falls Dam, and waters of the Salmon Falls River from its confluence with the Piscataqua River and upstream 6 river kilometers to the Route 4 Dam; and, (5) Merrimack River from the Essex Dam (also known as the Lawrence Dam) downstream for 48 river kilometers to where the mainstem river discharges at its mouth into the Atlantic Ocean. In total, these designations encompass approximately 244 kilometers (152 miles) of aquatic habitat.

As identified in the final rule, the physical features that are essential to the conservation of the species and that may require special management considerations or protection are:

- Hard bottom substrate (*e.g.,* rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (*i.e.,* 0.0 to 0.5 parts per thousand (ppt) range) for settlement of fertilized eggs, refuge, growth, and development of early life stages;
- Aquatic habitat with a gradual downstream salinity gradient of 0.5 up to as high as 30 ppt and soft substrate (*e.g.,* sand, mud) between the river mouth and

spawning sites for juvenile foraging and physiological development;

- Water of appropriate depth and absent physical barriers to passage (*e.g.,* locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support:
  - Unimpeded movement of adults to and from spawning sites;
  - Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and
  - Staging, resting, or holding of subadults or spawning condition adults.
- Water depths in main river channels must also be deep enough (*e.g.,* at least 1.2 m) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river.
- Water, between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that, combined, support:
  - Spawning;
  - Annual and interannual adult, subadult, larval, and juvenile survival; and
  - Larval, juvenile, and subadult growth, development, and recruitment (*e.g.,*13 °C to 26 °C for spawning habitat and no more than 30 °C for juvenile rearing habitat, and 6 milligrams per liter (mg/L) dissolved oxygen (DO) or greater for juvenile rearing habitat).

The paragraphs that follow are excerpted from the ESA Section 4(b)(2) Report for Atlantic sturgeon critical habitat (NMFS, 2017). That document provides background information on the current status and function of the four critical habitat units designated for the Gulf of Maine DPS, and summarizes their ability to support reproduction, survival, and juvenile development, and recruitment. Additional information on the status of the Gulf of Maine DPS relevant to the current status and function of critical habitat can be found in Section 4.5.

> The Kennebec River was the only known spawning river for the Gulf of Maine DPS when the DPS was listed as threatened (ASSRT, 2007; 77 FR 5880, and February 6, 2012). Spawning has since been confirmed in the Androscoggin River (Wippelhauser, 2012). The Brunswick Dam is the upstream limit of Atlantic sturgeon distribution in the Androscoggin River, and the likely historical upstream limit given the dam is built at the head of tide at Pejepscot Falls, a natural barrier to sturgeon passage. The Brunswick Dam is located approximately 10 RKMs upstream of the confluence of the Kennebec and Androscoggin rivers (ASMFC, 1998; ASSRT, 2007; NMFS, 2013; Wippelhauser and Squiers, 2015). The Lockwood Dam at RKM 103 is the current upstream limit for Atlantic sturgeon in the Kennebec River and is also located at the site of a natural falls; considered the historic upstream limit for Atlantic sturgeon on the River (ASSRT, 2007). From 1837 to 1999, the Edwards Dam was the upstream limit of Atlantic sturgeon in the Kennebec River. Located near the head of tide, approximately 29 RKMs downstream of the Lockwood Dam, the Edwards Dam (formerly at RKM 74) prevented Atlantic

sturgeon from accessing historical habitat. Sturgeon were sighted above the former Edwards Dam site after removal of the dam. In June 2005, an Atlantic sturgeon was incidentally captured as far upriver as RKM 102 (ASSRT, 2007; Wippelhauser, 2012).

Substrate type in the Kennebec estuary is largely sand and bedrock (Fenster and Fitzgerald 1996; Moore and Reblin, 2008). Mesohaline waters occur upstream of Doubling Point (approximately RKM 16) during summer low flows, transitioning to oligohaline waters and then essentially tidal freshwater from Chops Point (the outlet of Merrymeeting Bay at approximately RKM 30) 10 upriver to the head of tide on the Kennebec and Androscoggin rivers (ASMFC, 1998; Kistner and Pettigrew, 2001; Moore and Reblin, 2008; Wippelhauser, 2012).

During the period 1977-2001, Atlantic sturgeon in spawning condition (i.e., ripe males releasing milt) or of size presumed to be sexually mature adults (i.e., > 150 centimeter total length) were caught between RKM 52.8 and RKM 74 of the Kennebec River between June 13 and July 21 in multiple years; during most of this period, the Edwards Dam restricted sturgeon movements upstream of RKM 74. From 2009 to 2011, 31 Atlantic sturgeon, including 6 ripe males, were caught in the Kennebec River between RKM 70 and RKM 75 (Wippelhauser, 2012; Wippelhauser and Squiers, 2015). Sturgeon in the Upper Kennebec Estuary (defined as RKM 45 to RKM 74 at head of tide in the cited document) repeatedly moved between RKM 48 and RKM 75 (Wippelhauser, 2012). An additional eight sturgeon, including one ripe male, were caught in the Androscoggin in June and July of 2009-2011 (Wippelhauser, 2012). Three larvae were captured in the Upper Kennebec Estuary, 1 to 1.6 RKMs upstream of the former Edwards Dam site (RKM 74) (Wippelhauser, 2012). The spawning period in the Kennebec River is considered to be mid-June to mid-July (Wippelhauser, 2012).

Merrymeeting Bay and the Lower Kennebec Estuary were used by postspawn adults, juveniles, and other life stages at least as late as November 7. Tagging detections the following spring suggest that some subadult Atlantic sturgeon may have overwintered in Merrymeeting Bay (Wippelhauser, 2012). Sturgeon captured and tagged in the Saco and Penobscot rivers were also detected in the Kennebec Estuary, typically Merrymeeting Bay and downstream locations, although at least one male, captured in the Saco in 2010, was the single ripe male also captured in the Androscoggin (Wippelhauser, 2012). Genetic information to identify this Atlantic sturgeon to the river of origin is not available.

The Penobscot River estuary is about 51 RKMs long from the head of tide to Searsport, ME. During spring freshets tidal freshwater extends to Winterport (RKM 29), and during low flow months the salt front extends upstream as far as Hamden (RKM 40) (ASMFC, 1998). The two lowermost dams on the Penobscot River, Great Works Dam and Veazie Dam (at RKM 56), were removed in 2012 and 2013, respectively, opening up all known historical Atlantic sturgeon habitat in the Penobscot River, and access to more of the tidal freshwater habitat.

The upper part of the Penobscot River estuary (RKM 34 to RKM 43) is characterized as freshwater, with depths of 2.5 – 9 meters depending on tide and position in the river, and are predominantly cobble and gravel substrate. The middle part (RKM 26 to RKM 31) has an average water depth of 7.5 meters with maximum salinity of 2.5 ppt (i.e., oligohaline waters) in June, and muddy substrate with high levels of organic matter (mostly decaying wood chips and sawdust), whereas the lower part of the estuary (RKM 21 to RKM 24) has salinities of approximately 15 ppt during summer, and a predominance of sand substrate (Dzaugis, 2013).

The Piscataqua River is formed by the confluence of the Salmon Falls and Cocheco Rivers, and is part of the Great Bay Estuary. The Piscataqua River is tidal throughout its length, approximately 21 RKMs, to its mouth at Portsmouth Harbor. Head of tide occurs upriver of the confluence, at the location of the lowermost dams on the Salmon Falls and Cocheco Rivers (Short, 1992; SBCC, 2009). Salinity of the Piscataqua River ranges from polyhaline at the mouth of the river to oligohaline at the head of tide on the Salmon Falls and Cocheco rivers. Overall, the estuary is heavily influenced by the tidal flow. Dissolved oxygen is typically above 6.0 mg/L, and is very consistent throughout the water column in the Piscataqua River. The average depth at mid-tide is approximately 3.2 meters although this varies with both tide and topography. Substrate varies from soft mud to hard sand to gravel (Short, 1992; ASMFC, 1998; Trowbridge, 2007). The 2007 Atlantic sturgeon status review provided information on directed effort to catch Atlantic sturgeon in the Piscataqua River, and incidental capture of a large, ripe female Atlantic sturgeon near the head of tide in the Salmon Falls River in 1990. Between 2010 and 2016, three Atlantic sturgeon were detected in the Piscataqua River using passive acoustic array (M. Kieffer, USGS, pers. comm.). There are no current directed studies for Atlantic sturgeon in the Piscataqua River or Great Bay Estuary other than the use of the passive acoustic receivers for a part of the year in some areas of the river.

In the 1800s, construction of the Essex Dam on the Merrimack River (at RKM 48) blocked Atlantic sturgeon access to about 58 percent of historical habitat (ASMFC, 1998; Oakley, 2003; ASSRT, 2007). Tidal influence extends to RKM 35. The salt front extends upriver to RKM 16 in summer at the lowest river discharges (Kieffer and Kynard, 1993; ASMFC, 1998). The non-tidal section is dominated by sand and gravel and depths less than three meters. Thus, there is approximately 19 RKM of tidal freshwater and 11 RKM of freshwater habitat available for the early life stages of Atlantic sturgeon during the summer months. Atlantic sturgeon are regularly present in the Merrimack River. Although there are no recent reports of Atlantic sturgeon spawning in the Merrimack River, the success of shortnose sturgeon spawning in the river suggests Atlantic sturgeon spawning would be successful as well.

While there is no current evidence that Atlantic sturgeon are spawning in Gulf of Maine rivers other than the Kennebec and Androscoggin, captures of sturgeon in the Merrimack, Penobscot and Piscataqua/Salmon Falls/Cocheco rivers indicate that there is the potential for spawning to occur in these rivers.

Gulf of Maine DPS Atlantic sturgeon travel great distances in the marine environment, and their marine range includes waters under Canadian jurisdiction. Genetics information is available for Atlantic sturgeon captured in six specific areas of their marine range: Bay of Fundy, Connecticut River estuary and Long Island Sound, New York and New Jersey coast, Delaware coast, Long Island coast off of Rockaway, New York, and waters off of the Virginia/North Carolina border. The Gulf of Maine DPS comprised 0 to 14.5 percent of Atlantic sturgeon sampled in these areas with the exception of the Bay of Fundy collection where the Gulf of Maine DPS comprised 35 percent of the Atlantic sturgeon sampled (Laney et al., 2007; Dunton et al., 2012; Wirgin et al., 2012; Waldman et al., 2013; O'Leary et al., 2014; Wirgin et al., 2015a). The greater concentration of Gulf of Maine DPS Atlantic sturgeon in some parts of its marine range suggests certain marine habitats are more useful to and perhaps also essential to the Gulf of Maine DPS. As previously noted, we cannot designate critical habitat in areas outside of U.S. jurisdiction.

The action area for the proposed work considered in this Opinion covers a portion of the Kennebec River critical habitat unit. The critical habitat designation is bank-to-bank within the Kennebec River. The portion of the action area that overlaps with the Kennebec River critical habitat unit contains PBFs 1, 3, and 4; it does not contain PBF 2 because the salinity in the action area is less than 0.5 ppt. More information on the PBFs within the action area is contained in the Environmental Baseline section below (section 4.4).

4 Environmental Baseline

Environmental baseline "refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private action and other human activities in the action area, the anticipated impacts of all Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing federal facilities that are not within the agency's discretion to modify are part of the environmental baseline" (50 C.F.R. § 402.02). The environmental baseline therefore, includes the past impacts of the operation of the Lockwood, Hydro-Kennebec, Shawmut, and Weston Projects. Consistent with the definition of environmental baseline, the consequences to listed species and critical habitat from the existence of these four dams (e.g., barrier to passage, creation of the impoundment), through the terms of their current licenses, are not consequences of the proposed actions but are part of the environmental baseline. This determination has been made based on our understanding that it is not within FERC's discretion to require modifications or removal of the physical dam structure outside of a relicensing. We note, however, that we consider future effects of the existence of the Shawmut Dam during the terms of any new license as Effects of the Action rather than the Environmental Baseline. This is because it is our understanding that it is within FERC's discretion to deny a new license for the Project and to potentially require the removal of the structure. As such, we consider the impacts associated with the continued existence of the Shawmut Dam over the term of the proposed new license to be consequences of the proposed relicensing.

The environmental baseline for this biological opinion includes the effects of several activities that have affected the condition, or status, of listed species and critical habitat in the action area. As explained above, the action area includes the mainstem of the Kennebec River from the Weston Dam impoundment downstream to a point 0.75-km downstream of the Lockwood Dam. Past and present impacts of the operation of the dams are considered in the Environmental Baseline.

4.1 Status of Atlantic salmon and Critical Habitat in the Action Area

A summary of the status of the species range wide and designated critical habitat in its entirety was provided above. This section will focus on the status of Atlantic salmon and designated critical habitat in the action area. The Kennebec River watershed supports a naturally reared run of Atlantic salmon and an egg and smolt stocking program. As such, all life stages of Atlantic salmon are present in the action area. As described in section 3, the Kennebec contains the majority of the designated critical habitat within the Merrymeeting Bay SHRU. The river contains 74% of all modeled rearing habitat in the critical habitat in the SHRU, as well as 78% of the most suitable habitat (analysis based on Wright et al. (2008)). As most of this habitat lies upstream of the dams in the Sandy River, the action area serves as an essential migratory corridor for Atlantic salmon moving to that habitat to spawn, and for juvenile and postspawn salmon migrating to the ocean. Given the extent of modeled rearing habitat that occurs in the Sandy River and the amount of habitat in the Kennebec River watershed compared to the rest of the Merrymeeting Bay SHRU, we consider access to, and successful use of, the Sandy River to be essential to the recovery of the Kennebec River population of Atlantic salmon and the Merrymeeting Bay SHRU as a whole.

4.1.1 Prespawn Adult Atlantic Salmon

Based on historical reports, Atlantic salmon were once abundant in the Kennebec River (Foster & Atkins, 1867). Dams, pollution, oceanic conditions, and overfishing have contributed to the decline of Atlantic salmon in the Kennebec River. The returns of adult Atlantic salmon (counted at the Lockwood Dam) in recent years have been largely adults resulting from egg stocking in the Sandy River (USASAC, 2022; CMS, 2022). The 10-year (2012-2021) average annual return to the Kennebec over the last decade is 29, ranging between 5 and 60. Although small, the Kennebec River run is primarily naturally reared and comprises 63% of the total return to the Merrymeeting Bay SHRU (10-year average; USASAC, 2021). Given that not all returning adults successfully enter the fishway and that the count of returns is made of fish that enter the fishway, these counts are an underestimate of the number of salmon returning to the Kennebec River. Based on an estimated average efficiency of 67% (discussed below), we anticipate that on average an additional 14 Atlantic salmon (i.e., 29/0.67=14) may have entered the Kennebec annually and not been captured at the Lockwood Project. These salmon may spawn in habitat in tributaries below Lockwood (e.g., Bond Brook, Togus Stream, Seven Mile Stream, Messalonskee Stream, Outlet Stream, Sebasticook River), or they may stray to other watersheds.

4.1.2 Juveniles

The USFWS conservation hatchery program supports the Atlantic salmon recovery program by growing and releasing early life stages (egg, fry, parr, and smolts) of Atlantic salmon throughout the GOM DPS. The objective of this stocking is to maintain the existing salmon populations while increasing the proportion of wild or naturally reared adults returning to Maine rivers. As indicated in the Recovery Plan (2019) the program is "intended to provide demographic support and maintain genetic diversity appropriate for the purpose of recovering Atlantic salmon in the Gulf of Maine DPS." The Recovery Plan also notes that the hatcheries are "vital to preserving and stabilizing individual and composite genetic stocks until freshwater and marine conditions improve." Phase two of recovery (the current phase) "focuses on ensuring the persistence of the GOM DPS through the use of the conservation hatcheries while abating imminent threats to the continued existence of the DPS." Downlisting or delisting the DPS requires increasing abundance and addressing threats (i.e., the five listing factors outlined in the ESA). Therefore, the species cannot be recovered merely by increasing numbers through hatchery releases. The primary threats as outlined in the listing rule and the 2019 Recovery Plan are dams, road stream crossings, marine survival, and climate change (USFWS & NMFS, 2019). As none of the salmon runs are currently self-sustaining, the existing abundance and distribution of the species within the GOM DPS is driven by stocking.

In the Kennebec River, stocking primarily consists of egg stocking in the Sandy River, which has been occurring since 2006. Over the last decade, MDMR has stocked an average of 770,000 eggs into the Sandy River annually (USASAC, 2021). Egg stocking allows for freshwater selection, which means that the salmon that survive may pass down traits that improve freshwater survival in future generations. These fish are also considered naturally-reared, which means they count towards achievement of the downlisting criteria. In addition, naturally-reared smolts are five to eight times more likely to result in an adult return when compared to hatchery smolts (USASAC, 2022)[14]. However, the trade-off is that most of the eggs will not survive to

[14] The 10-year average smolt-to-adult (2SW) return rate for hatchery smolts in the Penobscot is 0.140%. The smolt to adult return rate for naturally reared smolts in the Sheepscot and Narraguagus Rivers is 0.540% and 1.17%, respectively (USASAC, 2022).

become a smolt. The Northeast Fisheries Science Center estimated that the average egg-to-smolt survival is 1.31% (90% CI: 0.5-2.4%) (Nieland & Sheehan, 2020). This is what is expected given the many threats posed to eggs and juvenile salmon (e.g., predation, water quality, insufficient flows or food resources, etc.) in freshwater streams. Given the average number of eggs stocked and the average survival, we would anticipate that an average of approximately 10,000 smolts (range 4,000 to 18,000) are produced by stocking in the Sandy River annually. This is consistent with estimates (13,229 +/- 1,294) based on rotary screw trapping in the Sandy River in 2021 (USASAC, 2022). In comparison, the Penobscot River was stocked with over 600,000 hatchery smolts in 2021 (CMS, 2022), which is typical for that river. Even with the survival advantage that naturally reared smolts have, such differences in stocking effort have led to a significant difference in the run size in the DPS rivers.

Rotary screw trapping in the Sandy River in 2021 and 2022 indicates that the smolt run begins in mid-April and the last capture by the end of the first week of June. Specifically, the total run length in these two years was 53 and 48 days, respectively (USASAC, 2022; Noll, J., MDMR, Personal communication, 11/15/2022). This is a longer duration than what was observed on the Sheepscot River between 2015 and 2019 (Table 13). It is also longer than what was observed in other rivers (i.e., Narraguagus, East Machias) in those same years (Hawkes, J., NEFSC, personal communication, 1/24/2023). However, the timing is still consistent with the general timing of the smolt run. Considering the larger geography of the Sandy River basin compared to the Sheepscot River and the greater variety in ice conditions, water temperature, and flow, it is not unexpected that the smolt run timing would be broader for the Sandy River compared to the Sheepscot. Given the distribution of capture dates in the Sheepscot and Sandy Rivers, we anticipate that the majority of the smolt run in the Kennebec River occurs during the month of May, but that a significant proportion could pass in the month of April as well.

Table 13. The timing of naturally reared smolt captures in rotary screw traps on the Sheepscot River between 2015 and 2019 (USASAC, 2016, 2017, 2018, 2019, 2020), and on the Sandy River in 2021 (USASAC, 2022) and 2022 (Noll, J., MDMR, personal communication, 11/30/2022).

		Capture Dates			
River	Year	First	Median	Last	Run Length (Days)
Sheepscot	2015	2-May	12-May	29-May	27
	2016	20-Apr	9-May	27-May	37
	2017	29-Apr	10-May	21-May	22
	2018	1-May	9-May	22-May	21
	2019	30-Apr	16-May	4-Jun	35
Sandy	2021	14-Apr	8-May	6-Jun	53
	2022	13-Apr	13-May	31-May	48

Although there is variability in the time of day when smolts migrate, the majority move during nighttime hours. Kocik et al. (2009) monitored run timing of naturally reared smolts in the

Narraguagus River and documented that approximately 80-95% of smolts migrated during night and twilight hours while in freshwater. The proportion of smolts migrating during night and twilight hours declined to 35-75% in the tidal portion of the river (Kocik et al., 2009). Haralstadt et al. (2017) and Ibbotson et al. (2006) both documented that the proportion of smolts that migrate at night decreases as temperatures increase. They determined that the proportion of smolts that move in the day and night become equivalent (50% at night-50% during the day) by the time the temperature reaches 12-13℃ (Haraldstad et al., 2017; Ibbotson et al., 2006). Temperature loggers maintained in the mainstem Kennebec indicate that the average temperature in the month of May varies between 11-12℃[15], suggesting that the early part of the run (mid-April to mid-May) likely occurs prior to the meeting of this threshold and the latter half of the run likely occurs after it has been exceeded. Brookfield has provided analysis from smolt survival studies conducted at the four lower Kennebec River dams that indicate that between 40% and 75% of smolts pass the projects at night (8:00 pm to 8:00 am) (Supplement SPP; FERC Accession #: 20220921-5117). This range varies somewhat from what was reported by Kocik et al. (2009), which is likely due to the use of hatchery smolts rather than naturally reared smolts, as well as migratory delay caused by the dams.

In summary, Atlantic salmon return annually to the Kennebec River as a result of hatchery supplementation and natural spawning that occurs in the Sandy River. Although some suitable habitat for all life functions exists in the accessible portions of the Kennebec River downriver of the Lockwood Dam (largely in the tributaries), we expect the action area to primarily serve as a migratory corridor for adult and juvenile salmon migrating to and from the abundant habitat upstream of the Weston Dam, primarily in the Sandy River.

4.1.3 Critical Habitat

In 2009, NMFS designated critical habitat for the GOM DPS of Atlantic salmon (74 FR 29300; June 19, 2009). As defined in the ESA, critical habitat is "specific areas within the geographical area occupied by the species at the time of listing, on which are found those physical or biological features [PBFs] that are essential to the conservation of the listed species and that may require special management considerations or protection." As described in the critical habitat designation, the PBFs for Atlantic salmon include features of spawning and rearing and migration habitat (as described in Section 3.2.1). We have designated critical habitat for Atlantic salmon in the Kennebec River, including the entirety of the action area (Figure 7). The action area primarily functions as a migratory corridor for adult and juvenile salmon that are moving between the marine environment and spawning and rearing habitat in freshwater. There is spawning and rearing habitat in the action area, as well as in the Sandy River which is upstream of the four dams in the lower Kennebec. The status of this habitat is addressed below. Understanding the distribution, abundance and suitability of those features in the Kennebec

[15] SHEDS. Stream Temperature Database. Public Data Viewer. http://db.ecosheds.org/viewer (accessed on 5/4/2022). 2014-2018 temperature data from stations near Anson Dam (MEIFW-5), Weston Dam (MEIFW-4) and Shawmut Dam (MEIFW-2), Hydro-Kennebec Dam (MEIFW-1).

River as a whole is essential to understanding the importance of the PBFs in the action area; therefore, this information is presented below in order to establish the necessary context for considering the effects of the actions considered in this Opinion.

4.1.3.1 PBFs for Spawning and Rearing Habitat

Our approach to describing the status of the spawning and rearing PBFs in the action area has two parts. First, we identify whether the features are physically present and whether they have the potential to function within the action area. Second, we identify whether the necessary life stages of salmon actually have access to the PBFs. The second step is essential to understanding the conservation value of the habitat feature. For instance, although certain areas may have the physical features necessary to support spawning, if prespawn salmon cannot access it, it does not provide conservation value to the species. Table 8 describes the suitable range of various physical, chemical, and biological parameters that are necessary for the PBFs to be functioning. If outside of those ranges, the features are considered present but not functional. If the status of the features fall within the defined ranges, they are considered functional. Functional habitat is further differentiated into fully and limited functioning, based on the suitability of the habitat. For example, salmon parr can survive under temperatures ranging between 7°C and 22.5°C, but they feed and grow optimally when the temperature range is between 15°C and 19°C in the summer. In this example we would consider the 15°C to 19°C range to be fully functioning, whereas temperatures between 7°C to 15°C and 19°C to 22.5°C are in the limited function range. Below, we will make a determination for each PBF based on whether they are functioning and if they are, whether they are functioning at full or limited capacity. Once that has been established, we will determine whether the conservation value of the PBF is affected by accessibility. If the needed life stage has full access (no barriers), then accessibility will not affect the conservation value. Likewise, if there is a barrier that has a highly effective fishway then it would not affect the conservation value of the PBF. If, however, there is no, or limited, passage to the habitat then that would have a corresponding affect to the conservation value. For instance, if there is a dam without a fishway downstream of the habitat then the PBF could have the potential to function but would have low conservation value. Similarly, a dam with a marginally effective fishway would only allow the PBF to function with moderate conservation value. These accessibility functional categories are consistent with what is incorporated into the 2019 Final Recovery Plan for Atlantic salmon and, therefore, with the habitat recovery criteria.

PBF SR1-SR3

Deep, oxygenated pools and cover (e.g., boulders, woody debris, vegetation, etc.), near freshwater spawning sites, necessary to support adult migrants during the summer while they await spawning in the fall (SR1).

Freshwater sites that contain clean, permeable gravel and cobble substrate with oxygenated water and cool water temperatures to support spawning activity, egg

incubation, and larval development (SR2), as well as to support emergence, territorial development, and feeding activities of Atlantic salmon fry (SR3).

Maine DMR conducted spawning and rearing habitat surveys between 1983 and 2020 throughout much of the Kennebec River basin, including within the watersheds that have been designated as critical habitat[16]. Spawning habitat has been mapped in the mainstem and tributary habitat downstream of the Lockwood Dam (3,462 units), as well as throughout the Sandy River (1,849 units). Some of this mapped mainstem spawning habitat (779 units) occurs in the action area between the Lockwood Dam and the Sebasticook River confluence. We don't expect most of the surveyed habitat downstream of Lockwood to function fully as it occurs in the mainstem, but a small amount was also mapped in almost every tributary MDMR surveyed downstream of Lockwood (i.e., Bond, Togus, Seven Mile, Messalonskee, Outlet, and the Sebasticook). Bond Brook and Togus Stream in particular have both supported small runs of salmon in the past (MASRSC, 1986; NRC, 2004), and redd surveys have documented redds as recently as 2018 in Togus, and 2019 in Bond (USASAC 2019; USASAC 2020). According to the mapping conducted by MDMR, it is apparent that the PBFs for spawning are abundant in both the Sandy River and in habitat below Lockwood. Although there is twice as much mapped spawning habitat downstream of Lockwood than in the Sandy, we expect that much of the habitat in the mainstem does not function, or else functions at a limited capacity. However, given the quantity of surveyed habitat, and the fact that it occurs in multiple tributaries as well as the mainstem, we expect that there is potential for some spawning to occur downstream of the Lockwood dam.

There is minimal information on spawning habitat within the action area itself. Habitat surveys have not been conducted between the Lockwood Dam and the confluence with the Sandy River, likely due to the fact that prespawn adults are transported to the Sandy from Lockwood by truck and, therefore, do not currently have access to mainstem that habitat. Although they were not included in MDMR's recent surveys, the Maine Atlantic Sea-Run Salmon Commission (MASRSC) (now a part of MDMR) indicated that similar spawning areas are expected to occur in the tributaries (and even in the mainstem) upstream of the Lockwood Dam (MASRSC, 1986). They indicate that Wesserunsett, Carrabassett, and Martin Streams (all between Shawmut and Weston) contain abundant rearing habitat, and sufficient spawning habitat to allow for a minimum escapement (i.e., the minimum number of adult fish returning to spawn) of 272, 26, and 38 adults, respectively (MASRSC, 1986).

MDMR monitored temperatures in the tributaries (including Wesserunsett, Messalonskee, Carrabassett, and Seven Mile Streams) to the mainstem of the Kennebec in 2001, and documented that, in that year, temperatures exceeded the lethal level for salmon parr during the summer months, particularly in Wesserunsett and Messalonskee Streams:

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[16] Maine Department of Marine Resources. 2017. Atlantic salmon Habitat (ASHAB). Updated March 17, 2021. Accessed through Maine Office of GIS Data Catalog: https://maine.hub.arcgis.com/datasets/1cd03b001cec43e1b33b87f7af3063e8/explore?location=45.232742%2C-69.119381%2C7.38

> Wesserunsett Stream had the highest recorded temperature at 32°C, as well as readings that exceeded 30°C for 11 days during the summer sampling period. Minimum daily temperatures ranged between 17°C and 20°C, but a peak minimum of 23°C was recorded during this time period. Messalonskee Stream never achieved the maximum temperatures observed in Wesserunsett Stream, but temperatures remained constantly warm throughout each day. Maximum temperatures were found to exceed 27°C for 22 days, while minimum temperatures were found to exceed 22°C for 43 of the 132 days the logger was deployed. Both Wesserunsett and Messalonskee Streams exhibited temperatures in 2001 that are detrimental to Atlantic salmon survival. Temperatures above 30°C can be lethal for even very short periods of time (<2 hours). However, it is difficult to characterize the temperature profile of an entire river or stream system with only a single year of data collected at a single site. Additionally, the summer of 2001 was the driest summer on record in the 107 years that weather information has been kept, which could have exacerbated the temperature regime of both streams. It is also unknown where spring seeps that are beneficial to salmon survival are located in these streams. (MDMR, 2001)

Although one year of data is insufficient to "characterize the temperature profile of an entire stream system," this information does suggest that particularly in low flow years these streams may not support parr rearing. To further approximate the conditions in these tributaries, we have considered temperature data provided from data loggers maintained by the State of Maine in lower Wesserunsett Stream (2014-2015) and the East Branch Wesserunsett (2018-2019) (Table 14). As this stream was the warmest documented during MDMR's 2001 monitoring effort, the information from the loggers provides a worst-case approximation of what would be expected in the other tributaries. The logger information indicates that, unlike in 2001, the maximum temperature in Wesserunsett did not exceed 30°C in any of the four years monitored, although it did reach 29°C on a single day in August of 2015. During that month (the hottest month documented in this four year time series) temperatures exceeded 27.8°C for only five days[17]. Additionally, the monthly average temperatures during the summer are below those identified as leading to the cessation of parr feeding (22.5°C), which suggests that there are significant periods of cool water temperatures adequate to support parr development. Although there are periods in Wesserunsett that exceed safe temperature for salmon (i.e., exceed the threshold for feeding cessation), it appears that 2001 may have been an anomalous year, and that in most years the temperatures are cool enough to support salmon rearing. We also expect that there are areas of cool water (groundwater seeps) within Wesserunsett Stream where salmon parr can aggregate during the warmer months. These areas likely occur in the upper reaches of the East Branch of Wesserunsett Stream, where Lombard et al. (2021) modeled a higher mean August baseflow (proportion of 0.31-0.37), as compared to the lower portion of the tributary (0.19-0.30) (Lombard

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[17] Elliott (1991) indicated that temperatures above 27.8°C could be lethal to parr if they are exposed to for at least seven days.

et al., 2021). As such, and as Wesserunsett was the warmest of the streams monitored by MDMR in 2021, we expect that the tributaries to the Kennebec provide water temperatures that are sufficiently cool to allow for at least limited functioning of spawning and rearing habitat.

Table 14. Temperature information for Wesserunsett Stream in Skowhegan, Maine (derived from information from SHEDS Stream Temperature Database).

		June		July		August		September	
Year	Location	Ave	Max	Ave	Max	Ave	Max	Ave	Max
2014	Lower					20.9	26.4	17.2	24.9
2015	Lower	17.8	24.0	22.4	27.9	22.6	29.0	19.7	27.1
2018	East Branch	17.3	22.4	21.5	27.8	21.0	26.2	16.0	22.3
2019	East Branch	16.6	21.5	20.1	25.6	19.1	23.8	14.6	17.8

To further estimate the distribution of spawning habitat throughout the action area, we can consider the modeled rearing habitat as a proxy. The rearing habitat model (Wright et al., 2008) does not directly predict features that are suitable for spawning. However, as spawning and rearing habitat are correlated with each other, for this analysis we can assume that the proportion of spawning habitat distributed throughout the action area is roughly equivalent to the proportion of modeled rearing habitat (Figure 9). This is a reasonable assumption as juveniles are reared near the redds where eggs are deposited. NMFS (2009) indicated that the model helps to “reveal stream segments with gradients that would likely represent areas of riffles or fast moving water, habitat most frequently used for spawning and rearing of Atlantic salmon”. Further, they indicate that:

> Although we have found the model to be nearly 75 percent accurate in predicting the presence of sites for spawning and rearing within specific areas, and we have an abundance of institutional knowledge on the physical and biological features that distinguish sites for spawning and sites for rearing, the model cannot be used to distinguish between sites for spawning and sites for rearing across the entire geographic range. This is because: (1) sites used for spawning are also used for rearing; and (2) the model is unable to identify substrate features most frequently used for spawning activity, but rather uses landscape features to identify where stream gradient conducive to both spawning and rearing activity exists. (NMFS, 2009)

Based on these conclusions and the assumption that spawning and rearing habitat are correlated, we conclude that although it is inappropriate to use the model to estimate abundance of spawning habitat, it can be used to determine the relative proportion of habitat that supports spawning PBFs in different reaches. Based on this assumption and the distribution of class 1 habitat, we can conclude that the habitat within the action area upstream of Weston (not including the Sandy) contains 15% of the spawning habitat in the action area, with 50% occurring between Shawmut and Weston (where Wesserunsett, Carrabassett, and Martin Streams are located), 1%

between Hydro-Kennebec and Shawmut, 19% between Lockwood and Hydro-Kennebec, and 12% between Lockwood and the Sebasticook confluence. This analysis does not suggest that spawning habitat is abundant in any of these reaches; only that some portions of the action area contain relatively more than the other portions. However, as spawning PBFs were documented in similar mainstem and tributary habitat below Lockwood, it is reasonable to expect it to occur in unsurveyed reaches upstream of Lockwood as well. Specifically, the distribution of modeled habitat in the action area suggests that the reach between Shawmut and Weston is the most likely to contain the PBFs that support spawning, and that smaller amounts could occur upstream of Weston, between Lockwood and Hydro-Kennebec, and downstream of Lockwood. Based on the distribution of modeled rearing habitat, we can predict that much of this habitat would occur within the tributaries outside of the action area, but that some could occur in the mainstem as well.

In the analysis below, we determine that although the PBFs SR 1 - 3 are present in the mainstem habitat in the action area, they only have the potential to function at a limited capacity due to elevated temperatures, excessive depths, and the presence of abundant nonnative species, some of which prey on juvenile salmon.

Most of the action area occurs upstream of the Lockwood Project, which has a fish trap where adult salmon are captured. These salmon are transported above the action area to the Sandy River. Therefore, although the PBFs for spawning are present and have the potential to function at a limited capacity, the lack of access for the necessary life stage means that the features in the action area have low conservation value.

PBF SR4-SR7

Freshwater rearing sites with the space (SR4), habitat diversity (SR5), cool water (SR6), and diverse food resources (SR7) necessary to support growth and survival of Atlantic salmon parr.

Modeling conducted by Wright et al. (2008) indicates that salmon rearing habitat exists in the mainstem of the Kennebec, as well as in its tributaries. Four watersheds within the Kennebec River basin have been designated as critical habitat for Atlantic salmon, with all four containing modeled habitat. The two uppermost watersheds (the Sandy River, and the Kennebec River at Waterville Dam watersheds[18]) contain the majority of the habitat, with approximately 35,000 habitat units identified in each (Figure 9). In addition to abundance, the model also identifies the proportion of each modeled reach that is expected to be suitable for juvenile rearing. The Maine Stream Habitat Viewer[19] categorized these proportions into three classes with the first, second, and third classes predicted to contain >50%, 27-50%, and <26% rearing habitat, respectively. As such, class 1 habitats are expected to be the most suitable for rearing and class 3 habitats

[18] Hydrologic Unit Code (HUC) 10 watersheds. https://nas.er.usgs.gov/hucs.aspx.
[19] Maine Stream Habitat Viewer. https://webapps2.cgis-solutions.com/MaineStreamViewer/

expected to be least suitable.[20] Using the model and the established classification, we have been able to describe how the suitability and abundance of rearing habitat compares between the Sandy River, Kennebec River at Waterville Dam, Kennebec River at Merrymeeting Bay, and the Kennebec River estuary watersheds (Figure 9). The model indicates that approximately 70% of the class 1 (i.e., most suitable) rearing habitat in critical habitat in the Kennebec River watershed is located in the Sandy River and its tributaries. Additionally, it shows that a large portion of the class 3 (i.e., low suitability) habitat lies in mainstem habitat in the action area (Figure 9). This is addressed in more detail below.

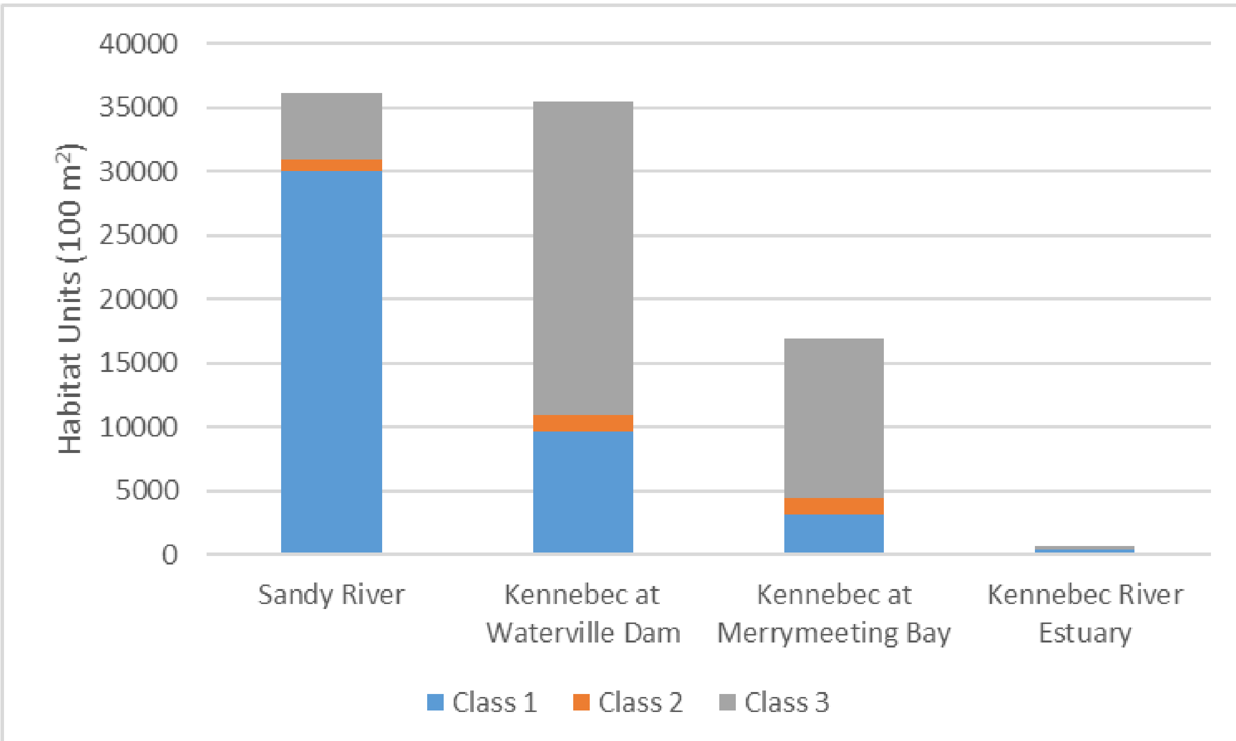

Figure 9. The number of habitat units modeled in each of the four watersheds designated as critical habitat for Atlantic salmon in the Kennebec River, as well as the proportion of the habitat that is expected to contain the features necessary to support juvenile salmon development.

The results of the modeling analysis are consistent with the qualitative assessment in the Biological Valuation conducted to support the designation of critical habitat in 2009 (NMFS, 2009). Habitat quality scores were assigned to watersheds based on information and input from fisheries biologists that had specific knowledge and expertise about the geographic region. A minimum of three biologists with knowledge and expertise of each geographic area in the GOM

[20] In the context of the Wright et al. (2008) model, what we refer to as suitability is actually a measure of habitat abundance or density within a stream reach, rather than a measure of quality. A segment of river modeled as class 1 would be expected to have a higher proportion of productive habitat than one modeled as class 3. However, this does not suggest that a unit of habitat in a class 1 reach would necessarily produce more salmon parr than a unit of habitat in a class 3 reach (i.e., quality).

DPS were asked to independently assign habitat scores to watersheds based on the presence and quality of physical and biological features essential to the conservation of the species. The scoring criteria ranked qualitative features as being highly suitable ("3"), suitable ("2"), marginally suitable ("1") or not suitable ("0") for supporting Atlantic salmon. Emphasis was placed on identifying whether or not the physical and biological features needed for Atlantic salmon spawning and rearing. When analyzing the status of these four watersheds, the fisheries biologists assigned the habitat in the Sandy River and Kennebec River at Waterville Dam watersheds a score of 2, whereas the Kennebec River at Merrymeeting Bay and Kennebec River Estuary watersheds were assigned a score of 0. Although the two lower watersheds were generally not thought to be suitable for spawning and rearing, the mainstem river fills the essential function of allowing salmon to migrate to and from the suitable habitat in the upper two watersheds.

In addition to indicating the amount and suitability of habitat in the designated watersheds, we can also use the salmon rearing habitat model (Wright et al., 2008) to determine how the habitat in the Kennebec River is distributed in the action area in relation to the five hydroelectric dams (i.e., the four subject dams as well as the Abenaki Dam, which is on the mainstem of the Kennebec upstream of its confluence with the Sandy River) (Figure 10). All of the dams are located within the Kennebec River at Waterville Dam watershed, which is downstream of the Sandy River watershed, and upstream of the lower two watersheds. The model indicates that 53% of the modeled rearing habitat (as well as 70% of the class 1 habitat) in designated critical habitat in the Kennebec River lies in between the Weston and Abenaki Projects (primarily in the Sandy River). An additional 18% of the habitat (as well as 12% of the class 1 habitat) lies between the Shawmut and Weston Projects, whereas a negligible amount occurs between Hydro-Kennebec and Shawmut (4%) and between Lockwood and Hydro-Kennebec (2%).

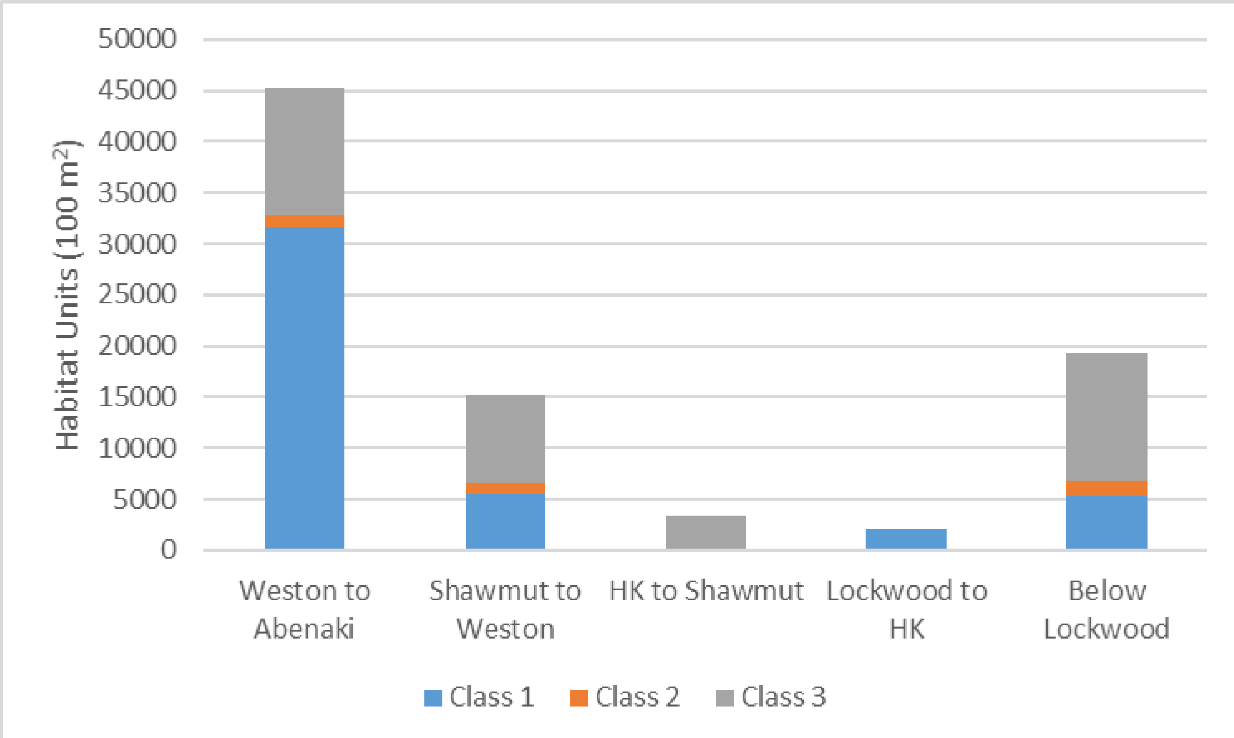

Figure 10. The amount of salmon habitat units suitable for rearing in the Kennebec River watershed below the Abenaki Dam (as derived from modeling conducted by Wright et al.,(2008)). The habitat is classified by the proportion that are expected to be suitable for salmon rearing (Class 1: >50%, Class 2: 27-50%, Class 3: <26%). The Sandy River flows into the Kennebec River in between the Weston and Abenaki Dams.

The entirety of the action area consists of mainstem habitat that has been modeled as rearing habitat (Wright et al., 2008). As the model inputs do not include the parameters listed in Table 8, its identification of the habitat in the action area as rearing habitat does not by itself indicate that it is functional. However, it is a useful screening tool for identifying areas that are likely to support the PBFs. The model indicates that there are 22,269 habitat units of rearing habitat in the action area, but that 85% of it is of low suitability (class 3). The remaining 15% (~3,500 units) is classified as class 1 highly suitable habitat; this habitat is located between the Hydro-Kennebec Project and the Sebasticook River confluence. As defined, less than 26% of class 3 habitat actually contains the features necessary for rearing; whereas 50% or more of class 1 habitat is expected to contain these features.

Although we don't have specific information regarding the rearing PBFs in the action area, we can make reasonable assumptions based on what we know about mainstem habitats generally. Mainstem habitats tend to have warmer temperatures (SR 6), deeper water (SR 4), and lower habitat diversity (SR 5) than what would be observed in smaller streams, which would tend to be cool and shallow, with greater habitat complexity. Although some rearing occurs in mainstem habitat, Atlantic salmon tend to use large riverine habitats primarily as migratory corridors to access lower order tributaries that can provide suitable spawning and rearing habitat. This differential use of river and stream habitat for salmon migration and spawning/rearing is reflected in both the model's classification of the action area (predominantly class 3), as well as the qualitative scores established by salmon biologists when the habitat was designated as critical habitat (NMFS, 2009) (quality score of 0). As such, we would not expect that the PBFs for spawning and rearing habitat would be fully functioning given the habitat that we have identified as occurring in the action area. Below, we describe in greater detail how the parameters identified in Table 8 limit the functioning of the PBFs in the action area.

Temperature Effects to Spawning and Rearing PBFs

Cool water temperatures are important for Atlantic salmon, and are critical to several of the PBFs, including those for spawning and embryo/fry development (SR 1-3) and for parr development (SR 6). According to Stanley and Trial (Stanley & Trial, 1995), Atlantic salmon parr grow best between 13°C and 19°C (Dwyer & Piper, 1987), and can tolerate temperatures up to 27°C for short periods (DeCola, 1970). However, they cease feeding at 22.5°C and will die if exposed to temperatures exceeding 27.8°C for seven days (Elliott, 1991). Elliot (1991) further determined that temperature tolerance increased by approximately two degrees (~29.5°C), if parr were only exposed to warmer temperatures for 16 hours or less. Embryo development occurs around 6°C, but temperatures above 12°C will cause direct mortality, and above 8°C may cause secondary mortality due to fungal infections (Garside, 1973). Spawning can occur between 7°C and 10°C, with the optimal temperature for fertilization around 6°C. Consistent with PBF SR1, adult salmon need deep, oxygenated pools and cover (e.g., boulders, woody debris, vegetation, etc.) to rest and wait for conditions to be right for spawning. Atlantic salmon become stressed when water temperatures exceed 20°C, and may die if temperatures approach or exceed 25°C (Breau, 2013). Decola (1970) determined that Atlantic salmon can survive exposure to temperatures of 24 to 27°C if that exposure is for short periods (i.e., less than 7 days). In section 3, we identified the temperature thresholds that allow for functional rearing and spawning habitat. In Table 15, we have further broken down these thresholds to indicate what temperatures are necessary to allow for full versus limited functioning of the habitat.

Table 15. Temperature thresholds for functioning of the rearing and spawning PBFs.

Stage	Time of Year	Full Function	Limited Function
Adult spawning (SR2)	October to December	Always 7°C -10°C	Often 7°C -10°C
Adult migration/holding (SR1 and M2)	May to December	<20°C	>20°C
Embryo/Fry	October to April	Averages ~6°C	Averages <4°C, or

Development (SR3)		(0.5°C to 7.2°C)	ranges between 8°C and 10°C
Parr Development (SR 6)	All Year	15°C -19°C during the summer	7°C - 22.5°C

The mainstem of the Kennebec warms considerably, especially in the summer months. Temperature loggers placed near the Abenaki (located upstream of the Weston impoundment and the Sandy confluence), Weston (downstream of the dam), Shawmut (downstream of the dam), and Hydro-Kennebec (upstream of the impoundment) projects monitored hourly water temperatures from 2014 to 2018 (Figure 11)[21]. As these loggers are distributed throughout the action area, and monitored temperature consistently over a five year period, they represent the best available information on water temperature in the action area. It should be noted that the relatively long distance between the loggers means that the information has a coarse resolution. As such, we anticipate that there are areas between the loggers that may have cooler water temperatures then what was observed at the loggers, such as near groundwater discharge areas or at the confluence with cool water tributaries. Below, we use the information from these loggers to determine the functional status of the relevant PBFs in the action area in relation to temperature.

[21] SHEDS. Stream Temperature Database. Public Data Viewer. http://db.ecosheds.org/viewer (accessed on 5/4/2022). 2014-2018 temperature data from stations near Anson Dam (MEIFW-5), Weston Dam (MEIFW-4) and Shawmut Dam (MEIFW-2), Hydro-Kennebec Dam (MEIFW-1).

Figure 11. The location of temperature loggers (black circles) in relation to the dams in the lower Kennebec River (red triangles).

During the period relevant for adult spawning (SR 2), the average monthly temperatures at all four temperature loggers in October, November, and December are approximately 14°C, 7°C, and 2°C, respectively (Figure 12). When compared to the values in Table 15, this suggests that the spawning PBF in the action area is in the limited functioning range for temperature in October, but in the fully functional range in both November and December when the majority of spawning likely occurs.

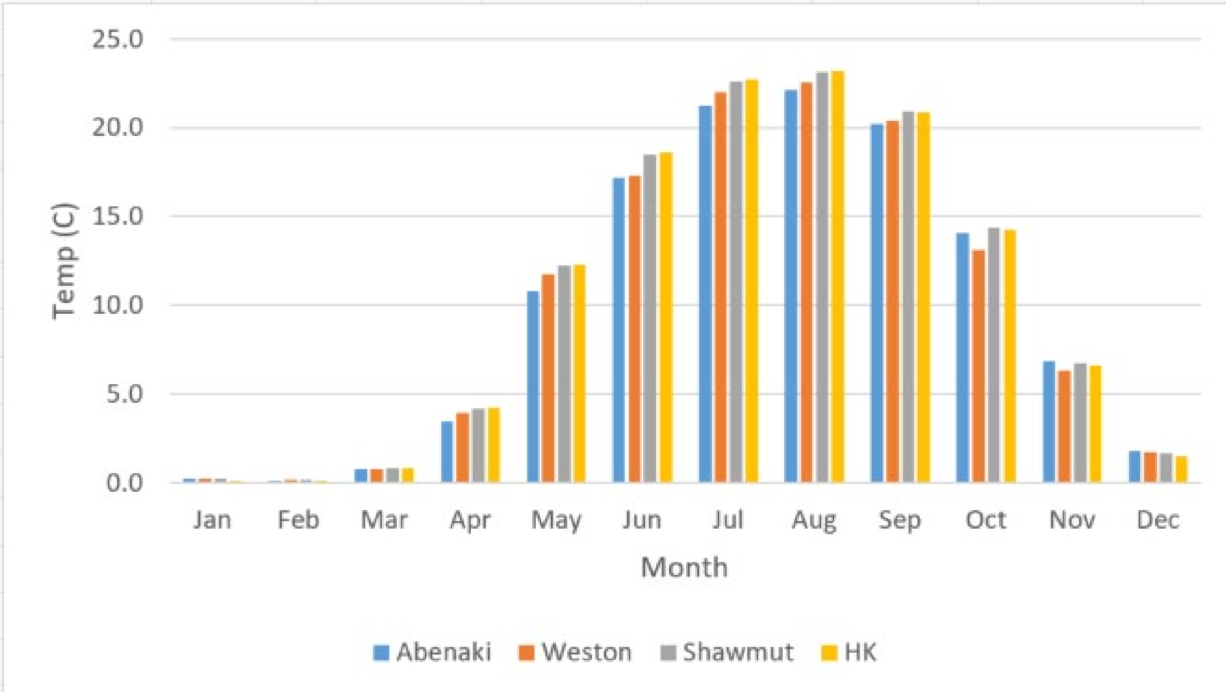

Figure 12. Monthly average water temperature between 2014 and 2018 monitored by data loggers within the action area (SHEDS Stream Temperature Database). The Weston impoundment lies between the Abenaki and Weston loggers, and the Shawmut impoundment lies between the Weston and Shawmut loggers.

Monthly average temperatures exceed the 20°C threshold for limited functioning of adult salmon migration habitat from July through September at all four stations. Additionally, although it's not the norm, maximum temperatures in those months are within the 24°C to 27°C range defined by Decola (1970) and Breau (2013) as potentially being lethal for adult salmon for prolonged exposure (Breau, 2013; DeCola, 1970). However, the need for "deep, oxygenated pools" (SR 1) and "cool, oxygenated water" (M 2) during migration is precisely due to this type of condition regularly occurring in mainstem habitat. According to the Biological Valuation that was developed to support the critical habitat listing "adults that arrive early require holding areas in freshwater and estuarine areas that provide shade, protection from predators, and protection from other environmental variables such as high flows, high temperatures, and sedimentation" (NMFS, 2009). Therefore, the average temperature in the river as a whole may emphasize the importance of these PBFs in the action area, rather than the absence of them.

When temperatures warm above 20°C in the river, adult salmon will seek out thermal refuge (e.g., holding pools near cold water tributaries or groundwater discharge areas) in the action area, or else move into the tributaries. Although we can't identify particular holding areas in the action area, we know that there are several accessible tributaries that likely provide relatively cool flow at times of year when the mainstem is too warm. However, given the conditions in the mainstem (which comprises the action area), we determine that PBF SR 1 and M 2 are present and have the potential to function at a limited capacity in the action area.

To determine the functionality of embryo and fry development habitat (PBF SR 2 and 3), we have averaged the monthly average temperatures between October and April. The average temperature across months was 4°C or less at all four stations. The average temperature in January and February at all four stations was below the minimum (0.5°C) for fully functioning habitat. Except for the month of November (average 6-7°C), the average temperature in each individual month was either below 4°C or above 10°C (October). At all four stations the average temperature in October exceeded 12°C, indicating that direct mortality of embryos could occur. Therefore, PBF 2 and 3 do not function during that month. However, we consider the PBFs for embryo/fry development (SR 2 and SR 3) in the action area to be functioning at a limited capacity from November to April due to temperature.

For the habitat in the action area to function for parr development (PBF SR 6), the temperature needs to stay below 22.5°C and above 7°C throughout the year. According to the information provided by the temperature loggers, the average water temperature in the mainstem Kennebec River at the Shawmut and Hydro-Kennebec loggers exceeds 22.5°C in the months of July and August and, in some years, exceeds that threshold June through September. The average temperature at the Weston Dam is a little cooler, and only exceeds 22.5°C in the month of August. However, maximum water temperatures recorded during that period exceed that threshold in June, July, August, and September, and exceed the 27.8°C threshold for mortality in the month of July. In order for these maximum temperatures to be lethal for parr, Elliott (1991) indicated that parr would need to be exposed to these temperatures for at least seven days. Based on the data from the temperature loggers, we would not expect this to occur regularly at any of the loggers. Additionally, Elliott's study indicated that parr would die if temperatures exceeded 29.5°C for as little as one day (16 hours) (Elliott, 1991). That temperature was not exceeded at any of the loggers during the five year period. As such, we do not anticipate that the lethal temperature threshold for salmon parr is exceeded in the action area. Although we do not anticipate that temperatures are currently lethal in the action area, it is apparent that the threshold for feeding (22.5°C) is regularly exceeded during the summer months. During these periods, the PBF is not functioning. As we expect that temperatures will not be sustained at that level, and as parr are mobile and are able to move to cold water areas during the summer (McCormick et al., 1998), it is possible that the habitat can still function at a limited capacity. As such, although the PBF requiring "cool, oxygenated water" for parr development (SR 6) is not functioning at all times, it still provides limited functioning for much of the year. During warm periods, parr would need to move to groundwater discharge areas in the mainstem, or potentially to cool water tributaries outside of the action area.

Impoundments created by dams slow the rate of flow and increase depths, making the naturally riverine habitat more pond-like. The ponding of water increases the residence time of the water and increases the surface area, which leads to an increase in temperature. The hydro projects in the lower Kennebec operate as run-of-river (i.e., inflow equals outflow), which means that the impoundments are more riverine than would be found at a project that peaks (i.e., stores water upstream in order to generate when demand is high). However, it is likely that the large impoundments at the Weston and Shawmut Projects contribute to the increase in the water temperature in the action area to some degree. Large impoundments have greater volume and surface area, so they are likely to warm a larger volume of water than smaller impoundments. Conversely, the Lockwood and Hydro-Kennebec impoundments are small (and therefore the water has a shorter residence time and surface area) and are unlikely to have a measurable effect on temperature compared to what the river reach would experience absent the impoundment. Temperature loggers below the Abenaki Dam (upstream of the Weston impoundment), the Weston Dam, and the Shawmut Dam can be used to estimate how temperature increases in the Weston impoundment (difference between the Abenaki logger and the Weston logger[22]) and the Shawmut impoundment (difference between the Weston logger and the Shawmut logger). The results of this analysis suggest that while there is little difference in the winter months, the average monthly river temperature increases by 0.1°C to 0.8°C during the summer months in the Weston impoundment; and by an additional 0.6°C to 1.2°C in the Shawmut impoundment. As the average monthly temperature of the river flowing into the action area (Abenaki logger) during the 2014-2018 timeframe did not exceed the 22.5°C threshold for parr development in any month, the combined warming that occurs in the impoundments (0.7°C to 2.0°C increase) may contribute to the exceedance of the feeding threshold in the months of July and August (Figure 14).

It is important to note that these impoundments are relatively riverine, as compared to large impoundments upstream of peaking facilities, and that some of the increase in water temperature in the action area likely would occur regardless of the presence of the dams, due to the natural warming of the water as it flows downstream exposed to warm summer air temperatures. Both surface (e.g., runoff, tributary flow) and groundwater sources could also be affecting the temperature of the mainstem Kennebec River. For example, modeling conducted by Lombard et al. (2021), indicates that the contribution of groundwater, which is colder than surface water, to river flow in the lower part of the action area, is less than it is in the upper portion of the action area during the warm summer months. Despite these background factors, it is likely that the warming rate in the impounded reaches (primarily at Weston and Shawmut) is higher than what would be expected in an unimpounded reach. However, as the total increase through the impoundments is very small (i.e., 2.0°C/40 km=0.05°C per km) and is potentially attributable to multiple factors, it is unlikely that the effect of the impoundments on temperature in the action area has more than an insignificant effect on habitat suitability.

In addition to temperature, there are other parameters that define the functionality of the rearing habitat in the action area. To be functional, habitat must be of sufficient depth to support juvenile development. As the action area is comprised of mainstem riverine habitat, very little of

[22] This reach contains the confluence with the Sandy River, which likely influences the temperature in the mainstem.

it would be sufficiently shallow to support rearing even absent the dams. As indicated in Table 8, functional rearing habitat for salmon should be less than 30 cm (1 ft) deep. Given the depth of the mainstem, which is increased by the dam impoundments, we expect habitat in this depth range to primarily occur in the areas along the river banks. The rearing habitat model (Wright et al., 2008) indicated that there are approximately 2,000 habitat units of class 1 rearing habitat downstream of the Lockwood Dam. Water depth was not a model input (nor is water temperature), however, so despite its categorization in the model it is likely that much of this habitat would fall outside of the functional range as well. As such, we anticipate that most of the action area is not functioning as rearing habitat due to depth, but that there may be isolated shallow areas (mostly along the banks) where it may function.

In addition to abiotic features, functional spawning and rearing habitat must host abundant native fish species, and few nonnative species. Nonnative fish, some of which prey on juvenile Atlantic salmon, are abundant in the action area. Both smallmouth and largemouth bass occur throughout the mainstem Kennebec, as does black crappie (Yoder et al., 2006). As discussed further below for PBF M 3, the dams significantly limit the abundance of native diadromous fish in the action area upstream of the Lockwood Project. Given the high abundance of nonnative species, and the lack of passage for native sea-run species, this feature is functioning at a limited capacity.

We have determined that the PBFs for rearing in the action area have the potential to function at limited capacity. The functioning of the habitat is affected by depth, high temperatures, reduced abundance of native fish species, and an abundance of nonnative predators. The PBF that defines the need for cool water temperatures for parr development (SR6) does not function at certain times as the temperature in the summer regularly exceeds the threshold for feeding. However, parr are highly mobile and have adapted to move to cool water areas (e.g., groundwater discharge areas, cool water tributaries) when temperatures are elevated.

Most of the action area occurs upstream of the Lockwood Project, which has a fish trap where adult salmon are captured. These salmon are transported above the action area to the Sandy River to spawn. As adults do not have access to the action area to spawn, and as no stocking of juvenile salmon occurs between Lockwood and the Sandy River, juvenile life stages do not have access to the PBFs. Therefore, although the PBFs for rearing are present and have the potential to function at a limited capacity, the lack of access for the necessary life stage means that the features in the action area have low conservation value.

PBFs for Migration Habitat

The conservation value of the habitat in the action area is to function as a migratory corridor for adults attempting to access spawning habitat throughout the lower Kennebec River and for smolts emigrating from the Sandy River to the Atlantic Ocean. The presence of the four dams in the lower Kennebec River substantially alters the function of several PBFs for migration habitat.

M 1: Freshwater and estuary migratory sites free from physical and biological barriers that delay or prevent access of adult salmon seeking spawning grounds needed to support recovered populations.

For this PBF to function fully, any barriers to passage (dams and road-stream crossings) must allow for the safe, timely, and effective upstream passage of adult Atlantic salmon. The four dams in the lower mainstem of the Kennebec River delay and prevent access of adult salmon moving to spawning grounds. These effects are described in detail in sections 4.1 and 6.2. Under current conditions, adult salmon cannot migrate past the Lockwood Dam without being handled and transported to habitat in the Sandy River by humans. Therefore, the dams are currently barriers that prevent access of adult salmon to upstream spawning habitat. As such, PBF M1 is not currently functioning.

M 2: Freshwater and estuary migration sites with pool, lake, and instream habitat that provide cool, oxygenated water and cover items (e.g., boulders, woody debris, and vegetation) to serve as temporary holding and resting areas during upstream migration of adult salmon.

As a large river with diverse habitat, river form, and flow patterns, the lower Kennebec River generally provides PBF M 2 function for Atlantic salmon. As average summer temperatures in the action area exceed the 20°C stress threshold, PBF M 2 is particularly critical for providing cool water refuge for migrating prespawn adults. Although we expect cool water habitats to be available in the tributaries, the conditions in the main stem likely mean that this PBF only has the potential to function at a limited capacity in the mainstem action area itself. As the dams block migration to this PBF it currently has low conservation value.

M 3: Freshwater and estuary migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation.

Of particular relevance to PBF M 3 is the abundance and distribution of native alosine fish (i.e., alewife, blueback herring, and American shad). The presence or absence of these species likely play important roles in mitigating the magnitude of predation on Atlantic salmon smolts and adults from predators such as striped bass, double-crested cormorants, harbor seals, and gray seals. The migration time of prespawn adult alewives overlaps in time and space with the migration of Atlantic salmon smolts (Saunders et al., 2006). In the Kennebec, this overlap is mostly limited to the lower river and estuary, as smolts start migrating through the action area in mid-April, but adult alewives are not generally trapped at Lockwood in significant numbers until the first or second week of May. However, we would expect the overlap to be more significant in the lower river and the estuary as the peak of the outmigrating smolt run coincides in space and time with the peak of the upstream alewife migration.

The historical distribution of alewife and American shad in the Kennebec River extended up to Norridgewock Falls (river kilometer 156; site of the Abenaki Project) on the mainstem, and included extensive use of the Sandy River, the Sebasticook River, and Cobbosseecontee Stream (Foster and Atkins, 1867). Today, the range of these species is largely limited to the Sebasticook River and the mainstem of the Kennebec River below Lockwood. At historical abundance levels, alewives greatly exceeded densities of Atlantic salmon smolts, making them more available to predators. In addition, the caloric content per individual alewife is greater than that of an Atlantic salmon smolt (Schulze, 1996), making the alewife a more desirable prey species (Saunders et al., 2006). Similarly, adult American shad enter rivers and begin their upstream spawning migration at approximately the same time as adult Atlantic salmon (Fay et al., 2006). Historically, American shad runs were considerably larger than salmon runs (Atkins and Foster, 1867). Thus, native predators of medium to large size fish in the estuarine and lower river zones (i.e., harbor seals and gray seals) could have preyed on these 1.5 to 2.5 kg size fish readily (Fay et al., 2006; Saunders et al., 2006). In the absence of, or with reduced abundance of, alewives and American shad, it is expected that predation risks to Atlantic salmon smolts and adults would be higher (Saunders et al., 2006). Thus, PBF M3 is essential to the conservation of Atlantic salmon because, without highly prolific abundant alternate prey species such as alewives and American shad, the less prolific Atlantic salmon are more likely to be preyed upon which decreases survival rates of smolts and adults in the estuary.

As indicated, much of the benefit of prey buffering occurs in the lower river and estuary, downstream of the action area, when outmigrating salmon smolts overlap in time and space with upstream migrating river herring and American shad, as well as abundant predators, such as harbor seals, gray seals, and striped bass. This critical area does not occur within the action area but the abundance of alosines is affected by productivity upstream of the dams on the Kennebec and Sebasticook Rivers and, therefore, is limited by passage survival and effectiveness at those projects. The Sebasticook contains the majority of the alewife spawning habitat in the Kennebec basin, with approximately two-thirds of the total historical spawning habitat occurring in that watershed (derived from Table 1 in Wippelhauser 2021). The remaining habitat occurs in the Kennebec, with 8% occurring in Seven Mile Stream (a tributary to the Kennebec downstream of Lockwood) and the remaining 25% occurring upstream of Lockwood. Although only 54% of the habitat in the Sebasticook is accessible to alewives (Wippelhauser, 2021), large runs (2 - 5.5 million) are passed annually at the first dam (Benton Falls Project). The average number of alewives passed into the Sebasticook River over the most recent five year period (2017-2021) (i.e., 3,762,936) is 18 times higher than the average number trapped at the Lockwood Project and passed into the Kennebec (i.e., 209,017)[23]. Although this number is significantly less than what would have been expected historically, it does indicate that there are abundant adult and juvenile herring in the estuary that likely allow for some functioning of the PBF. Although the Sebasticook provides the majority of alewife historical habitat and production in the system, the habitat above the Lockwood project needs to be accessible to alosines in order for it to contribute to the functioning of the PBF in the lower river and estuary, as well as in the freshwater habitat within the action area itself.

[23] Maine DMR. Trap Count Statistics. Historical annual data for 2011-2021. https://www.maine.gov/dmr/fisheries/sea-run-fisheries/programs-and-projects/trap-count-statistics

The current lack of adequate fish passage at the four dams in the lower mainstem of the Kennebec River preclude alosine species from historic portions of their native habitat (Wippelhauser, 2021). These species are stocked into the headponds above Hydro-Kennebec and Shawmut, as well as the Sandy River via a trap and truck program operated by Maine DMR. As the trucking of fish removes these species from the migratory corridor, these fish are not available to contribute to the functioning of the PBF in the action area; but may still contribute to the overall production of these species in the river, which could improve the functioning of the PBF in the lower river and estuary. Recent progress in terms of improved fish passage (largely through the removal of Edwards and Fort Halifax Dams and the construction of fish lifts in the Sebasticook River) has resulted in substantial increases in abundance of alewives in the Kennebec River basin (Wippelhauser, 2021). However, Wippelhauser (2021) notes that "despite this progress, approximately 60% of historical alosine habitat above the Lockwood Project and 54% of the lake/pond habitat primarily in the Sebasticook River remain inaccessible." Thus, alewives and American shad remain substantially restricted compared to their historical abundance and distribution, and the function of this PBF in the lower river and estuary is limited as a direct result of the lack of adequate fish passage at dams in both the Kennebec and Sebasticook Rivers. PBF M 3 is not functioning within the action area upstream of the Lockwood Dam, as river herring and shad cannot swim past the project under existing conditions.

M 4: Freshwater and estuary migration sites free from physical and biological barriers that delay or prevent emigration of smolts to the marine environment.

For this PBF to function fully, any barriers to passage (dams and road-stream crossings) must allow for the safe, timely, and effective downstream passage of Atlantic salmon smolts. The four dams in the lower mainstem of the Kennebec River delay and directly and indirectly kill Atlantic salmon smolts during their migration to the marine environment. They also delay the arrival of smolts to the estuary that do successfully migrate past the dams in the lower Kennebec River. These effects are described in detail in sections 4.5 and 6.2. Thus, PBF M4 is limited functionally.

To summarize, in this analysis we have indicated that the PBFs in the action area (SR 1 - 7; M 1 - 4) are present in the action area and most (all except M 1 and M 3, which do not function given the lack of upstream fishways) have the potential to function at a limited capacity. However, in order for the PBFs to realize that potential the necessary life stages of salmon must be able to access the habitat. As the habitat upstream of the Lockwood Dam is currently inaccessible to salmon, the PBFs cannot function at their potential level, and as such they have low conservation value. The action area currently functions at a limited capacity for downstream migrating smolts (M 4), as they are able to access the action area. The PBFs in the action area downstream of the Lockwood Dam are fully accessible to adult and juvenile Atlantic salmon, and therefore function at a limited capacity.

4.2 Status of Shortnose Sturgeon in the Action Area

Shortnose sturgeon occur in the estuarine complex formed by the Sheepscot, Kennebec, and Androscoggin rivers. Atkins (1887) documented the presence of sturgeon in Maine rivers, though they were identified as common sturgeon (*Acipenser sturio*). Fried and McCleave (1973) discovered shortnose sturgeon within Montsweag Bay in the Sheepscot River in 1971 and 1972. This was the first reported occurrence of shortnose sturgeon in Maine. Shortnose were subsequently found in the Kennebec River by ME DMR in 1977 and 1978 (Squiers and Smith, 1979). The historical upstream extent of shortnose sturgeon in the Kennebec is considered to be Ticonic Falls (river kilometer 103, the current location of the Lockwood Dam) (NMFS & USFWS, 1998). While the distribution of shortnose sturgeon only overlaps with the small portion of the action area downstream of the Lockwood Dam, information on use of the Kennebec River generally is presented here for context.

Sturgeon were tagged with Carlin tags from 1977 to 1981, with recaptures in each of the following years. A Schnabel estimate of 7,222 (95% CI, 5,046 to 10,765) adults for the combined estuarine complex was computed from the tagging and recapture data from 1977 through 1981 (Squiers et al., 1982). A Schnabel estimate using tagging and recapture data from 1998 - 2000 indicates a population estimate of 9,488 (95% CI, 6,942 to 13,358) for the estuarine complex (Squiers, 2003). The average density of adult shortnose sturgeon/hectare of habitat in the estuarine complex of the Kennebec River was the second highest of any population studied through 1983 (Dadswell et al, 1984). The Schnabel estimate from 1998-2000 is the most recent population estimate for the Kennebec River System shortnose sturgeon population; however, it does not include an estimate of the size of the juvenile population. A comparison of the population estimate for the estuarine complex from 1981 (Squiers et al., 1982) to 2000 (MDMR, 2003) suggests that the adult population grew by approximately 30% between 1981 and 2000. In 1999, the removal of the Edwards Dam on the mainstem of the Kennebec River opened up an additional 29 rkm of habitat, restoring access to the presumed historical spawning habitat. Use of this area has been documented and is considered to have possibly facilitated even further recruitment into this river (Wippelhauser et al., 2015). Tagging and tracking studies indicate that some Kennebec River fish migrate to the Penobscot River but return to the Kennebec River to spawn. It is hypothesized that this may be a result of increased competition for estuarine foraging resources in the Kennebec River due to increased population size (Altenritter et al. 2018). It is currently unknown if the Kennebec River population of shortnose sturgeon is continuing to increase; however, there are no indications that it has decreased from the 1998-2000 population estimate. As such, we consider the population to at least be stable however, without more information on the status of more recent year classes (i.e., juveniles) it is difficult to speculate about the long term survival and recovery of this population.

Spawning in the Kennebec River

In 1999, the Edward's Dam (river kilometer 74), which represented the first significant impediment to the northward migration of shortnose sturgeon in the Kennebec River, was removed. The Lockwood Dam continues to operate, though it is not thought to impede shortnose access to historic habitat given its location at Ticonic Falls (river kilometer 103), the presumed historic upstream extent of shortnose in the Kennebec River. Thus, with the removal of the Edwards dam almost 100% of historic habitat is now accessible. Since the removal of the Edwards Dam, shortnose sturgeon have been documented just downstream of the Lockwood Dam (river kilometer 103) indicating this habitat is being utilized (Wippelhauser et al., 2015).

Wippelhauser and Squiers (2015) summarized field studies on shortnose and Atlantic sturgeon from 1977-2001 in the Kennebec River system that sought to produce population estimates and documentation of spawning, overwintering, and foraging habitat. Based on the capture of 172 adult shortnose sturgeon between May 1-31 over a period of 22 years (including two ripe males releasing sperm during handling) from river kilometer 47.5-74 in the Kennebec River, they identified spawning run timing and potential spawning habitat. Maine DMR conducted ichthyoplankton surveys from 1996 through 2001. Sampling sites were located both above and below the dam and were surveyed using surface tows with plankton nets and stationary sets with D-shaped plankton nets. Through these efforts, researchers captured 54 eggs and 10 larvae at two sampling locations (river kilometer 65 and 72.7), confirming that spawning occurs in that 9 river kilometer stretch below the former Edwards Dam (Wippelhauser and Squiers, 2015).

Between 2007 and 2013, Wippelhauser et al. (2015) tagged 134 adult shortnose sturgeon throughout the Gulf of Maine (Penobscot, Kennebec, Saco, and Merrimack). Twenty-one (20%) of 104 shortnose sturgeon tagged in the Penobscot River, two (50%) of four tagged in the Kennebec system, one (50%) of two tagged in the Saco River, and 16 (37%) of 43 tagged in the Merrimack River moved into the Kennebec system and made suspected spawning runs. These adults displayed two distinct prespawning behaviors. Some (~35%) emigrated to the Kennebec system in the summer or fall and overwintered one to two seasons before participating in a spring spawning run, while the majority (~65%) migrated to the Kennebec system in the early spring and participated in a spawning run that same year. Tagged shortnose were detected in spawning areas from April 7 through June 6 as water temperatures increased and discharge decreased. During this time, bottom temperatures in the Kennebec River ranged from 5.8-17.6 ºC and fish spent an average of 9.9-12.5 days in the spawning sites (varied by Kennebec location). Discharge when shortnose sturgeon were at the spawning areas was typically ≤558 m^3/s; however, flows reached as high as 1,487 m^3/s in some years. Spawning was documented for the first time in the restored portion of the Kennebec (above the former Edwards Dam (river kilometer 74)) between May 17-19, 2010, as two larvae were captured below the Lockwood Dam at rm 63.4 (river kilometer 102) using D-nets. Spawning was again confirmed below the former Edwards Dam with the capture of 23 larvae between river kilometer 64-72 in a sampling period from May 19-June 15, 2009, as well as the capture of seven larvae between rm 42-45 (river kilometer 67-73) in a sampling period from May 3-June 6, 2011 (Wippelhauser et al., 2015).

A study conducted by ERC in 2001 in preparation for the relicensing of the Lockwood project, determined that although suitable depths, temperatures and substrates exist within the Lockwood Project waters, suitable spawning area is likely limited by low water velocities, particularly in the bypassed reach. Although any spawning would occur during high spring flows, mean water column velocities within the deeper portions of the bypassed reach are relatively low (<0.5 feet/second) at both leakage and spillage flows, due to the inherent bedrock-ledge hydraulic controls that create the deep backwatered pool that occupies much of the bypassed reach. The only suitable water velocities within the project area are in the tailwaters below the project, but based upon all habitat characteristics, this reach is thought to contain only marginal spawning habitat (ERC, 2001).

Overwintering

Studies indicate that at least a portion of the shortnose sturgeon population in the Kennebec River overwinters in Merrymeeting Bay (Squiers and Robillard, 1997). The seasonal migrations of shortnose sturgeon are believed to be correlated with changes in water temperature. In 1999, when a tracking study was performed by Normandeau Associates, the water temperature near Bath Iron Works (BIW) reached the 8-9ºC threshold (believed to be the trigger prompting spawning fish to migrate to the spawning area) in mid-April. Also during the tracking study, several fish presumed to be non-spawning sturgeon, were documented in the Chops Point and Swan Island areas (north of Doubling Point) in late March and then were found to have migrated south to the BIW region (e.g., north and south of the BIW Pier and Museum Point) early in April.

Until a study aimed at specifically determining overwintering locations was conducted by the MDMR in 1996 for the Maine Department of Transportation (DOT), the sites thought to be the most likely overwintering sites were deep pools below Bluff Head, and possibly in adjacent estuaries such as the Sheepscot (Squiers and Robillard, 1997). The 1996 study of overwintering activity suggests that at least one overwintering site is located above Bath. This is based on tracking 15 shortnose sturgeon collected and released in the vicinity of the Sasanoa River (Pleasant Cove), Winnegance Cove (near the Doubling Point reach), and Merrymeeting Bay (north of Bath and the Sasanoa River entrance). Tracking was done from October through January. Eleven of these fish were relocated in Merrymeeting Bay. Two of the fish from Pleasant Cove were never found in Merrymeeting Bay; one Pleasant Cove fish moved to Winnegance Cove and back to Pleasant Cove and another moved to Days Ferry (half way between Bath and Merrymeeting Bay). All of the fish that continued to transmit after November were only found in upper Merrymeeting Bay on the east-side of Swan Island (~river kilometer 40-42). Fish departed the wintering site between April 7-25, with most moving downstream toward the lower Kennebec estuary (Wippelhauser and Squiers, 2015). This is consistent with the trends for movement of shortnose sturgeon in the Delaware River (O'Herron et al., 1993). Overwintering sturgeon in the Delaware River are found in the area of Newbold Island, in the Trenton to Kinkora river reach, in an area geographically similar to the area around Swan Island.

Expected Seasonal Distribution of Shortnose Sturgeon in the Action Area

The discussion below summarizes the expected seasonal distribution of shortnose sturgeon in the action area. As noted above, the action area is limited to less than 1 km below the dam.

Adult shortnose sturgeon spawn between April and June. As described above (section 3.5), eggs and yolk-sac larvae remain near the spawning site. The egg development, hatching, and yolk-sac larvae (YSL) stage takes approximately 25 days. The post yolk-sac larvae (PYSL), a phase ends ~12-40 days post hatch. Table 16 illustrates anticipated timing of the presence of shortnose sturgeon early life stages in the Kennebec River, with the dates at the end of each time period based on the latest dates of spawning. Based on the information above, we do not expect any shortnose sturgeon life stages to be in the action area once the adults and early life stages have moved downstream following the spawning season.

Table 16. Timing of shortnose sturgeon lifestages and behaviors that may occur in the action area.

Lifestage	**Time of Year Present in Action Area**	**Behavior in Action Area**
Adults	April 1-June 15	Migration of spawning adults in the spring to and from spawning site.
Eggs & Yolk-Sac Larvae (YSL)	April 1-July 10	Eggs adhere to the substrate quickly after being deposited. Hatch times range from approximately 8-13 days postspawn. The YSL phase lasts approximately 8-12 days and is characterized by "swim up and drift" behavior. YSL are photonegative and seek cover in hard substrate. YSL remain near the spawning site.
Post Yolk-Sac Larvae (PYSL)	April 16-August 7	PYSL begin feeding (on aquatic insects, insect larvae and other invertebrates) and are free-swimming; they disperse downstream of the spawning/rearing area. The PYSL phase ends at about 12-40 days post-hatch. PYSL are typically found in the deepest water available

4.3 Status of Atlantic Sturgeon in the Action Area

As noted above, historical records provide evidence of commercial fisheries for Atlantic sturgeon in the Kennebec and Androscoggin Rivers dating back to the 17th century (Squiers et and Smith, 1979). Following the 1880s, the sturgeon fishery was almost non-existent due to a collapse of the sturgeon stocks. While directed fishing and retention as by-catch has been prohibited since 1998, the GOM DPS of Atlantic sturgeon remains threatened. Based on the NEAMAP survey data, we estimate an ocean population of 7,455 adult and subadult GOM DPS Atlantic sturgeon. In the marine range, GOM DPS Atlantic sturgeon are still incidentally captured in federal and state managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (Stein et al., 2004; ASMFC, 2007). Habitat disturbance and direct mortality from anthropogenic sources are primary concerns. Due to the lack of recaptures, to date, we do not have a population estimate for adult Atlantic sturgeon in the Kennebec River system (Wippelhauser and Squiers, 2015). For a summary of threats faced by the GOM DPS of Atlantic sturgeon, see section 3.6.4.

Coastal Movements

As part of a study to assess coastal movements of Atlantic sturgeon in the Gulf of Maine, Wippelhauser et al. (2017) captured 681 sub-adult and adult Atlantic sturgeon within four study rivers (Merrimack, Saco, Kennebec, and Penobscot). Approximately 25% (169) were tagged with acoustic transmitters for tracking using a series of acoustic receiver arrays in each of the rivers, as well as compatible arrays in the marine coastal environment. Of the 169 tagged sturgeon, 20 were captured and tagged in the Merrimack, 51 in the Saco, 55 in the Kennebec, and 43 in the Penobscot. Fifty-nine (59) individuals tagged elsewhere were detected in the Kennebec system. Non-spawning Atlantic sturgeon entered the Kennebec system in late May (median date of May 30) and departed early in the late summer or early fall (median date of August 25).

Spawning in the Kennebec River System

To date, despite captures of sturgeon in the Merrimack, Penobscot and Piscataqua/Salmon Falls/Cocheco rivers, as well as the necessary physical and biological features to support spawning in each of those rivers, the only confirmed spawning locations for the GOM DPS of Atlantic sturgeon are in the upper Kennebec River estuary and the Androscoggin River.

In the Wippelhauser et al. (2017) study, between 2010 and 2014, most tagged Atlantic sturgeon entered the Kennebec system during April and May (May 6 on average, with a range of April 11-June 17). They then moved to the spawning grounds mostly in June (average of June 14, range May 8-July 20), and remained at the spawning grounds through July (average of July 13, range of June 12-August 20). Water temperatures were typically over 16°C when Atlantic sturgeon occupied spawning areas, and freshwater discharge was usually less than 399 m^3/s. After spawning, some tagged individuals from the 2009-2011 study remained in Merrymeeting Bay or the lower Kennebec estuary for approximately 60 days before departing the system in October (Wippelhauser et al., 2017).

Expected Seasonal Distribution of Atlantic Sturgeon in the Action Area

Adult Atlantic sturgeon move into the action area to spawn in early June, departing by the end of July. Because we only expect Atlantic sturgeon to spawn in their natal river, all Atlantic sturgeon in the action area will be from the GOM DPS (ASSRT, 2007). As described above, eggs and yolk-sac larvae remain near the spawning site. The egg development, hatching, and yolk-sac larvae (YSL) stage lasts approximately 18 days. Post yolk-sac larvae (PYSL, a phase which ends ~40 days post hatch), could be in the action area from approximately mid-June until mid-September (i.e., 46 days from latest spawning date, September 15, all Atlantic sturgeon PYSL will become young of the year); however, only those larvae whose eggs were fertilized near the end of the spawning period (end of July) could possibly be present this late in the season (Table 17). We expect all Atlantic sturgeon to have entered the PYSL stage by approximately August 18, at which point they will begin to move downstream out of the action area, which is practically at the upstream limit of the spawning area. Based on the information above, we do not expect any Atlantic sturgeon life stages to be in the action area once the adults and early life stages have moved downstream following the spawning season.

Table 17. Timing of Atlantic sturgeon lifestages and behaviors that may occur in the action area.

Lifestage	Time of Year Present in Action Area	Behavior in Action Area
Adults	June 1-July 31	Migration of spawning adults in the spring to and from spawning site.
Eggs & Yolk-Sac Larvae (YSL)	June 1-August 18	Eggs adhere to the substrate quickly after being deposited. Hatching occurs ~3-6 days after egg deposition and fertilization. The YSL phase lasts approximately 8-12 days and is characterized by “swim up and drift” behavior. YSL are photonegative and seek cover in hard substrate. YSL remain near the spawning site.
Post Yolk-Sac Larvae (PYSL)	June 11-September 15	PYSL begin feeding (on aquatic insects, insect larvae and other invertebrates) and are free-swimming; they disperse downstream of the spawning/rearing area. The PYSL phase ends at about 40 days post-hatch. PYSL are typically found in the deepest water available

4.4 Status of Atlantic Sturgeon and Critical Habitat in the Action Area

As noted in section 2.6, the action area considered in this Opinion extends from the upper extent of the Weston Dam impoundment (approximately 20 kilometers upstream of the dam) to the confluence with the Sebasticook River, approximately 2,500 feet (0.75 kilometers) downstream of the Lockwood Dam (Figure 1). The Kennebec River critical habitat unit extends from Ticonic Falls/Lockwood Dam (approximately rm 64; river kilometer 103) downstream to where the mainstem river discharges at its mouth into the Atlantic Ocean. Therefore, only the uppermost 0.75 km of the critical habitat unit overlaps with the action area.

The Kennebec River in the action area is entirely freshwater (salinity <0.5ppt); therefore, PBF 2 of Atlantic sturgeon critical habitat (i.e., aquatic habitat with a gradual downstream salinity gradient of 0.5 up to as high as 30 ppt and soft substrate (*e.g.,* sand, mud) between the river mouth and spawning sites for juvenile foraging and physiological development) is not present in the action area. The other three PBFs are found in the action area, and we discuss their status below.

PBF 1

Hard bottom substrate in low salinity waters suitable for the settlement of fertilized eggs, refuge, growth, and development of early life stages (i.e., PBF1) can be found within the action area.

Studies conducted to date indicate that Atlantic sturgeon are utilizing spawning habitat that became accessible after the removal of Edwards Dam in 1999. Stone and Webster Environmental Technology Services (1995) surveyed the entire Edwards Dam impoundment, and found the most common sediment types were coarse sands, gravel, and mixtures of gravel with cobble. A survey of the lower Edwards Dam impoundment (river kilometer 75-87) found approximately 90% of the area consisted of rock, sand, and gravel or combinations of these substrates (Dudley 1999). Areas wetted by flows directly below the Lockwood Dam in the bypassed reach consist almost entirely of bedrock (FERC, 2005).

As stated above, two shortnose sturgeon larvae, which require similar rearing habitat conditions to Atlantic sturgeon, were captured below Lockwood Dam at river kilometer 102 (Wippelhauser et al., 2015). Spawning activity, which was used to identify critical habitat in the Kennebec system, was inferred from the detection of tagged Atlantic sturgeon in previously inaccessible portions of the river during the putative spawning season from mid-June to mid-July (Wippelhauser and Squires, 2015). As part of a study to assess coastal movements of Atlantic sturgeon in the Gulf of Maine, Wippelhauser et al. (2017) detected tagged Atlantic sturgeon by receivers located at river kilometer 87 and 102 in the restored Kennebec River.

We do not have substrate maps for the action area, but based on the collection of resources referenced above, we have a general picture of the substrate in the action area. Hard bottom habitat exists from below the Lockwood Dam (river kilometer 102) downstream as far as the

Sebasticook River confluence (river kilometer 101). Within that reach, some of the habitat is rock, cobble, or gravel with the interstitial spaces needed for spawning and rearing. Therefore, based on salinity and substrate, PBF1 is present in the action area.

PBF 3

PBF 3 requires water of appropriate depth and absent physical barriers to passage between the river mouth and spawning sites necessary to support:

(i) Unimpeded movement of adults to and from spawning sites;
(ii) Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary
(iii) Staging, resting, or holding of subadults or spawning condition adults.

Water depths in main river channels must also be deep enough (*e.g.,* at least 1.2 m) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river. Considering these criteria, PBF 3 is present throughout the portion of the action area below the Lockwood Dam.

Both historically and today, the location of the Lockwood Dam (Ticonic Falls) is the upstream limit for Atlantic sturgeon in the Kennebec River. From its construction in 1837 to its removal in 1999, Edwards Dam, located at the tidal limit of the upper Kennebec Estuary prevented sturgeon from accessing spawning habitat in the Kennebec River. Within the action area, while there are bankside developments (e.g., public boat launch) and ledge outcroppings on the eastern bank of the Kennebec River, there are no physical obstructions preventing passage of sturgeon. In addition to navigating around existing structures, sturgeon movements can also be impacted by gear set in the river, vessel traffic, and in-water stressors from ongoing construction projects (e.g., turbidity from dredging, sound pressure waves from pile driving, etc.). We are not aware of any ongoing construction projects in the action area.

The Lockwood Project is operated in a run-of-river mode. The project is operated to minimize the fluctuation of the reservoir surface elevation by maintaining a discharge from the project so that, at any given time, flows immediately below the project approximate the sum of inflows to the project reservoir. Seasonal and year-to-year variations in river flows are controlled through upstream storage in the basin at the Flagstaff, Brassua, and Moosehead Projects. Daily upstream peaking operations are re-regulated at the Williams Project, upstream of the Lockwood Project, so that inflows to the project area are relatively uniform (FERC License Order for the Williams Project; FERC Accession #20171103-3012).

Information pertaining to the hydraulic characteristics of the Kennebec River following the removal of Edwards Dam is sparse, but based on the detection of tagged Atlantic sturgeon by receivers located in the restored Kennebec River just below the Lockwood Dam, we are confident that the action area has the required water depths in the main river channel to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river.

PBF 4

PBF 4 (i.e., water between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that combined support spawning, survival, and larval, juvenile, and subadult development and recruitment), is present throughout the action area; however, we do not expect juvenile or subadult development to occur in the action area.

Spawning sites for the Atlantic sturgeon DPSs are well-oxygenated areas with flowing freshwater at the time of spawning, ranging in temperature from 13 °C to 26 °C (NMFS, 2017). Water quality factors of temperature, salinity and dissolved oxygen are interrelated environmental variables, and are constantly changing from influences of the tide, weather, season, etc. Dissolved oxygen concentrations in water can fluctuate given a number of factors including water temperature (e.g., cold water holds more oxygen than warm water) and salinity (e.g., the amount of oxygen that can dissolve in water decreases as salinity increases). This means that, for example, the dissolved oxygen levels that support growth and development will be different at different combinations of water temperature and salinity. Similarly, the dissolved oxygen levels that we would expect Atlantic sturgeon to avoid would also vary depending on the particular water temperature, salinity, and life stage. As dissolved oxygen tolerance changes with age, the conditions that support growth and development and likewise, the dissolved oxygen levels that would be avoided, change (82 FR 39160; NMFS, 2017).

Before the Clean Water Act of 1972, textile, pulp and paper, and municipalities discharged directly into the Kennebec River causing it to be one of the most heavily polluted rivers in the United States. Pollution caused reductions in fish and other aquatic organisms due to anoxic conditions during the summer months. However, even with this pollution, dissolved oxygen levels in the Androscoggin River just above the Brunswick Dam were measured at ~6 mg/L in the 1930s (Brennan et al., 1931 in Moore and Reblin (2010)). The main stern of the Kennebec River downstream of Augusta has restricted fish consumption due to the presence of dioxin from industrial point sources. Combined sewer overflows in Augusta and other communities along the river produce elevated bacteria levels, thus inhibiting recreation uses of the river (primary contact). The lower 22.7 miles of the Kennebec River downstream of its confluence with the Carrabassett River is impaired due to contamination of polychlorinated biphenyls. Other tributaries to the Kennebec River including the Sebasticook River area impaired due to contamination of mercury, PCBs, dioxin, and bacteria from industrial and municipal point sources. With the implementation of legal mandates on pollution discharge, dissolved oxygen levels have continued to improve in the Kennebec and Androscoggin Rivers (Moore and Reblin 2010). Surveys conducted in 2004 in the Kennebec estuary from approximately Popham Beach to Merrymeeting Bay returned surface and bottom DO levels ranging from 7.2-9.1 mg/L (Souther, 2005 in Moore and Reblin (2010)).

At present time, water quality in the action area is affected by pollutant discharge from the regulated river flow released by upstream storage projects plus inflow from the contributing drainage area. The basin above the project ranges from rural and forested unorganized townships, through sparsely populated rural areas, agricultural development, and smaller industrial communities and cities. There are five municipal and industrial wastewater discharges in the watershed above the project.

The State of Maine classifies the waters of the Kennebec River that are downstream of the Lockwood Project as Class B waters. Per the states regulations (§465)(Maine Legislature 2019):

> Class B waters. Class B waters shall be the 3rd highest classification.
>
> A. Class B waters must be of such quality that they are suitable for the designated uses of drinking water supply after treatment; fishing; agriculture; recreation in and on the water; industrial process and cooling water supply; hydroelectric power generation, except as prohibited under Title 12, section 403[24]; navigation; and as habitat for fish and other aquatic life. The habitat must be characterized as unimpaired.

Based on known water quality parameters of the action area (12.9-26.1°C between May and August (Wippelhauser et al., 2017); salinity below 0.5 ppt; dissolved oxygen levels at or above approximately 7 mg/L), as well as past captures of shortnose sturgeon larvae, and the capture and tracking of adult shortnose and Atlantic sturgeon during the spawning season, we are confident that the action area has the temperature, salinity, and oxygen values that combined support Atlantic sturgeon spawning and the survival of early life stages (eggs and larvae).

4.5 Consideration of Federal, State and Private Activities in the Action Area

4.5.1 Federal Activities in the Action Area

In the Environmental Baseline section of the Opinion, we discuss the impacts of all proposed Federal actions in the action area that have already undergone formal or early section 7 consultation.

On April 19, 2022 the USFWS issued a Biological Opinion for the construction of a bridge replacement over the Kennebec River that goes over the Lockwood Project and therefore is within the action area[25]. USFWS anticipated "a total non-lethal incidental take for this project of 324 adult and 52,916 smolt Atlantic salmon and a total lethal take of 4 adult Atlantic salmon. No lethal take of smolt Atlantic salmon is expected or authorized and no other life stages are expected to experience adverse effects or be subject to Incidental Take" (USFWS, 2022). They determined that, other than the lethal take of four adults, the adverse effects of bridge construction (e.g., turbidity, construction noise, habitat modification) would only result in

[24] Under Maine Statute Title 12, Chapter 200, 403, the Legislature granted special protection for outstanding river segments by declaring that "certain rivers, because of their unparalleled natural and recreational values, provide irreplaceable social and economic benefits to the people in their existing state" (Maine Legislature 2019).

[25] USFWS. 2022. Biological Opinion for the Ticonic Bridge Replacement Project, Waterville-Winslow, Maine (WIN 23138.00). (FWS #: 2022-0019427)

temporary impacts to behavior, such as foraging, migration, and holding. The Opinion indicates that the project is expected to start in the fall 2022 and will take approximately 3 to 4 years to complete. It also suggests that the project schedule may be extended if construction of the Lockwood bypass fishway, which is considered in this Opinion, takes longer to complete than planned. In-water work will occur in the Lockwood Project footprint at times of year when adult Atlantic salmon are in the action area.

4.5.1.1 Dams and Hydroelectric Facilities

There are four FERC-licensed dams within the action area in the lower Kennebec River that impact Atlantic salmon (i.e., Weston, Shawmut, Hydro-Kennebec, and Lockwood). As indicated above, all four projects are operating under FERC licenses that were amended to incorporate measures that minimize effects to salmon and sturgeon. We consulted on the issuance of the amended licenses and issued Opinions in 2012 and 2013 that expired in 2019. Despite the expiration of the Biological Opinions, the four projects continue to operate consistent with licenses that were amended to incorporate the provisions of the SPPs. The effects of the proposals to once again amend these licenses, as well as to issue a new license for the Shawmut Project, are the subject of this Opinion. For the four amendment proposals we analyze the future effects of the projects over the remainder of the existing licenses under the terms of the proposed SPP in the Effects of the Action section (section 6.0). However, as the dams are operating under amended licenses that have undergone consultation, and as they significantly affect listed salmon and sturgeon within the action area, we consider their past effects as part of the environmental baseline. As such, we consider the past effects of the Projects, including the effects to riverine processes (e.g., flow fluctuations, impoundments) and fish passage in the Kennebec River (i.e., passage efficiency, passage survival and injury, and migratory delay) in this section. Effects to salmon and sturgeon from the existence of the dams, including the resulting creation of impoundments, are considered solely as an aspect of the environmental baseline for the proposed license amendments, as the existence of the dams and resulting impoundments are not effects of the proposed license amendments. Other effects of these actions are a result of the operation of the projects pursuant to their FERC license to produce electricity or to pass fish, and are therefore, considered both in this Environmental Baseline section and in the Effects of the Action section. In the Shawmut relicensing, FERC has the discretion to order the decommissioning and removal of the dam and, therefore, we analyze the effects of the existence of the dam and its impoundment as a past effect in the environmental baseline, and, in the context of considering consequences of issuing a new license, as an effect of the action in the Effects of the Action section.

4.5.1.2 Fish Passage

As indicated, there are four hydroelectric projects within the action area (i.e., Lockwood, Hydro-Kennebec, Shawmut, and Weston). Prior to 2006 there was no passage for diadromous fish beyond the Lockwood Project in Waterville. The Lockwood fish trap started operating in that year, and a fish lift was later constructed at the Hydro-Kennebec Dam. The Shawmut and

Weston dams currently lack upstream fish passage facilities. All four dams have downstream fishways. As described previously, under past conditions, migrating prespawn salmon are transported from the Lockwood fish trap upstream to the Sandy River, which is upstream of all four dams. These adults then have the opportunity to spawn naturally in the wild. Additionally, egg stocking occurs annually in the Sandy River. Therefore, given that all life stages of Atlantic salmon are present above all four dams, we expect that adult and juvenile salmon migrate past the projects every year as they make their way downstream to the marine environment.

Juvenile Atlantic Salmon

The Lockwood, Hydro-Kennebec, Shawmut, and Weston Projects affect out-migrating diadromous fish by injuring and killing juveniles directly though turbine entrainment and indirectly through habitat modification (i.e., impoundments). The project impoundments also alter water quality, stream channel migratory routes, and the timing and behavior of out migrating fish.

Brookfield's studies between 2012 and 2015 (BWPH, 2013, 2014, 2015, 2016), which were conducted by Normandeau Associates, evaluated smolt movements and survival at the four lower Kennebec River dams. These studies are critical to understanding how the projects affect juvenile Atlantic salmon in the action area. These studies utilized the paired release methodology developed by Skalski et al. (2010) to estimate survival at each project over three years. The paired release method attempts to separate dam-related mortality from background levels of mortality by adjusting the survival of test fish that pass the dam (S1) by the survival of control fish released downstream of the dam (S2) (Figure 13). The adjustment to survival is made by dividing the survival of the test fish by the survival of the control fish (S1/S2=adjusted survival).

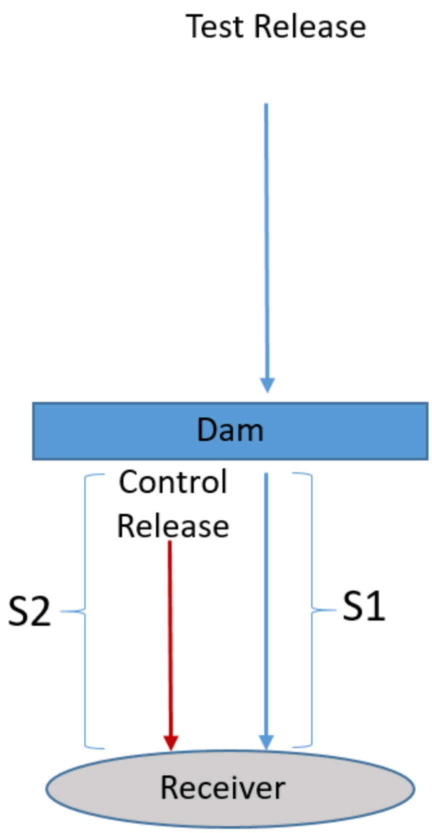

Figure 13. A simple illustration of the study design applied at the four hydroelectric projects on the Kennebec River. This is based on the methodology developed by Skalski et al. (2010). The adjusted survival is calculated by dividing the survival of the treatment fish (S1) by the survival of the control fish (S2).

In any survival study, it is essential that the monitored study reach be sufficiently long to capture all mortality attributable to dam passage. One of the primary assumptions of the paired-release method as developed by Skalski et al. (2010) is that "the first downstream detection site is sufficiently far below the dam to avoid false-positive detections of tagged fish that died during dam passage" (Skalski et al., 2010). They further indicate that this assumption "can be achieved logistically by appropriate spacing of release and detection site". In Skalski et al. (2010) the monitored reach downstream of the Rocky Reach Dam on the Columbia River was 22-km long. Conversely, the reaches used to monitor direct survival at the Kennebec dams between 2012 and 2015 ranged between 0.8-km and 8.9-km. A reach that is too short will only capture a portion of the total mortality that has occurred at the project. As the distance between the dam and the first downstream receiver is different for each project evaluated in Brookfield's 2012-2015 smolt studies (i.e., Weston: 8.9 km, Shawmut: 1.8 km, Hydro-Kennebec: 0.8 km, Lockwood: 2.8 km), it is probable that the proportion of total mortality incorporated into the estimate varies project to project. The violation of this assumption is apparent in Brookfield's study results, as presented in their Biological Assessment, where additional dam-related mortality was regularly observed downstream of those first receivers (when compared to mortality of the control release fish). It is likely that much of the mortality that occurs downstream of the dam is due to smolts succumbing to sublethal injury sustained during passage, but it could also be attributed to disorientation (leading to higher rates of predation) or significant scale loss. In addition to mortality occurring later in time and distance than the first receiver, it is possible that fish killed during passage could float past downstream receivers if they are too close and therefore be erroneously counted as alive. This effect has been documented in studies on the Penobscot and Union Rivers (BBHP, 2017; Music et al., 2010).

We have determined that the survival rates being reported in the study reports and in FERC's BA do not capture the entirety of the dam-related mortality occurring in the river. In order to more accurately analyze dam effects we need to consider dam-related mortality that was documented further downstream than the first downstream receiver in Brookfield's studies. Given the placement of receivers in the studies, we have determined that survival should be monitored at least to the next dam downstream, such that survival of fish passing Weston would be monitored downstream to the Shawmut Dam, that the survival of fish passing Shawmut should be monitored downstream to the Hydro-Kennebec Dam, and so on. For instance, instead of just considering the mortality that was documented prior to the first receiver downstream of Shawmut (1.75-km downstream) as was done in the study reports, we should consider the mortality that occurred prior to fish passing the receiver upstream of Hydro-Kennebec (an additional 7.7-km downstream). This mortality would be corrected using the survival of the control released fish (i.e., fish that were released just downstream of the Shawmut dam) through the same reach to estimate dam-related mortality. We conducted a preliminary analysis using this approach, which we presented to Brookfield staff in a meeting on May 23, 2022. Brookfield then independently replicated the analysis, which they submitted to us in a memo on June 23, 2022. The revised analysis (filed with FERC on September 21, 2022) confirms that additional dam-related mortality occurred downstream of the first receiver. We have incorporated the updated mortality estimates into our direct mortality analysis. It should be noted that Brookfield's revised analysis separates the survival at the project into two components; immediate survival (survival from passage to the first downstream receiver) and latent survival (survival of smolts between the first downstream receiver and the receiver immediately upstream of each dam). As the distance between the dam and the first downstream receiver is arbitrary and is different for each dam we do not believe that the distinction between immediate and latent in this context is meaningful. Therefore, in our analysis below we have combined the two (i.e., immediate survival x latent survival) to estimate the direct survival at each dam.

The paired release methodology has been applied widely at hydroelectric projects on the Columbia River using larger sample sizes than has been typical for studies of Atlantic salmon in Maine. Paired release methodology inflates the error associated with any survival estimate and, thus, overestimates survival when sample sizes are small (Zydlewski et al., 2016). The studies conducted by Normandeau Associates on the Kennebec used approximately 160 fish per project

(100 test fish + 60 control fish), however, Zydlewski et al. (2016) concluded that "paired release is generally not advantageous at release sizes less than 1000". Therefore, when sample sizes are small it is preferable to conduct a single release study, rather than a paired release, as there is less of a risk of overestimating dam survival (Zydlewski et al., 2016). However, a single release study assumes all mortality that occurs within the study reach is attributable to the dam, despite the general understanding that some amount of mortality (largely due to predation) occurs even in rivers without dams. Stich et al. (2015) determined that the average level of mortality through a free-flowing reach in the Penobscot River was 0.5% per kilometer (Stich, Bailey, et al., 2015). Although this seems minor, when you apply this rate to a 30 km reach (the approximate length of the action area) one would expect a total background mortality of 14%, which is significant. Goulette et al. (2017) released smolts downstream of the Lockwood Dam in 2014 and 2015 and documented 0.9-1.6% mortality per km through a 15-21 km free flowing freshwater reach between Sydney and Augusta, Maine (Goulette et al., 2017). As non-dam related mortality has been documented in the river just downstream of the action area, we believe that it is appropriate to adjust the results of the survival studies to account for it. Given the adjustments to the study reach length as described above, the overall dam related direct survival in the river using the paired release method (as reported below), is not significantly different from the average survival of smolts released at Weston to a point downstream of Lockwood. In comments filed with FERC on January 17, 2023[26], the Kennebec Coalition estimated that the 2013-2015 average survival of smolts between the release location above Weston and the last receiver downstream of Lockwood (including both dam related and background effects) was approximately 66% (2013-70.0%; 2014-69.7%; 2015-60.2%). As indicated below, we have estimated that total dam-related mortality allows for a total direct survival of 70.1%. Given the similarity in these results, we believe that the paired-release method provides the best available information as it adjusts the survival to allow for the background mortality that we know occurs in the river.

Direct Mortality

We consider direct mortality of smolts to encompass mortality that occurs immediately after dam passage, as well as mortality that occurs later in time in the river due to injury sustained during passage. In regard to the 2012-2015 smolt survival studies, we consider direct mortality to incorporate the dam-related losses, corrected for background mortality, documented between a point 200 meters upstream of each dam to a point 200 meters upstream of the next downstream dam (with the exception of the Lockwood Dam, where survival was monitored to the most downstream receiver in the river). It is reasonable to expect that these reaches would capture the majority of the mortality attributed to each individual project and that the revised analysis represents the best available information regarding smolt survival at the four projects.

The project specific survival rates as presented in Brookfield's September 2022 revised analysis vary between 87% and 96%, with a cumulative survival of approximately 70% (Table 18). It should be noted that the mode of operation has changed in some respects at these projects since

[26] FERC Accession #: 20230117-5043

the studies were conducted in 2012-2015. We will address these changes as they relate to salmon survival in the effects analysis (section 6.2.1).

Table 18. Average Atlantic salmon smolt survival documented at the four lower Kennebec Projects over three years of evaluation (Brookfield's Supplemental SPP; Accession # 20220921-5117).

Project	Reach (km)	Average
Weston	21.7	90.4%
Shawmut	9.5	87.1%
Hydro-Kennebec	1.6	93.0%
Lockwood	6.0	95.7%
Cumulative		**70.1%**

In addition to overall survival, Brookfield has provided route specific survival rates in their revised analysis (Table 19). Although the general survival trend at hydroelectric dams is for non-turbine routes (i.e., spillways and downstream bypasses) to have higher survival rates than turbine routes, this is not what was documented at Weston and Shawmut in these studies. At both of those projects, the non-turbine routes were at least as lethal as the turbine routes, and at the Weston Project the turbine route survival was significantly higher than what was documented at the non-turbine routes.

Table 19. Average route-specific survival rates for Atlantic salmon smolts at the four lower Kennebec Projects over three years of evaluation (Brookfield's Supplemental SPP; Accession # 20220921-5117)

Project	Spill	Bypass	Unit Type 1	Unit Type 2
Weston	84.5%	88.9%	97.0%	NA
Shawmut	87.7%	86.8%	84.5%	88.4%
Hydro-Kennebec	97.5%	94.5%	89.7%	69.4%
Lockwood	97.3%	97.1%	85.5%	88.1%

Indirect Mortality

The spatial and temporal scope of indirect mortality to Atlantic salmon smolts is much larger than direct mortality. In the below analysis we identify two primary sources of indirect mortality; 1) mortality in the impoundment that is a consequence of a reduced rate of movement in smolts, which may result in an increase in predation from other fish or birds, and 2) mortality that occurs later in time in the estuary as a result of migratory delay and sub-lethal injury attributed to the passage at multiple dams (i.e., hydrosystem delayed mortality).

Impoundment Mortality

Impoundment mortality is the excess mortality associated with impoundments above the expected level of natural mortality. Although the Weston, Shawmut, Hydro-Kennebec and Lockwood Projects operate as run-of-river and do not have significant fluctuations in headpond level, they do have impoundments of varying size (BWPH, 2014; Weston: 20.1 km, Shawmut: 19.3 km, Hydro-Kennebec: 4.7 km, Lockwood: 1.6 km). Impoundments created by dams limit access to habitat, alter habitat, and degrade water quality through increased temperatures and turbidity, as well as lowered dissolved oxygen levels. Furthermore, because hydropower dams are typically constructed in reaches with moderate to high underlying gradients, significant areas of free-flowing habitat have been converted to impounded habitats in the Kennebec River watershed. There is abundant information that demonstrates that large project impoundments have a negative effect on salmonids and their habitat (Havn et al., 2018; Jepsen et al., 1998; Keefer et al., 2012; Liew et al., 2016; Raymond, 1988; Stich et al., 2014; Todd et al., 2017; Venditti et al., 2000). Impounding water significantly modifies flowing, riverine habitats by converting them into still-water, lake habitats. This habitat modification creates ideal spawning conditions for non-native fish predators (e.g., bass, pike, pickerel), while eliminating suitable riverine habitat needed by certain anadromous fish species (e.g., Atlantic salmon, American shad, blueback herring) for spawning, rearing, and migration.

We used the reach specific survival rates collected during the three years of smolt survival studies to estimate the level of impoundment mortality (BWPH, 2014, 2015, 2016). These studies were not designed to monitor impoundment mortality, and therefore no information was collected in the Weston impoundment (as no fish were released upstream of the Weston impoundment), and no information was collected on the causative factor of mortality (e.g., death due to dam-induced predation, exhaustion, or stranding). However, as these are the only studies of smolt survival that have been conducted through these reaches, they provide the best available information regarding impoundment mortality at three of the four dams. Survival of fish released below Weston, Shawmut, and Hydro-Kennebec through the impoundment reaches can be used to extrapolate mortality in the Shawmut, Hydro-Kennebec, and Lockwood impoundments. This estimate can then be compared to what would be expected in a free-flowing reach to approximate the effect of the impoundment.

There is no information available on the level of mortality that occurs in the 20.1 km Weston impoundment. However, given the similarity between the Shawmut and Weston impoundments, we anticipate that the mortality rates would be similar. Smolts released downstream of Weston were monitored as they migrated through approximately 13 km of the 19.3 km Shawmut impoundment. The reach immediately below Weston was excluded from this analysis so that effects of that dam or any post-release handling effects did not confound the results. Survival through the 13 km reach was 98% in 2013 (99.8%/km), and 100% in both 2014 and 2015. Given the very high survival rates, impoundment-related mortality at Shawmut could not be separated from background levels of mortality. Therefore, we do not anticipate that the Shawmut and Weston impoundments contribute significantly to mortality of smolts leaving the Kennebec River.

Smolts released downstream of Shawmut were monitored as they migrated through approximately 3.5 km of the 4.5 km Hydro-Kennebec impoundment. Only the monitored reach immediately above the Hydro-Kennebec dam was considered in this analysis, as the two reaches immediately below Shawmut are not entirely within the Hydro-Kennebec impoundment. Due to failure of the receiver upstream of Hydro-Kennebec in 2013, which limited the utility of the data, we only included 2014 and 2015 in this analysis. Survival through the 3.5 km reach was 100% in 2014, and 94% (98.2%/km) in 2015. Comparing the survival of fish through the impoundment to survival through free-flowing reaches downstream of Lockwood in the same years (Goulette et al., 2017; 98.4%/km in 2014 and 99.1%/km in 2015), we estimate there was no discernible effect of the impoundment in 2014, but that it may have contributed as much as 5% mortality in 2015. Therefore, we estimate that the Hydro-Kennebec impoundment causes an annual average of 2.5% mortality (i.e., (0%+5%)/2 years).

Smolts released downstream of Hydro-Kennebec were monitored as they migrated through the 1.6 km Lockwood impoundment. Given the short distance between the two dams, it is difficult to discern whether mortality of study fish released below the dam is attributable to the effects of handling or the effects of the Lockwood impoundment. Regardless, survival of smolts released below Hydro-Kennebec in the Lockwood impoundment was 98% in 2013 and 99% in 2014 (no smolts were released at Hydro-Kennebec in 2015), which is approximately the same or higher than what we would have expected in a free-flowing reach of that length[27]. Therefore, we do not anticipate that the Lockwood impoundment contributes significantly to mortality of smolts leaving the Kennebec River.

Given the available information, we anticipate that impoundment mortality at the four projects may be as low as 0% and as high as 5%, with an average of 2.5%. Based on this analysis we expect the total annual impoundment mortality to be approximately 2.5%; that is, on average we expect 2.5% of smolts that pass downstream through the action area will die as a result of impoundment effects.

<u>Hydrosystem Delayed Mortality in the Estuary</u>

In addition to direct mortality sustained by Atlantic salmon at the four Kennebec River dams and indirect mortality associated with impoundments, at least some smolts experience delayed

[27] Goulette et al. (2017) did not monitor survival in 2013, so for this analysis we applied the average survival from 2014 and 2015 to 2013, and used the 2014 estimate for the 2014 analysis.

mortality in the estuary attributable to their interactions with the projects. Numerous studies have investigated what is referred to as latent or delayed mortality,[28] which occurs in the estuary or ocean environment and is associated with passage through one or more hydro projects (Budy et al., 2002; Haeseker et al., 2012; ISAB, 2007; Schaller & Petrosky, 2007; Stevens, 2019; Stich, Zydlewski, et al., 2015; Storch et al., 2022).

Budy et al. (2002) examined the influence of hydropower experience on estuarine and early ocean survival rates of juvenile salmonids migrating from the Snake River to test the hypothesis that some of the mortality that occurs after downstream migrants leave a river system may be due to cumulative effects of stress and injury associated with multiple dam passages. The primary factors leading to hydrosystem stress (and subsequent delayed mortality) cited by Budy et al. (2002) were dam passage routes (e.g., turbines, spillways, bypass systems), migration conditions (e.g., flow, temperature), and collection and transport around dams, all of which could lead to increased predation, greater vulnerability to disease, and reduced fitness associated with compromised energetic and physiological condition.

More recent studies have corroborated the indirect evidence for hydrosystem delayed mortality presented by Budy et al. (2002) and provided data on the effects of in-river and marine environmental conditions (Schaller and Petrosky, 2007; Haeseker et al., 2012). Based on an evaluation of historical tagging data describing spatial and temporal mortality patterns of downstream migrants, Schaller and Petrosky (2007) concluded that delayed mortality of Snake River Chinook salmon was evident and that it did not diminish with more favorable oceanic and climatic conditions.

A recent study by Storch et al. (2022) indicates that "while there are several factors that may dictate SARs [smolt to adult return rates] in any given year, the strong influence of hydrosystem effects is evident when comparing the success of populations in different subbasins throughout the system. Populations of yearling Chinook Salmon and steelhead in the Columbia River Basin that migrate past four or fewer mainstem dams survive at rates higher than those that must pass eight dams". They indicate that Chinook salmon that pass three or four dams in the Columbia River system have SAR rates that are nearly four times as high as those that have to pass eight dams; and nearly three times higher for steelhead (Storch et al., 2022). They attribute the cause of these much lower return rates to sub-lethal effects of dams that make it more difficult for juveniles to transition from freshwater to saltwater. Specifically, they indicate that "the condition of these fishes can be compromised by mechanical injury and stress during passage through bypass systems and turbines, with substantial delay in migration", and that "slowed outmigration may increase exposure to predation, competition, and elevated temperatures, thus increasing energetic costs and propensity for disease, and result in poorly timed estuary arrival" (Storch et al., 2022).

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[28] Hydrosystem delayed mortality is also referred to as latent mortality (Budy et al., 2002; Haeseker et al., 2012; ISAB, 2007; Schaller & Petrosky, 2007). For clarity, we will utilize the term delayed mortality throughout.

The extent that freshwater experience affects survival of smolts migrating through the estuarine and marine environment is contentious and the cause of the effect on Pacific salmonids continues to be debated (Storch et al., 2022). However, Storch et al. concludes that “an expansive body of evidence based on research and analyses across decades supports the role of freshwater factors as important determinants of life-cycle survival, and effects of these drivers can manifest during early ocean experience (i.e., delayed, or latent effects)” (Storch et al., 2022).

Although much of the research on hydrosystem delayed mortality has focused on Pacific salmon, studies have been conducted on the potential for it to affect Atlantic salmon in Maine. Stich et al. conducted an analysis on eight years (2005 to 2013) of Atlantic salmon smolt movement and survival data in the Penobscot River to determine what effect several factors (e.g. release location and date, river discharge, photoperiod, gill NKA enzyme activity, number of dams passed) have on survival through the estuary (Stich et al., 2015). They determined that estuary survival decreased as the number of dams passed during freshwater migration increased from two to nine (Figure 14). They estimated that each dam passed in the Penobscot led to a mortality rate of 6% in the estuary, which is distinct from direct mortality that occurs in the freshwater environment. Similar to Storch et al. (2022), Stich et al. (2015) attributed the cause of this mortality to migratory delay and sublethal injuries (such as scale loss) sustained during dam passage. These effects make smolts more susceptible to predation and disease.

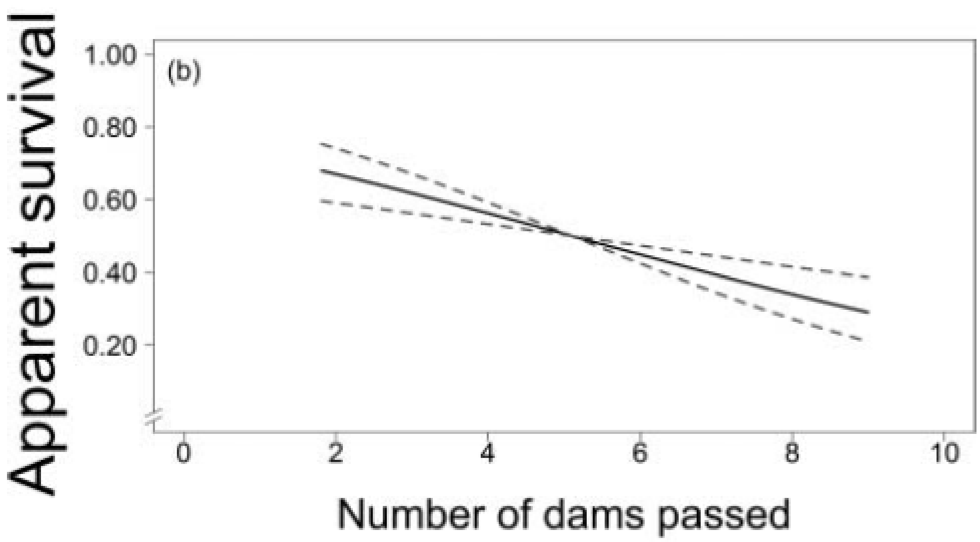

Figure 14. Apparent (or estimated) survival of Atlantic salmon smolts in the Penobscot River estuary based on the number of dams they passed during freshwater migration. The dark line is the mean survival and the dashed lines show the 95% confidence interval. The figure is excerpted from Stich et al. (2015).

No directed studies have been conducted to assess the amount of hydrosystem delayed mortality that occurs at the Weston, Shawmut, Hydro-Kennebec, and Lockwood Projects. However, given the occurrence of migratory delay and sublethal injury, we expect that delayed mortality occurs. It is not clear to what degree these two factors contribute to hydrosystem delayed mortality. Based on their similarity to the hydro dams on the Penobscot we assume that the Kennebec dams have a similar level of delayed mortality as what was described by Stich et al. (2015) (i.e., average of 6% per dam). We acknowledge that 6% is an average estimate of delayed mortality based on smolts that passed two to nine dams on the Penobscot River, and that an individual project's contribution may vary significantly from that average. We also recognize that delay and sublethal injury rates may vary based on conditions in the river and on the specifics of each individual project. However, applying the 6% average to these projects allows us to quantitatively estimate that the total delayed mortality in the system is 24% (6% x 4 dams). However, the relative amount of hydrosystem delayed mortality that occurs at each individual project is based on the degree to which they delay and injure smolts. Therefore, to better inform the Kennebec River delayed mortality estimate, we consider the scale of delay and injury that are currently caused by the four dams in the lower Kennebec.

Migratory Delay

Dams can significantly delay smolt outmigration, especially in low water years, because the individual fish must search and find an available passage route. Delays can lead to mortality of Atlantic salmon by creating conditions that increase the risk of predation (Blackwell & Juanes, 1998), and can also reduce overall physiological health or physiological preparedness for seawater entry and oceanic migration (Budy et al., 2002). Researchers have identified a "smolt window" or period of time in which smolts must reach estuarine waters or suffer irreversible negative effects (McCormick et al., 1998). Late migrants lose physiological smolt characteristics due to high water temperatures during spring migration. Similarly, artificially induced delays in migration from dams can result in a progressive misalignment of physiological adaptation of smolts to seawater entry, smolt migration rates, and suitable environmental conditions and cues for migration. If this occurs, these delays are expected to reduce smolt survival (McCormick et al., 1998).

The Weston, Shawmut, Hydro-Kennebec, and Lockwood Projects cause migratory delay of Atlantic salmon smolts in the Kennebec River. In the smolt survival studies conducted between 2012 and 2015, Normandeau Associates documented the amount of time that smolts spent in the area within 200 meters upstream of each dam prior to passage; referring to this time as project residence time. Residence time is a useful metric for evaluating the effectiveness of measures implemented to reduce delay (by increasing guidance to non-turbine passage routes), but it underestimates total delay as it does not consider delay associated with reduced flow rates in the project impoundments. Here we will address residence time at the four projects, but we will consider impoundment delay below. The average proportion of smolts that had a project residence time (within 200 meters upstream of the dam) exceeding 24 hours varied from 6.3% at

Lockwood to 19.2% at Weston (Table 20; BWPH 2013, 2014, 2015, 2016). The interannual variation suggests that flow over the spillway contributes to reduced delay. The average proportion of smolts taking more than 24 hours to pass each dam during the high flow year in the time series (2014) is approximately one third of what was observed during the low flow years (2013, 2015) (i.e., 5% and 14%, respectively). However, when Weston is removed from that analysis, the difference in the low flow years is nearly halved (from 14% to 8%).

Table 20. Migratory delay measured at the four Kennebec dams during smolt telemetry studies between 2012 and 2015 by Brookfield and Normandeau Associates. Delay is measured from the time the fish approaches within 200 meters of each dam to when it passes over the dam.

Project	Year	Median (hr)	Range (hr)	> 24 hours	
				Per Year	Average
Weston	2013	0.4	0.1-161.5	16.7%	19.2%
	2014	0.4	0.1-134.6	3.4%	
	2015	6.7	0.4-271.5	37.5%	
Shawmut	2013	0.7	0.1-118.5	13.7%	8.5%
	2014	0.3	0.1-73.6	5.4%	
	2015	0.3	0.1-48.2	6.5%	
Hydro-Kennebec	2012	1.4	0.1-46.5		7.3%
	2013	0.2	0.1-98.8	6.3%	
	2014	0.3	0.1-325.5	8.2%	
Lockwood	2013	0.1	0.1-206.0	6.3%	6.3%
	2014	0.1	0.1-59.5	3.1%	
	2015	0.6	0.2-99.0	9.5%	

In their BA, Brookfield analyzed system-wide migratory delay by looking at the cumulative residence time of each individual smolt that survived passage through all four dams. In this analysis they considered the threshold of effect to be 96-hours (i.e., 24 hours x 4 dams). They determined that, of the smolts that survived passage from above Weston to below Lockwood in 2013 and 2014, 98% and 100%, respectively, were delayed by less than 96 hours by the four dams (Table 21). Brookfield provided additional cumulative delay information for 2015 in response to a request from NMFS (K. Maloney, Brookfield, personal communication, March 4, 2022). Information from 2015 was not included in the initial analysis as project-specific delay was not measured at the Hydro-Kennebec Project that year.[29] Nevertheless, the supplemental information suggests that delay at the four projects was more significant in 2015 with approximately 87% of the smolts passing all four projects within 96-hours. Therefore, the

[29] Residence duration specific to Hydro-Kennebec during 2015 was calculated as the duration of time from detection approximately 200 m upstream of the Project until initial detection at Lockwood. Residence duration at Hydro-Kennebec was calculated as duration of time from detection at point 200 m upstream of Project until confirmed downstream passage during 2013 and 2014. This represents a difference of approximately 1 river mile (K. Maloney, Brookfield, personal communication, March 4, 2022).

available information indicates that on average approximately 95% of smolts that survive passage at all four dams over the three year study period passed all four projects within 96 hours

Table 21. The proportion of Atlantic salmon smolts that migrated from Weston to Lockwood during different time intervals during the 2013-2015 smolt survival studies conducted by Brookfield (K. Maloney, Brookfield, personal communication, March 4, 2022).

Duration (hours)	Annual Period				
	2013	2014	2015*	2013-2014	2013-2015*
0-24	72.0%	87.5%	49.1%	79.6%	68.9%
24-48	14.0%	10.4%	15.1%	12.2%	13.2%
48-72	6.0%		22.6%	3.1%	9.9%
72-96	6.0%	2.1%		4.1%	2.6%
96-120			3.8%		1.3%
120-144	2.0%		3.8%	1.0%	2.0%
144-168			1.9%		0.7%
168-192					
192-216			3.8%		1.3%
96 or Less	**98.0%**	**100.0%**	**86.8%**	**99.0%**	**94.7%**

It is important to note that Brookfield's cumulative analysis only summarizes delay for fish that *survived* passage past the four dams. Fish that died during the study period, for any reason, including as a result of significant delay (e.g., due to energetic effects, predation, etc.) are not included in the analysis. Table 16 indicates that at every *individual* project there were at least some years where some fish were delayed by more than 96-hours. Undoubtedly, there are additional fish that were cumulatively delayed by more than 96-hours. Given the results of Brookfield's analysis, it appears that many of these fish did not survive to the receiver downstream of Lockwood. This mortality would be accounted for in the direct mortality estimates described above. Despite this, the cumulative analysis is useful as it indicates that an average of 95% (three year range 87%-100%) of the smolts surviving passage through all four dams were delayed by an average of less than 24 hours at each of the four dams. The fact that fish experiencing delay in excess of 96 hours did not survive suggests that the ability for smolts to migrate through the river quickly may be essential to their survival, and emphasizes the need to minimize delay at each individual project to the maximum extent possible. As this analysis indicates that 5% (range between 0% and 13%) of the *surviving* fish are significantly delayed upstream of the dams, it is likely that migratory delay contributes to hydrosystem delayed mortality, particularly in low flow years. Although we do not know what amount of dam-induced delay constitutes a risk to salmon in the estuary, it is reasonable to expect that a period of 24-hours to pass each dam (96 hours cumulative) allows for smolts to follow their natural diurnal migratory behavior and that additional delay would have negative consequences to individuals. We anticipate that smolts that are delayed in excess of 24 hours per project are more likely to miss there physiological smolt window (i.e., the period when they are physiologically prepared to transition from freshwater to saltwater), more likely to be predated, and are more likely to be negatively affected due to energetic effects.

As indicated, the above estimates do not consider delay associated with the reduced rate of movement through the project impoundments that comprise the majority of the action area. Although Brookfield did not directly consider the amount of delay through the project impoundments, it can be extrapolated from the rate of movement information provided in the 2013 and 2015 smolt studies, at least at the Shawmut, Hydro-Kennebec, and Lockwood projects (no smolts were released above the Weston impoundment). Comparing the rate of movement through the impoundments in 2014 and 2015 to the rate observed through freshwater reaches below Lockwood by the NMFS Northeast Fisheries Science Center (NEFSC) allows us to estimate the project specific delay caused by the impoundments at each project (Goulette et al. 2017). As no tagged salmon smolts migrated through the Weston impoundment during these studies, we assumed that the rate of movement would be the same as what was observed in the Shawmut impoundment. This is appropriate as the two impoundments are approximately the same length and have similar morphology and flow, which should allow for a similar rate of movement for migrating smolts. Delay attributable to the impoundments is in addition to the residence time (200-meter zone upstream of each dam) reported by Brookfield (Table 22).

Table 22. Migratory delay associated with reduced rate of movement through the project impoundments. No study fish were released into the Weston impoundment so the Shawmut rate of movement was used.

Project	Length (km)	2014 Delay (hrs)	2015 Delay (hrs)	Average (hrs)
Weston	20	9	15	12
Shawmut	19	9	14	11
Hydro-Kennebec	5	0	2	1
Lockwood	2	0	1	0
Cumulative	46	18	32	25

Given their relatively short lengths, it is unlikely that the Lockwood and Hydro-Kennebec impoundments contribute significantly to the cumulative delay in the river regardless of the flow. However, it is apparent that the Weston and Shawmut impoundments combined contribute approximately a day to cumulative migration time; somewhat more in low flow years and somewhat less in high flow years. This delay is additive to the cumulative delay estimated by Brookfield in their analysis (Table 20), and therefore increases the probability that dam related mortality could contribute to hydrosystem delayed mortality. To approximate the effect that the impoundment delay could have on the cumulative delay through the system we have added 24 hours to the information in Table 21 above, such that the fish that passed all four projects between 72 and 96 hours (based solely on residence time) actually took between 96 and 120 hours when the impoundment delay is added in. This means that in addition to the 5% of smolts estimated by Brookfield to exceed the 96 hour delay threshold, another 3% of smolts on average exceed that threshold. As such, we expect that, on average, 8% of smolts exceeding the 96 hour delay threshold. We anticipate that this additional delay is attributable largely to reduced rate of movement through the Weston and Shawmut impoundments.

Injury

The available information indicates that a certain amount of sublethal injury will occur when smolts pass the Weston, Shawmut, Hydro-Kennebec, and Lockwood Projects. These fish either succumb to their injuries in the river or estuary, are predated upon due to their reduced fitness, or continue their migration without obvious fitness consequences. At this time we do not have sufficient information to determine the proportion of injured fish that fall into any of these three categories. As described above, sublethal injury is considered to be one of the causes of hydrosystem delayed mortality in the estuary. Although no empirical studies of injury have been conducted at these projects, FPL Energy (FPLE) conducted a desktop assessment of initial injury rate at Weston, Shawmut, and Lockwood that was included in their Biological Evaluation for the interim species protection plan in 2013 (FPLE, 2013; Accession #20130221-5160). This model can be used to approximate the injury of smolts that survived passage. FPL Energy evaluated smolt injury and mortality rates based on numerous studies at projects with similar turbine characteristics. In their analysis, they estimated that 7.5% of smolts that migrated through Kaplan units, and 23.8% of those that pass through Francis units would be injured (FPLE, 2013). The Francis units at the Weston Project were estimated to injure 16.2% of smolts as those turbines rotate at a slower rate. Hydro-Kennebec was not evaluated by FPL Energy, so for this analysis we assumed the two Kaplan units at that project are sufficiently similar to the Kaplan turbines at Lockwood and Shawmut to assume the same calculated rates as for those turbines. In a 2017 study report at a different project, Normandeau Associates conducted an analysis of the potential factors leading to injury rates through non-turbine routes (BBHP, 2017). In their analysis they compiled data from studies conducted at 22 facilities under 200 test conditions. They determined that the project head (i.e., the difference in elevation between the water level upstream and downstream of a dam) had a significant correlation with visible injury rate (Figures 15). The four projects considered in this opinion are low-head dams, ranging between 21-feet (Lockwood) and 34-feet (Weston), which according to Normandeau's analysis would suggest that the injury rates through non-turbine routes at these projects would be extremely low. Therefore, Normandeau Associates' analysis would suggest that fish that migrate through a non-turbine route at such low head dams would have an injury rate of close to 0%. However, the results of Brookfield's revised analysis suggest that non-turbine route (i.e., bypass, spillway) survival is relatively low at both the Shawmut and Weston Projects. Lacking empirical injury studies at these projects, we will assume that the non-turbine route injury rate is equivalent to what was observed in an injury assessment at the Ellsworth Hydro Project (BBHP, 2017);

therefore, we anticipate an injury rate of 3.8% at the Shawmut and Weston projects. In this analysis, we also reduce the expected injury associated with passage through the Francis units at the Weston Project, as the smolt survival through those turbines was unexpectedly high (97%). To be conservative, however, we will assume that some injury still occurs through that route, but that it is equivalent to what we would expect for Kaplan units (7.5%) rather than the rate assumed for Francis units by FPL Energy (16.2%), as described above.

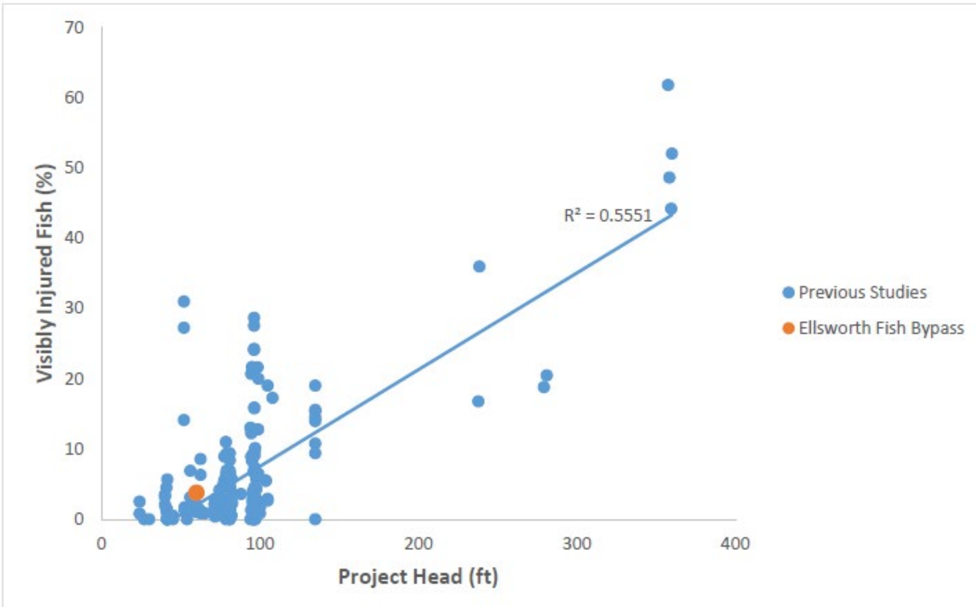

Figure 15. The relationship between project head and visible injury rate from previous studies of spillways and bypass structures (BBHP, 2017). For reference, the orange dot signifies the Ellsworth Hydro Project in Maine, which has a head of 70-feet, which is much higher than the projects in the lower Kennebec (<34-feet) that are being considered in this analysis.

Using the FPL Energy (2013) and Normandeau Associates (BBHP, 2017) information regarding estimated injury rates, as well as the passage route information from the three years of studies at the projects (BWPH 2013, 2014, 2015, 2016), we estimate that injury rates at Lockwood, Hydro-Kennebec, Shawmut, and Weston average approximately 2.2%, 2.1%, 6.9%, and 5.0%, respectively. As we anticipate that approximately 16% of smolts that survive passage through the four dams are injured during that passage, it is probable that these injuries contribute to hydrosystem delayed mortality.

Based on the available information (Stich et al., 2015, Stevens et al., 2019, Storch et al., 2022), we have identified migratory delay and injury as probable causes for hydrosystem delayed mortality. Absent studies that identify to what degree these two factors contribute to delayed mortality, we assume that they contribute equally. Normandeau Associates' analysis above indicates that the average proportion of smolts taking longer than 96 hours to pass all four projects (measured within 200 meters of each dam) is 5%, ranging between 0% and 13%, annually. In addition, our analysis of Normandeau's 2014-2015 study results (BWPH, 2015, 2016) suggests that the impoundments could be slowing fish by an additional day on average. Although we can't estimate the total proportion of fish that are delayed by more than 96 hours when impoundment delay is considered without more information on individual study smolts, it could be substantial, particularly in low flow years. As such, we believe that the cumulative effects of delay will contribute to the amount of hydrosystem delayed mortality that occurs in the Kennebec River. Our injury assessment, based on the desktop analysis conducted by FPL Energy (2013), indicates that an average of 16% of smolts would be injured as a result of passing through one or more dams but ultimately survive passage at the four dams and reach the estuary[30]. We have estimated that, on average, passage at a single dam can lead to 6% delayed mortality in the estuary and that half of this effect would be attributable to migratory delay and the other half to sublethal injury. Absent information regarding hydrosystem delayed mortality specific to the Kennebec River, information from the Penobscot River constitutes the best available information. As such, we anticipate that the average 6% hydrosystem delayed mortality per dam observed on the Penobscot River is an appropriate estimate for the Kennebec River. As such, we anticipate that 24% (6% x 4 dams) of the smolts that survive passage die in the estuary and marine environment due to effects associated with passage. Although these estimates are approximate, they are consistent with what has been observed elsewhere in the GOM DPS, and reflect the condition of the causative factors in the Kennebec River. As the 6% per project estimate is an average, we have weighed the project specific contribution by the relative degree that they affect the causative factors (Table 23). For instance, as injury and delay observed at Weston is more than twice what occurs at Lockwood, the hydrosystem delayed mortality estimate for that project is more than twice as high. Although imprecise, this approach recognizes that not all projects will lead to an equivalent amount of delayed mortality, and that project specific rates depend on the degree to which they delay and injure smolts.

Table 23. The calculation used to estimate the amount of hydrosystem delayed mortality attributable to each project[31].

[30] As we anticipate that these smolts will survive to the estuary prior to dying, they are distinct from the direct mortality, which is documented mortality that occurs in the river downstream of each dam.

[31] The '% Affected' column contains the estimated proportion of smolts affected by injury and delay at each project. The '% of Total' is the proportion of the total injury and delay found at all four projects that is attributed to each individual project. To estimate the HDM contribution for injury and delay at each project, we multiply the '% of Total' value by the anticipated cumulative HDM for the four projects (12% for both injury and delay). For example, 30.9% of the total injury occurring at the four projects is associated with Weston; therefore, it contributes 3.7% to HDM (i.e, 30.9% x 12%=3.7%). The baseline HDM is estimated by adding the 'Weighted HDM' contribution for both injury and delay.

Baseline	% Affected		% of Total		Weighted HDM		
Project	Injury	Delay	Injury	Delay	Injury	Delay	Baseline HDM
Weston	5.0%	19.2%	30.9%	46.5%	3.7%	5.6%	9.3%
Shawmut	6.9%	8.5%	42.6%	20.6%	5.1%	2.5%	7.6%
Hydro-Kennebec	2.1%	7.3%	13.0%	17.7%	1.6%	2.1%	3.7%
Lockwood	2.2%	6.3%	13.6%	15.3%	1.6%	1.8%	3.5%
Total	16.2%	41.3%	100.0%	100.0%	12.0%	12.0%	24.0%

To summarize, there are several sources of mortality associated with downstream passage through the four projects in the Kennebec, including direct and indirect mortality (Table 24). Given the baseline mortality rates, we anticipate that on average if 100 smolts migrated through the action area, approximately 47 would die due to direct or indirect effects caused by the projects. This does not include background levels of mortality in the action area that would occur regardless of the presence of the dams.

Table 24. The estimated dam-related mortality associated with smolt passage through the action area.

Project	Direct	Impoundment Indirect	HDM Indirect*	Project Cumulative[32]
Weston	9.6%	0.0%	9.3%	18.0%
Shawmut	12.9%	0.0%	7.6%	19.5%
HK	7.0%	2.5%	3.7%	12.7%
Lockwood	4.3%	0.0%	3.5%	7.6%
Cumulative	**29.9%**	**22.1%**		**46.8%**

*Hydrosystem Delayed Mortality
^ Mean (Range)

Postspawn Atlantic Salmon (Kelts)

Based on available information on returns to the Kennebec River, we anticipate that postspawn adults (i.e., kelts) pass downstream through the Weston, Shawmut, Hydro-Kennebec, and Lockwood Projects annually in the spring and late fall (Baum, 1997). At all four of these dams, there is potential for turbine entrainment, in addition to spillway and fishway passage. The Miramichi Salmon Association (MSA) measured the width of 93 Atlantic salmon kelts in 2012

[32] Cumulative survival is multiplicative, rather than additive. It is calculated as direct mortality x hydrosystem delayed mortality. This is because the types of mortality happen sequentially. Only those fish that survive the direct effects of passage are exposed to hydrosystem delayed mortality in the estuary

and determined that the average width was 4.1 inches (Range 2.6-6.1 inches) (Reid, J., MSA, Personal Communication, May 18, 2012). As the spacing on the racks at the turbine intakes (3.5-4") of all four projects exceed that width, we anticipate that smaller kelts can be entrained in the turbines. It is possible that the racks provide some behavioral deterrent to passing through despite spacing. Brookfield reports in their BA that there has only been a single kelt study conducted on the Kennebec River, and that the information gathered was limited to the Lockwood Project:

> Due to the limited availability of adult salmon, downstream passage studies for kelts in the Kennebec are limited to a single pilot study which was conducted at Lockwood during the late fall and early-winter 2007 (Normandeau 2008). Downstream passage data collection was limited to eleven hatchery-reared Atlantic salmon kelts that were released either just upstream of Lockwood or directly into the Lockwood power canal. The limited observations during this study indicated that 60% of out-migrating kelts passed downstream via spill into the bypassed reach with the remaining fish entering the power canal. Once in the power canal, kelts utilized the downstream bypass (50%) and the single Kaplan unit (Unit 7; 50%) (BWPH Draft BA 2021).

The available information is very limited, but does indicate that, as expected, salmon will pass via spill in relatively high proportions when it is present, and will use both the existing bypass and turbines for passage. It should be emphasized that kelts that passed through the turbines in this study all went through the Kaplan unit, which is the only turbine at the Lockwood Project under existing conditions that has rack spacing of greater than 2 inches. Although the empirical information is sparse, the former licensee conducted a desktop assessment of potential mortality at three of the four projects in the action area (all but Hydro-Kennebec) in their Biological Evaluation for the interim species protection plan in 2013 (FPLE 2013; Accession #20130221-5160). Given the lack of site-specific empirical data related to the route selection of Atlantic salmon kelts through the various turbine units, FPL Energy assumed (for modeling purposes) that the distribution of kelt passage through the turbines would be equal to the proportion of flow that passes through those units at maximum discharge. This distribution does not account for the presence of floating guidance booms at three of the projects that would deter kelts from passing through the powerhouse. To account for this we have conducted a separate analysis that assumes the project specific turbine and non-turbine survival rates used by FPL Energy for the Weston, Shawmut, and Lockwood Projects, but assumes that adults pass through the project routes in proportion to what was observed for juvenile Atlantic salmon during the 2012-2015 studies conducted by Normandeau Associates, when the guidance booms were in place at three of the projects. For the purposes of this analysis, we considered that the survival of kelts through the Kaplan units at the Hydro-Kennebec project, would be the same as what was estimated by FPL for the Kaplan units at the Lockwood Project. Under these conditions, we estimate that survival rates of 85%, 92%, 90%, and 92% would be expected at the Weston, Shawmut, Hydro-Kennebec, and Lockwood Projects, respectively. This equates to a cumulative survival through the four projects of 65%. Therefore, based on the results of this analysis, we expect that under existing conditions the cumulative effect of dam passage through the four dams leads to a loss of 35% of kelts due to dam related impacts in the action area.

<u>Prespawn Adult Atlantic salmon</u>

The Lockwood Project has a fish lift and trap to facilitate the capture of Atlantic salmon and river herring, which are trucked upstream, as well as to prevent invasive fish from moving further into the river. In 2016 and 2017, Brookfield conducted Atlantic salmon adult radio-telemetry studies of upstream passage at the Lockwood Project, where adult salmon captured at the Lockwood Dam were tagged and then released approximately 1.9 km back downstream of the dam. In both years, a total of 20 adult salmon were tagged at Lockwood. In 2016, 16 of the 18 test fish that returned to the vicinity of the dam were recaptured in the fish lift. In 2017, 14 of the 20 test fish were recaptured in the fish lift. Of the 20 adults tagged in 2017, two ascended the bypass reach and were able to pass upstream of the dam into the Lockwood impoundment (BWPH, 2018). In 2018 and 2019, Rubenstein (2021) conducted a study at the Milford Dam on the Penobscot River, and the Lockwood Dam on the Kennebec River, that evaluated the energetic effects of migratory delay of Atlantic salmon at dams. During the study, adult salmon were trapped at the Lockwood Project, tagged, and then returned to the river downstream of the dam. In 2018, four out of six (66%) tagged salmon were recaptured, whereas in 2019, nine out of twenty (45%) were recaptured (Rubenstein, 2021). When the 2016-2019 study results are pooled, 43 of 64 (67%) tagged adult salmon that returned to the Lockwood Project area were recaptured at the fish lift.

Trap and Truck

The Lockwood Project does not currently provide swim-through passage for any species of diadromous fish. Rather, fish are trapped at the dam, loaded into tanks on trucks, and transported to habitat above the dams. River herring are transported to numerous locations “both in and outside of the Kennebec River basin” (BWPH, 2021), whereas Atlantic salmon are driven up to the Sandy River, above Weston Dam. In general, there are benefits to this method of passing fish, assuming that a trap is efficient and that upstream migrants are able to locate the entrance and enter the trap. However, there are also negative effects. As salmon are trucked to a particular location, they do not have the ability to self-select suitable habitat. Salmon are transported directly to the Sandy River, bypassing smaller tributaries, where some suitable spawning habitat exists. This artificially limits the potential for spawning to occur throughout the watershed, reducing the potential for resilience afforded by spatial distribution. A second issue with trap and truck is that passage can only occur when staff are available to operate the trap, and transport the fish. Unlike with fish lifts, the operation of a trap is not automated. This may substantially affect the opportunities for a fish to pass the project in a given day. This may result in delay, which may limit opportunities for spawning. Additionally, a small proportion (2.4-2.6%) of Atlantic salmon that are trucked may stop migrating or fallback after they are released (Sigourney et al., 2015). This can be a problem if the salmon leaves the river prior to spawning, or if it drops down below a dam that lacks fish passage. Despite these concerns, the trap and truck operation at Lockwood does provide a means for prespawn adults to access abundant high quality spawning habitat in the Sandy River upstream of all four dams, which would otherwise be completely inaccessible.

Adult salmon that are unable to safely pass the Lockwood Dam either spawn in tributaries downstream of the dam where spawning habitat has been documented (e.g., Bond Brook, Togus Stream, Seven Mile Stream, Messalonskee Stream) (MDMR, 2017; MASRSC, 1986), or stray to other watersheds, such as the Sebasticook or the Androscoggin. Although no studies have looked directly at the fate of fish that fail to pass through Lockwood's upstream fish passage facilities, we convened an expert panel in 2010 to provide the best available information on the fate of these fish at fishways on the Penobscot River. The panel was composed of state, federal, and private sector Atlantic salmon biologists and engineers with expertise in Atlantic salmon biology and behavior at fishways. The group estimated a baseline mortality rate of 1% for Atlantic salmon that fail to pass a fishway at a given dam on the Penobscot River (NMFS, 2012). Therefore, assuming a similar effect occurs at the fish trap at Lockwood, 1% of the Atlantic salmon that fail to pass the Project may be subject to mortality. Therefore, it is assumed that of the Atlantic salmon that are motivated to pass the Lockwood Project, 67%[33] will pass successfully, 0.3% (1% x 33% failing to pass) will be killed attempting to pass, and 32.7% (99% x 33% failing to pass) will either spawn in downstream habitat in the Kennebec, or stray to another watershed (such as the Androscoggin or Sebasticook).

Migratory Delay

In 2016 and 2017, Brookfield conducted radio-telemetry studies of upstream passage by Atlantic salmon adults at the Lockwood Dam. The median delay documented by BWPH during the 2016 and 2017 studies was 9.9 days (range = 0.7 to 111.2) and 16 days (3.3-123.0 days), respectively; with 19 of 29 (65%) passing all four projects (due to trap and truck) in over 192 hours (BWPH, 2017, 2018).[34] This significant level of delay is likely attributable to several factors, including inadequate attraction to the existing fish trap, competing attraction into the bypass reach, and the inconsistent operation of the trap (does not operate at night or at temperature above 24.5°C). Although delay is extreme at Lockwood, once captured Atlantic salmon are released directly into spawning habitat in the Sandy River (rather than having to navigate through the river), which significantly reduces the effect of that delay.

Delay at dams can, individually and cumulatively, affect a salmon’s ability to access suitable spawning habitat within the narrow window when conditions in the river are suitable for migration. Additionally, migratory delay has negative energetic effects that may reduce the

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[33] As described above, 67% is the average upstream passage efficiency of the Lockwood fish lift, as determined by passage studies conducted in 2016-2019.

[34] We consider the delay of Atlantic salmon greater than 48 hours from when they approach within 200 meters of a dam as an effect that would not have occurred but for the presence of that dam. In a four dam system, we consider the cumulative delay effect threshold to be 192 hours (i.e., 4 dams x 48 hours).

likelihood that salmon will successfully spawn and out migrate to the estuary following spawning. A small increase in energy expenditure could affect an individual's ability to spawn, or reduce the likelihood that they could survive to spawn in a subsequent year (Rubenstein, 2021). Although Pacific salmon are generally semelparous (i.e., spawn in a single year) and die after spawning, Atlantic salmon have evolved to be iteroparous (i.e., spawn in multiple years) and are capable of returning to the ocean after spawning and subsequently returning to their natal river to spawn again. Multi-year spawners tend to be larger and have increased reproductive potential, and therefore, are important demographic components of a population (Fleming, 1996; Maynard et al., 2017). However, repeat spawners have nearly been eliminated from the GOM DPS (Maynard et al., 2017).

The threshold for iteroparity has been hypothesized to be 80% energy expenditure during migration and spawning (Glebe & Leggett, 1981). That is, an individual that uses more than 80% of its energy reserves will likely die after spawning, while those that use less have the potential to survive to spawn in multiple years. At the completion of their spawning migration, the energy loss for Atlantic salmon during spawning has been estimated to be 60-70% (Jonsson et al., 1997). The amount of energy used likely varies based on the length of the migration and the environmental conditions they are exposed to during migration. Salmon that migrate under warmer conditions also use more energy than those that migrate under cool conditions. Water temperature directly affects the rate of all biochemical reactions in ectothermic animals, such as Atlantic salmon, including metabolic processes (Angilletta Jr et al., 2002). This effect predicts a theoretical doubling of biological processes every 10ºC, and this theoretical trend is validated by empirical data from salmonids (Brett & Groves, 1979). Although they spawn in late fall, Atlantic salmon have adapted to migrate to spawning grounds early in the summer, which minimizes the energetic cost of the migration. The optimum migration temperature for adult salmon is between 14°C and 20°C, which occurs primarily in the months of May and June in the GOM DPS. Frechette et al. (2018) found that Atlantic salmon used thermal refuges to maintain body temperatures between 16-20°C, indicating that temperatures above that range are likely to induce thermal stress. It is not unusual for the temperature in the mainstem of the Kennebec River (and other rivers in the GOM DPS) to exceed 20°C, particularly in the summer months at the tail end of the typical migration period (July through September).

In 2018 and 2019, Rubenstein (2021) conducted a study at the Lockwood Dam that evaluated the energetic effects of migratory delay of Atlantic salmon at dams, and how the effects are related to water temperature. In her examination of the thermal experience of adult salmon in the lower Kennebec River, Rubenstein (2021) found that 5 out of 8 tagged individuals exhibited behavioral thermoregulation, meaning that they were likely able to locate suitable thermal refuge. The remaining 3 salmon had a thermal experience that was similar to that of the downstream temperature logger, which potentially means that they could not locate cold water refuge, or else did not make significant use of it. Upstream delay of spawning adults associated with ineffective passage at dams may therefore force salmon to spend more time in warm water, which can increase the energy costs of migration, particularly if they cannot locate or make use of cold water refuge. Rubenstein found that salmon lost an average of 16.4% (range between 2.1% and 38.3%) of their original endogenous fat reserves between capture and recapture at the Lockwood Dam. This is likely an overestimate of dam-related energy depletion, as Rubenstein released fish 14 km downstream of the Lockwood Project, and therefore some proportion of that fat loss occurred prior to fish encountering the dam (average approach time to the dam was 4 days and 7.7 days in 2018 and 2019, respectively, as compared to average delay of 18.8 days and 15.1 days at the dam itself) (Rubenstein et al., 2022). Regardless, the energetic effects of cumulative delay imposed by multi-dam systems likely increase the chance that a returning adult Atlantic salmon will die before or after spawning (Rubenstein, 2021). In a model that utilized Kennebec River temperature data (which is significantly cooler than the Penobscot), Rubenstein demonstrated that the energetic effects to salmon due to migratory delay at one dam could result in 10.5% of adults dying before spawning and only 13.6% of adults surviving after spawning. To put this into context, the model results for a free-flowing (i.e., no dams) river indicated that 7% of salmon could die due to energetic effects before spawning, and that 17.4% would survive after spawning (Rubenstein, 2021). This effect would be even worse with multiple dams with similarly high rates of delay.

The energetic implications of migratory delay are compounded by the fact that adult salmon are potentially delayed both in their upstream migration to spawning habitat, as well as in their downstream migration after spawning, due the effects of dams. Migratory delay of kelts has the potential to lead to substantial depletion of energy reserves that can lead to considerable reduction in postspawn survival rates (Jonsson et al, 1997; Baktoft et al., 2020; Rubenstein, 2021). We do not have any information on the level of migratory delay experienced by postspawn Atlantic salmon as they migrate out of the Kennebec River. Babin et al. (2021) indicates that as kelts migrate high in the water column (the upper 5 meters), they are able to move quickly through surface passage routes, such as spillways and downstream bypass fishways. Many researchers have indicated that higher discharge through these routes leads to higher survival and lower migratory delay (Babin et al., 2021; Colotelo et al., 2018; Harnish et al., 2015; Nyqvist, 2016; Wertheimer & Evans, 2005). As such, we expect that during high flow periods on the Kennebec, when excess water spills over the spillways, kelts would migrate quickly through the action area. Similarly, at lower flows when no flow is going over the spillways, kelts would likely locate and use the downstream bypass fishways, which are operated at all four projects. However, delay may be more of a problem for kelts during these periods as most flow is going through the turbines, which appear to cause higher levels of delay. We do not know how much delay would contribute to a loss of fitness in Atlantic salmon kelts, and it likely varies due to flows and water temperature, as well as the amount of delay experienced by each individual fish during their upstream migration. It is further complicated by the fact that some kelts may start feeding after spawning, which would partially offset the energetic effects of any migratory delay (Johansen, 2001; Penney & Moffitt, 2014). Given the relatively cool water temperatures in the Kennebec River at the time when kelts are migrating, the fact that kelts are known to pass at periods when there is abundant spillway flow, and that the projects provide additional bypass route flow in low water periods, we do not expect that migratory delay of

Atlantic salmon kelts contributes significantly to the loss of postspawn salmon in the Kennebec River.

4.5.2 State or Private Activities in the Action Area

State of Maine Stocking Program

The State of Maine stocks other salmonids into the Kennebec River watershed, including brook trout, brown trout, and landlocked salmon.[35] Both native brook trout and non-native brown trout are stocked in the action area annually, most recently in 2022. Competitive interactions between wild Atlantic salmon and other salmonid fishes, especially introduced species, are not well understood in Maine. State managed programs supporting recreational fisheries often include stocking non-indigenous salmonid fish into rivers containing anadromous Atlantic salmon. Competition plays an important role in habitat use by defining niches that are desirable for optimal feeding, sheltering and spawning. Limited resources may also increase competitive interactions that may act to limit the time and energy fish can spend obtaining nutrients essential to survival. This is most noticeable shortly after fry emerge from redds, when fry densities are at their highest (Hearn, 1987) and food availability is limited. Prior residence of wild salmonids may confer a competitive advantage during this time over domesticated hatchery juveniles (Letcher, 2002; Metcalfe, 2003); even though the hatchery reared individuals may be larger (Metcalfe, 2003). This may limit the success of hatchery cohorts stocked annually to support the recovery of Atlantic salmon. Annual population assessments and smolt trapping estimates conducted on GOM DPS rivers indicates stocking of hatchery reared Atlantic salmon fry and parr in areas where wild salmon exist could limit natural production and may not increase the overall population level in freshwater habitats. The amount of quality habitat available to wild Atlantic salmon may also increase inter and intra-specific interactions between species due to significant overlap of habitat use during periods of poor environmental conditions such as during drought or high water temperatures. These interactions may impact survival and cause Atlantic salmon, brook and brown trout populations to fluctuate from year to year. However, since brook trout and Atlantic salmon co-evolved, wild populations should be able to coexist with minimal long-term effects (Hearn, 1987; Fausch, 1988).

Water Quality

Water quality has significant implications for the functioning of designated critical habitat. The parameters of particular importance to the suitability of Atlantic salmon are water temperature and dissolved oxygen (DO). Above, we have discussed water temperature in the action area and how it likely affects Atlantic salmon.

In their DEA, FERC summarized the water quality information provided by Brookfield for the Shawmut relicensing:

[35] Maine Department of Inland Fisheries and Wildlife. 2022 Stocking Report. www.maine.gov/ifw/fishing-boating/fishing/fish-stocking-report.html

> Throughout the sample period, the DO concentration at the trophic sampling location in the impoundment ranged from 1.4 mg/L to 9.7 mg/L. Low DO measurements (1.4 mg/L, and 3.0 mg/L) were measured on June 30 near the bottom of the impoundment. The highest DO concentration in the impoundment was 9.7 mg/L on October 18. The average DO concentration throughout the water column ranged from 7.0 mg/L on June 30 to 9.6 mg/L on October 18. With the exception of two low DO measurements near the bottom of the impoundment on June 30, the DO concentrations exceeded the state standard of 5 mg/L for Class C waters.
>
> In June and August 2016, DO downstream of the dam ranged from a minimum of 6.8 mg/L in August to a maximum of 9.6 mg/L in June. Average monthly DO concentrations ranged from 7.6 mg/L in August to 8.9 mg/L in June.

As indicated in Table 8, DO allows for functional habitat within these ranges: embryo development (between 7-8 mg/l), rearing (>2.9 mg/l), and migration (>4.5 mg/l). Although the mainstem may not be conducive for spawning and rearing for other reasons discussed previously, the information provided by Brookfield indicates that DO is within the functional range at the appropriate time of year. Although the bottom of the impoundment had low DO readings during the June sampling event, we would not expect spawning or fry development to be occurring at that time of year. The habitat would not function for parr rearing at those DO levels, but it is not expected that they would occur at the bottom of the 30 foot deep impoundment, as we expect parr to occur primarily in habitat that is less than one foot in depth.

We do not have dissolved oxygen information from other portions in the action area, however, we expect that similar conditions persist throughout. As temperature and DO in the action area are within the functional range for outmigration of smolts and kelts at the appropriate times of year, they are not expected to limit their migratory behavior.

Pollutants discharged from point sources affect water quality within the action area of this consultation. Common point sources of pollutants include publicly operated waste treatment facilities, overboard discharges (OBD, a type of waste water treatment system), and industrial sites and discharges. The Maine Department of Environmental Protection (MDEP) issues permits under the National Pollutant Discharge Elimination System (NPDES) for licensed point source discharges. Conditions and license limits are set to maintain the existing water quality classification. Generally, the impacts of point source pollution are greater in the larger rivers of the GOM DPS.

Poor water quality within segments of the Kennebec River is of particular concern for fisheries restoration. MDEP classifies the action area in the Kennebec River as follows.[36] [37]

- Sebasticook River upstream to Lockwood Dam: Class B Status: Impaired by pollutants-reasonably expected to result in attainment by 2030
- Lockwood Dam to Hydro-Kennebec Dam: Class C Status: Impaired by pollutants-reasonably expected to result in attainment by 2030
- Hydro-Kennebec Dam to Shawmut Dam: Class B Status: Impaired by pollutants-reasonably expected to result in attainment by 2030
- Shawmut Dam to the Fairfield-Skowhegan town line: Class C Status: Impaired due to dioxin and PCBs. Potential aquatic life use impairment.
- Fairfield-Skowhegan town line to the Sandy River: Class B Status: Impaired by pollutants-reasonably expected to result in attainment by 2030

Class B waters must be of such quality that they are suitable for the designated uses of drinking water supply after treatment; fishing; agriculture; recreation in and on the water; industrial process and cooling water supply; hydroelectric power generation, except as prohibited under Title 12, section 403; navigation; and as habitat for fish and other aquatic life. The habitat must be characterized as unimpaired. Class C waters must be of such quality that they are suitable for the designated uses of drinking water supply after treatment; fishing; agriculture; recreation in and on the water; industrial process and cooling water supply; hydroelectric power generation; navigation; and as a habitat for fish and other aquatic life (MDEP 2014).

The contaminants in these reaches may affect the growth rate and development of juvenile salmon in the action area (Lundin et al., 2021), potentially making this mainstem habitat less suitable for salmon spawning and rearing. However, these river reaches are primarily used as a migratory corridor for downstream migrating smolts and adults, and under existing conditions, are not used for spawning and rearing due to the lack of passage at the dams. We expect that smolts and kelts spend minimal time in the action area as they move relatively quickly once they start migrating (Babin et al., 2021; McCormick et al., 1998); likely exiting the action area within a period of days. This rapid migration limits their exposure to the contaminants as they are less likely to feed as they migrate to the estuary (and are therefore less likely to bioaccumulate contaminants in their tissues). Given the limited exposure to any contaminants in the action area, we do not expect them to significantly affect salmon health or behavior.

5 Climate Change

The discussion below presents background information on global climate change and information on past and predicted future effects of global climate change throughout the range of

[36] MDEP. Maine Statutory Water Classification. Accessed on May 12, 2022. https://maine.maps.arcgis.com/apps/webappviewer/index.html?id=397738f1d21d42589ab7ac989e2db568

[37] MDEP. 2018/2020/2022 Integrated Water Quality Monitoring and Assessment Report. Final Draft. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.maine.gov/dep/water/monitoring/305b/2022/2018-22_ME_IntegratedRpt-LIST-FinalDraft.pdf

the listed species considered here. Additionally, we present the available information on predicted effects of climate change on listed species and critical habitat in the action area over the lifespan of the proposed project. Climate change is relevant to the Status of the Species, Environmental Baseline and Cumulative Effects sections of this Opinion; rather than include partial discussion in several sections of this Opinion, we are synthesizing this information into one discussion, below.

5.1 Background Information on Global climate change

In its Sixth Assessment Report (AR6) from 2021, the Intergovernmental Panel on Climate Change (IPCC) stated that the "global surface temperature in the first two decades of the 21st century (2001–2020) was 0.99 [0.84 to 1.10] °C higher than 1850–1900" (IPCC 2021). Similarly, the total increase between the average of the 1850-1900 period and the 2010-2019 period is 1.07°C (likely range: 0.8° to 1.3°C). On a global scale, ocean warming has on average increased by 0.88 [0.68–1.01] °C from 1850-1900 to 19 2011-2020, with 0.60 [0.44–0.74] °C of this warming having occurred since 1980 (Fox-Kemper et al., 2021). In regards to resultant sea level rise, the global mean sea level increased by 0.20 (0.15 to 0.25) meters between 1901 and 2018. The average rate of sea level rise between 2006 and 2018 increased to 3.7 mm/yr (likely range of 3.2 to 4.2), up from 1.3 mm/yr between 1901 and 1971.

The IPCC (2021) climate model projections exhibit five scenarios, or shared socioeconomic pathways (SSP's) that cover a range of plausible future development of anthropogenic drivers of climate change, for both temperature and precipitation over the next several decades. SSP3-7.0 and SSP5-8.5 represent very high emission scenarios with CO_2 levels continuing to increase; SP2-4.5 represents a moderate emission scenario; and SP1-1.9 and SP1-2.6 represent low emission scenarios. Under all scenarios global surface temperature will continue to increase by 1.5 ºC to 2.0 ºC until at least mid-century unless there are deep reductions in CO_2 and other greenhouse gas emissions. A warmer climate is expected to result in increased climate extremes including intensified periods of very wet and very dry conditions resulting in increased periods of flooding and drought (IPCC, 2021). Climate warming has also resulted in increased river discharge and glacial and sea-ice melting (Greene et al. 2008). Over the remainder of the 21st century, upper ocean stratification, ocean acidification, and ocean deoxygenation will continue to increase at rates dependent on future scenarios (IPCC, 2021).

The most recent estimate of likely global mean sea level rise by 2100 ranges from 0.28-0.55 m under the lowest emissions scenarios, to 0.63 - 1.01 m under the highest emission scenarios (IPCC 2021). Over the long term, sea levels are expected to rise for centuries to millennia due to continuing deep-ocean warming and ice sheet melting.

The past three decades have witnessed major changes in ocean circulation patterns in the Arctic, and these were accompanied by climate associated changes as well (Greene et al., 2008). Shifts in atmospheric conditions have altered Arctic Ocean circulation patterns and the export of freshwater to the North Atlantic (Greene et al., 2008; IPCC, 2007). With respect specifically to the North Atlantic Oscillation (NAO), changes in salinity and temperature are thought to be the result of changes in the Earth's atmosphere caused by anthropogenic forces (IPCC, 2007). The NAO impacts climate variability throughout the Northern Hemisphere (IPCC, 2007). Data from the 1960s through the 2000s showed that the NAO index increased from minimum values in the 1960s to strongly positive index values in the 1990s and somewhat declined since (IPCC, 2007). On a global scale, large discharges of freshwater into the North Atlantic subarctic seas can lead to intense stratification of the upper water column and a disruption of North Atlantic Deepwater (NADW) formation (IPCC, 2007; Greene et al*.,* 2008). There is evidence that the NADW has already freshened significantly (IPCC, 2007). This in turn can lead to a slowing down of the global ocean thermohaline (large-scale circulation in the ocean that transforms low-density upper ocean waters to higher density intermediate and deep waters and returns those waters back to the upper ocean), which can have climatic ramifications for the entire world (Greene et al., 2008).

There is a high confidence, based on substantial new evidence, that observed changes in marine systems are associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels, and circulation. Ocean acidification resulting from massive amounts of carbon dioxide and pollutants released into the air can have major adverse impacts on the calcium balance in the oceans. Changes to the marine ecosystem due to climate change include shifts in ranges and changes in algal, plankton, and fish abundance (IPCC, 2007). These trends have been most apparent over the past few decades, although this may also be due to increased research. Information on future impacts of climate change in the action area is discussed below.

5.1.1 Regional Impacts

In the Northeast U.S. (West Virginia to Maine), between 1895 and 2011, temperatures increased by nearly 2ºC; precipitation increased by approximately 13 cm, and sea levels rose by approximately 30 cm (Melillo et al., 2014). Relative to other regions, the Northeast has experienced greater increases in extreme precipitation, and the rate of sea level rise exceeds the global average (Melillo et al., 2014). Looking forward, it is expected that temperatures in the Northeast could warm between 4.5ºC to 10ºC by the 2080s if carbon emissions continue to increase (Melillo et al., 2014).

In Maine, the average annual temperature has increased nearly 1.8ºC in the last 124 years with northern and western Maine (1.7ºC) warming at slower rates than coastal Maine (1.8ºC) (Fernandez et al., 2020). Most of the warming that has occurred in Maine has happened since 1960 with an average annual increase of 0.026ºC per year (Fernandez et al., 2020). The average annual precipitation in Maine has also increased. Maine's average annual precipitation has increased 15% (~15 cm) since 1895, with most of that increase in the form of rain and less snow. Much of the increased precipitation is associated with increases in storm intensity predominantly during the fall time (*summarized in* Fernandez et al., 2020). As for snowfall, the average annual snow depth has decreased by 20% (5.8 cm) since 1895 (Fernandez et al., 2020). Although Maine has seen a considerable increase in the average annual precipitation, Maine has also experienced increases in the severity and duration of drought events (Fernandez et al., 2020).

While predictions are available regarding potential effects of climate change globally, it is more difficult to assess the potential effects of climate change over the time period considered in this consultation on coastal and marine resources on smaller geographic scales, such as the action area, especially as climate variability is a dominant factor in shaping coastal and marine systems. The effects of future change will vary greatly in diverse coastal regions for the U.S. Additional information on potential effects of climate change specific to the action area is discussed below. The longest duration action considered in this consultation is the proposed relicensing of the Shawmut Project; if issued, the new license is expected to authorize operations for up to 50 years. Warming is very likely to continue in the U.S. over the time period considered in this consultation regardless of reduction in greenhouse gasses, due to emissions that have already occurred (Pörtner et al., 2022). It is very likely that the magnitude and frequency of ecosystem changes will continue to increase over this period, and it is possible that they will accelerate (Portner et al., 2022). Climate change can cause or exacerbate direct stress on ecosystems through high temperatures, a reduction in water availability, and altered frequency of extreme events and severe storms. Water temperatures in streams and rivers are likely to increase as the climate warms and are very likely to have both direct and indirect effects on aquatic ecosystems. Changes in temperature will be most evident during low flow periods when they are of greatest concern (NAST, 2000). In some marine and freshwater systems, shifts in geographic ranges and changes in algal, plankton, and fish abundance are associated with high confidence with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation (IPCC, 2007).

Expected consequences of climate change for river systems include a decrease in the amount of dissolved oxygen in surface waters and an increase in the concentration of nutrients and toxic chemicals due to reduced flushing rate (Murdoch et al. 2000). Increased warming may also invoke mutualistic and antagonistic interactions among species (Hulme, 2005) (i.e., give warmer water species an advantage over cool or cold water species). A warmer-wetter climate could ameliorate poor water quality conditions in places where human-caused concentrations of nutrients and pollutants currently degrade water quality (Murdoch et al., 2000). Increases in water temperature and changes in seasonal patterns of runoff will very likely disturb fish habitat. Surface water resources along the U.S. Atlantic coast are intensively managed with dams and channels and almost all are affected by human activities; in some systems water quality is either below recommended levels or nearly so. A global analysis of the potential effects of climate change on river basins indicates that due to changes in discharge and demands for water resources, the area of large river basins in need of reactive or proactive management interventions in response to climate change will be much higher for basins impacted by dams than for basins with free-flowing rivers (Palmer et al., 2008). Human-induced disturbances also influence coastal and marine systems, often reducing the ability of the systems to adapt so that systems that might ordinarily be capable of responding to variability and change are less able to do so. Because stresses on water quality are associated with many activities, the impacts of the existing stresses are likely to be exacerbated by climate change. Within 50 years, river basins that are impacted by dams or by extensive development will experience greater changes in discharge and water stress than unimpacted, free-flowing rivers (Palmer et al., 2008).

5.2 Anticipated Effects to Atlantic salmon and Critical Habitat

Atlantic salmon are one of the most vulnerable managed fish species in the Northeast U.S. Shelf to climate change as a function of their sensitivity and exposure to climate stressors (Hare et al., 2016). Factors such as fecundity, anadromy and finite range of suitable habitats and prey resources contribute to salmon's vulnerability. Water temperature is one of the most important environmental factors affecting all forms of aquatic life in rivers and streams (Annear et al., 2004). Temperature is especially important for Atlantic salmon given that they are poikilothermic (i.e., their body temperatures and metabolic processes are determined by temperature). Although temperature can be a stimulant for salmon migration, spawning, and feeding (Elson, 1969), they are cold water fish and, therefore, have a thermal tolerance zone where activity and growth is optimal (DeCola, 1970). Elliot (1991) identified the upper incipient lethal maximum temperature (i.e., the temperature at which 50% of the test fish survive) for juvenile Atlantic salmon as 27.8°C (survival over 7 days). Adult Atlantic salmon in rivers may experience thermal stress when temperatures exceed 20°C, and some fish will experience mortality when temperatures exceed 26°C (Shepard, 1995; Wilkie et al., 1996). Temperature can also significantly influence egg incubation success or failure, food requirements and digestive rates, growth and development rates, vulnerability to disease and predation, and may be responsible for direct mortality (Peterson et al., 1977; Spence et al., 1996; Whalen et al., 1999).

Atlantic salmon may be especially vulnerable to the effects of climate change in New England, since the areas surrounding many watersheds where salmon are found are heavily populated and have already been affected by a range of stresses associated with agriculture, industrialization, and urbanization (Elliott et al., 1998). Climate effects related to temperature regimes and flow conditions determine juvenile salmon growth and habitat (Friedland, 1998). One study conducted in the Connecticut and Penobscot rivers, where temperatures and average discharge rates have been increasing over the last 25 years, found that dates of first capture and median capture dates for Atlantic salmon have shifted earlier by about 0.5 days/year, and these consistent shifts are correlated with long-term changes in temperature and flow (Juanes et al., 2004). Temperature increases are also expected to reduce the abundance of salmon returning to home waters, particularly at the southern limits of Atlantic salmon spatial distribution (Beaugrand & Reid, 2003).

A study conducted in the United Kingdom that used data collected over a 20-year period in the Wye River found Atlantic salmon populations have declined substantially and this decline was best explained by climatic factors like increasing summer temperatures and reduced discharge more than any other factor (Clews et al., 2010). Changes in temperature and flow serve as cues for salmon to migrate, and smolts entering the ocean either too late or too early would then begin their post-smolt year in such a way that could be less optimal for opportunities to feed, predator risks, and/or thermal stress (Friedland, 1998). Since the highest rate of mortality affecting

Atlantic salmon occurs in the marine phase, both the temperature and the productivity of the coastal environment may be critical to survival (Drinkwater et al., 2003). Temperature influences the length of egg incubation periods for salmonids (Elliott et al., 1998) and higher water temperatures could accelerate embryo development of salmon and cause premature emergence of fry.

Since fish maintain a body temperature almost identical to their surroundings, thermal changes of a few degrees Celsius can critically affect biological functions in salmonids (NMFS and USFWS, 2005). While some fish populations may benefit from an increase in river temperature for greater growth opportunity, there is an optimal temperature range and a limit for growth after which salmonids will stop feeding due to thermal stress (NMFS and USFWS, 2005). Thermally stressed salmon also may become more susceptible to mortality from disease (Clews et al., 2010). A study performed in New Brunswick found there is much individual variability between Atlantic salmon and their behaviors and noted that the body condition of fish may influence the temperature at which optimal growth and performance occur (Breau et al., 2007).

The productivity and feeding conditions in Atlantic salmon's overwintering regions in the ocean are critical in determining the final weight of individual salmon and whether they have sufficient energy to migrate upriver to spawn(Lehodey et al., 2006). Survival is inversely related to body size in pelagic fishes, and temperature has a direct effect on growth that will affect growth-related sources of mortality in post-smolts (Friedland, 1998). Post-smolt growth increases in a linear trend with temperature, but eventually reaches a maximum rate and decreases at high temperatures (Brett 1979 in Friedland, 1998). When at sea, Atlantic salmon eat crustaceans and small fishes, such as herring, sprat, sand-eels, capelin, and small gadids, and when in freshwater, adults do not feed but juveniles eat aquatic insect larvae (FAO, 2012). Species with calcium carbonate skeletons, such as the crustaceans that salmon sometimes eat, are particularly susceptible to ocean acidification, since ocean acidification will reduce the carbonate availability necessary for shell formation (Wood et al., 2008). Climate change is likely to affect the abundance, diversity, and composition of plankton, and these changes may have important consequences for higher trophic levels like Atlantic salmon (Beaugrand and Reid, 2003).

In addition to temperature, stream flow is also likely to be impacted by climate change and is vital to Atlantic salmon survival. In-stream flow defines spatial relationships and habitat suitability for Atlantic salmon and since climate is likely to affect in-stream flow, the physiological, behavioral, and feeding-related mechanisms of Atlantic salmon are also likely to be impacted (Friedland, 1998). With changes in in-stream flow, salmon found in smaller river systems may experience upstream migrations that are confined to a narrower time frame, as small river systems tend to have lower discharges and more variable flow (Elliot et al*.,* 1998). The changes in rainfall patterns expected from climate change and the impact of those rainfall patterns on flows in streams and rivers may severely impact productivity of salmon populations (Friedland, 1998). More winter precipitation falling as rain instead of snow can lead to elevated winter peak flows which can scour the streambed and destroy salmon eggs (Battin et al., 2007).

Increased sea levels in combination with higher winter river flows could cause degradation of estuarine habitats through increased wave damage during storms (NSTC, 2008). Since juvenile Atlantic salmon are known to select stream habitats with particular characteristics, changes in river flow may affect the availability and distribution of preferred habitats (Riley et al., 2009). The critical point at which reductions in flow begin to have a damaging impact on juvenile salmonids is difficult to define, but generally flow levels that promote upstream migration of adults are likely adequate to encourage downstream movement of smolts (Hendry et al*.,* 2003).

Humans may also seek to adapt to climate change by manipulating water sources, for example in response to increased irrigation needs, which may further reduce stream flow and biodiversity (Bates et al., 2008). Water extraction is a high level threat to Atlantic salmon, as adequate water quantity and quality are critical for all life stages of Atlantic salmon (NMFS and USFWS, 2005). Climate change will also affect precipitation, with northern areas predicted to become wetter and southern areas predicted to become drier in the future (Karl et al., 2009). Droughts may further exacerbate poor water quality and impede or prevent migration of Atlantic salmon (Riley et al., 2009).

We anticipate that these climate change effects could significantly affect the functioning of Atlantic salmon critical habitat. Increased temperatures will affect the timing of upstream and downstream migration and make some areas unsuitable as temporary holding and resting areas. Higher temperatures could also reduce the amount of time that conditions are appropriate for migration (<23° Celsius), which could affect an individual's ability to access suitable spawning habitat. In addition, elevated temperatures will make some areas unsuitable for spawning and rearing due to effects to egg and embryo development.

5.2.1 Anticipated Effects to Atlantic salmon and Critical Habitat in the Action Area

Information on how climate change will impact the action area is extremely limited. As reported by the University of Maine's Climate Change Institute (Fernandez et al. 2020), models predict that Maine's annual temperature is projected to increase between 1.7–2.8°C by 2050, with continued increases in precipitation frequency and intensity. Under moderate to high emissions scenarios ocean temperatures in the Gulf of Maine are also expected to rise as much as 1.2ºC (2.2ºF) by 2050 and 2.2ºC (3.9ºF) by 2100, and sea levels are expected to rise as much as 30 to 90 cm by 2050 and 1.10 to 3.3 m by 2100. These rising sea levels would likely shift the salt wedge (i.e., layer of salt water in an estuary that underlies a layer of less dense freshwater) in the Kennebec River and other rivers in the GOM DPS. Because there remains uncertainty in the rate and timing of change as well as the effect of any changes that may be experienced in the action area due to climate change, it is difficult to predict the impact of these changes on Atlantic salmon. However, we use the best available information to anticipate how Atlantic salmon and designated critical habitat in the action area may be affected by climate change over the life of the actions considered in this consultation.

In the action area, it is possible that changing seasonal temperature regimes could result in changes in the timing of seasonal migrations for the GOM DPS of Atlantic salmon. The timing of spawning could shift later into the fall as water temperatures warm and spawning migrations could occur earlier in the year as salmon attempt to avoid peak summer water temperatures. However, because salmon spawning is not triggered solely by water temperature, but also by day length (which would not be affected by climate change) and river flow (which could be affected by climate change), it is not possible to predict how any change in water temperature or river flow alone will affect the seasonal movements of salmon throughout the action area. Increasing water temperatures will also likely increase energy consumption of upstream migrating Atlantic salmon, depleting energy reserves that may lead to lower spawning success and postspawn recovery (Rubenstein, 2021).

Dams and their associated impacts have been shown to exacerbate the effects of climate change as changes in streamflow, including dam impoundments and flow management through dams, can significantly affect water temperatures due to changes in thermal capacity, with water temperature being inversely related to discharge (Webb et al., 2003). Furthermore, any increases in stream temperatures associated with project operations, or delays in the migration of Atlantic salmon that increase their exposure time to warmer temperatures can negatively affect their reproductive success (Mantua et al., 2010; Rubenstein, 2021).

As described above, over the long term, global climate change may affect Atlantic salmon and critical habitat by affecting the location of the salt wedge, distribution of prey, water flows, temperature. However, there is significant uncertainty, due to a lack of scientific data, on the degree to which these effects may be experienced over the term of the proposed actions. While we can make some predictions on the likely effects of climate change on this species, without modeling and additional scientific data, these predictions remain speculative. Additionally, these predictions do not take into account the adaptive capacity of this species, which may allow them to deal with change better than predicted.

Despite the lack of certainty, we can make some predictions regarding potential outcomes of the warming climate. With an expected air temperature increase of 1.7–2.8°C by 2050, there is potential for significant effects to Atlantic salmon and designated critical habitat in the action area during the term of the proposed action. First, it is possible that the already thermally challenged mainstem of the Kennebec will become uninhabitable by juvenile Atlantic salmon during the summer months. The thresholds for mortality in juvenile and adult salmon discussed previously would be exceeded regularly, and it is less likely that any spawning in the mainstem would produce any outmigrating smolts. There may be times in the summer months when the mainstem becomes a thermal barrier to migrating adults. Under these conditions, adults would need to access cold water refuge, where they may need to hold for days at a time. Warmer water will also take an energetic toll on adult salmon (prespawn and postspawn) as they will deplete their energy reserves more quickly during their upstream and downstream migration. Unless delay at the dams can be reduced, we would anticipate a larger proportion of adults would not survive to spawn, and that repeat spawning will become a rarer event. The further warming of the impoundments will make them more suitable for warm water nonnative species, such as smallmouth and largemouth bass, which prey on juvenile Atlantic salmon (Baum, 1997). This increase in impoundment mortality could lead to a reduction in the number of salmon smolts leaving the Kennebec River, which will have a corresponding reduction in the number of returning adults coming back to the river.

5.3 Anticipated Effects to Atlantic and shortnose sturgeon

Hare et al. (2016) assessed the vulnerability to climate change of a number of species that occur along the U.S. Atlantic coast. The authors define vulnerability as "the extent to which abundance or productivity of a species in the region could be impacted by climate change and decadal variability." Atlantic sturgeon were given a Vulnerability Rank of Very High (99% certainty from bootstrap analysis) as well as a Climate Exposure rank of Very High. Three exposure factors contributed to this score: Ocean Surface Temperature, Ocean Acidification, and Air Temperature. The authors concluded that Atlantic Sturgeon are relatively invulnerable to distribution shifts and that while the effect of climate change on Atlantic Sturgeon is estimated to be negative, there is a high degree of uncertainty with this prediction.
Secor and Gunderson (1998) found that juvenile metabolism and survival were impacted by increasing hypoxia in combination with increasing temperature. Niklitschek and Secor (2005) used a multivariable bioenergetics and survival model to generate spatially explicit maps of potential production in the Chesapeake Bay; a 1°C temperature increase reduced productivity by 65% (Niklitschek and Secor, 2005). These studies highlight the importance of the availability of water with suitable temperature, salinity and dissolved oxygen; climate conditions that reduce the amount of available habitat with these conditions would reduce the productivity of Atlantic sturgeon. Changes in water availability may also impact the productivity of southern populations of Atlantic sturgeon. Spawning and rearing habitat may be restricted by increased salt water intrusion in rivers with dams or other barriers that limit access to upstream freshwater reaches; however, no estimates of the impacts of such change are currently available. Hare et al. conclude that most climate factors have the potential to decrease productivity (e.g., sea level rise; reduced dissolved oxygen, increased temperatures) but that understanding the magnitude and interaction of different effects is difficult.

As described by Hare et al. (2016), the effect of climate on shortnose sturgeon populations is not well understood. Like Atlantic sturgeon, shortnose sturgeon were given a Vulnerability Rank of Very High (99% certainty from bootstrap analysis) as well as a Climate Exposure rank of Very High. While many aspects of Shortnose Sturgeon life history and ecology are linked to temperature, river flow, dissolved oxygen, salinity, but the effect of change in these environmental variables on Shortnose Sturgeon is unclear (Cech and Doroshov, 2005; Ziegeweid et al., 2008a, 2008b). At the southern end of their range, productivity could be reduced by salt-water intrusion and decreases in summer dissolved oxygen (Jager et al., 2013). Changes in water availability may also impact the productivity of southern populations of shortnose sturgeon. Studies in the Hudson River indicate that flow volume and water temperature in the fall months preceding spawning were significantly correlated with subsequent year-class strength (Woodland and Secor, 2007), which suggests increased vulnerability in some future scenarios. Spawning and rearing habitat may be restricted by increased salt water intrusion in rivers with dams or other barriers that limit access to upstream freshwater reaches; however, no estimates of the impacts of such change are currently available. Hare et al. conclude that the effect of climate change on Shortnose Sturgeon is estimated to be neutral, but this estimate has a high degree of uncertainty (<66% certainty in expert scores) and that climate factors have the potential to decrease (sea level rise; reduced dissolved oxygen) or increase (temperature) productivity of Shortnose Sturgeon. The authors also conclude that the effect of ocean acidification over the next 30 years is likely to be minimal.

As stated above for Atlantic salmon, information on how climate change will impact the action area is extremely limited, but we generally expect Maine's annual temperature and total precipitation (especially in the form of rain) to increase, and we expect the salt wedge may shift up further in the Kennebec River estuary.

Water availability, either too much or too little, as a result of global climate change is expected to have an effect on the features essential to successful sturgeon spawning and recruitment of the offspring to the marine environment (for Atlantic sturgeon). The increased rainfall predicted by some models in some areas may increase runoff, scour spawning areas, and create flooding events that dislodge early life stages from the substrate where they refuge in the first weeks of life. High freshwater inputs during juvenile development can influence juveniles to move further downriver and, conversely, lower than normal freshwater inputs can influence juveniles to move further upriver potentially exposing the fish to threats they would not typically encounter. Increased number or duration of drought events (and water withdrawal for human use) predicted by some models in some areas may cause loss of habitat including loss of access to spawning habitat. Drought conditions in the spawning season(s) may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, all sturgeon life stages, including adults, may become susceptible to stranding or habitat restriction. Low flow and drought conditions are also expected to cause additional water quality issues including effects to the combined interactions of dissolved oxygen, water temperature, and salinity. Elevated air temperatures can also impact dissolved oxygen levels in the water, particularly in areas of low water depth, low flow, and elevated water temperature. Rising temperatures predicted for all of the U.S. could exacerbate existing water quality problems affecting dissolved oxygen and temperature.

The action area is well upstream from the present upper limit of salt water intrusion; as noted above the primary behavior of sturgeon in the action area is spawning and then development of eggs. It is extremely unlikely that salt water intrusion would extend into the action area. As such, we do not expect climate change to result in changes to the use of the action area. Spawning is not triggered solely by water temperature, but also by day length (which would not be affected by climate change) and river flow (which could be affected by climate change). It is difficult to predict how any change in water temperature or river flow will affect the seasonal movements of sturgeon through the action area. However, it seems most likely that spawning would shift to earlier in the year.

While additional modeling for climate change impacts, particularly salt water intrusion and seasonal temperature shifts, are needed for the action area to better assess the potential effects on shortnose and Atlantic sturgeon, as well as Atlantic sturgeon critical habitat, based on the best available information we do not expect use of the action area by shortnose or Atlantic sturgeon to change over the life of the proposed actions due to climate change. Additionally, we do not expect climate change to have effects on the PBFs of Atlantic sturgeon critical habitat in the action area over the life of the proposed action that would reduce the conservation value of the action area.

6 Effects of the Action

This section of a biological opinion assesses the effects of the proposed action on threatened or endangered species or critical habitat. Effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (50 CFR § 402.17). This Opinion examines the likely effects of the proposed action on the GOM DPS of Atlantic salmon, shortnose sturgeon, the GOM DPS of Atlantic sturgeon, and critical habitats designated for Atlantic salmon and Atlantic sturgeon. We consider these effects on the species and their habitats within the context of the species status now and projected over the course of the action.

FERC is proposing to amend the licenses for the Lockwood, Hydro-Kennebec, and Weston Projects for a term of 13 years; to amend the Shawmut license to cover the period before the issuance of a new license; and issue a new license for the Shawmut Project that will extend 30-50 years. As indicated, for this analysis we are assuming that the new Shawmut license will have a term of up to 50 years. As described in the Introduction, as we lack information regarding how Lockwood, Hydro-Kennebec, and Weston will operate after they undergo relicensing in 2036, we will consider the effects of the operational and structural changes described in the amendment proposal to persist through the end of the new Shawmut license. As such, we will consider the effects of operating the Lockwood, Hydro-Kennebec, and Weston projects for the duration of the period covered by the new Shawmut license, including the effects associated with proposed measures and standards, but excluding any effects resulting solely from the physical presence of the dam. As described previously, the past effects of Lockwood, Hydro-Kennebec, and Weston that are not affected by the amendments of the licenses to operate are considered as part of the environmental baseline (section 4.5.1), and therefore are not addressed in this section. For the proposal to issue a new license for the Shawmut Project, we will consider all effects of operating these projects over the term of the new license (including the passage measures incorporated in the DEA, as modified by the proposal in the supplemental SPP), as well as effects associated with the continued physical presence of the dam.

6.1 Species Presence

6.1.1 Atlantic salmon

As described in section 4.1, Atlantic salmon are stocked in the Sandy River in the Kennebec River watershed (USASAC, 2022). In the last decade, the average annual return to the river has been 29 individuals, ranging between 5 and 60 (USASAC, 2022; CMS, 2022). As this represents the number of salmon captured in the fish trap at Lockwood, it is significantly influenced by the effectiveness of the trap. Given the estimated efficiency (67%), we expect the actual returns to the river could be as much as a third higher than the recorded trap capture. Returning adult salmon intercepted at the Lockwood trap are trucked to spawning and rearing habitat in the Sandy River. Estimates of smolts leaving the Sandy range between 4,000 and 18,000, with an average of 10,000 annually.[38] Rotary screw trapping (RST) has confirmed that thousands of smolts are leaving the Sandy River and entering the action area annually. MDMR estimates, based on RST data, that approximately 13,229 (+/- 1,294) smolts migrated out of the Sandy River in 2021 (USASAC, 2022). Therefore, we anticipate that under current passage conditions, downstream migrating juveniles and adults occur in the entirety of the action area, but that upstream migrating salmon are excluded from the habitat between the Lockwood Dam in Waterville to the Weston Dam in Skowhegan.

6.1.2 Atlantic and shortnose sturgeon

Sturgeon are not passed above the Lockwood Project as it is located at Ticonic Falls, which is considered the historical upstream limit for both species in the Kennebec River, and no shortnose or Atlantic sturgeon have been documented in the fishway. However, sturgeon do occur in the portion of the action area that occurs downstream of the Lockwood Dam. As described above, the action area extends approximately 0.75 km downstream from the dam. Adult shortnose sturgeon and adult Gulf of Maine DPS Atlantic sturgeon have been documented in the action area (Wipplehauser et al., 2017) and are expected to spawn in any portion of the action area that has suitable substrate and water depth and velocity. Eggs and early larvae may also be present in the action area. No other life stages are expected to occur in the action area.

6.2 Effects of Hydroelectric Operations on Atlantic Salmon

In this Opinion we are considering the effects of five different actions that FERC has proposed at four hydroelectric dams in the mainstem Kennebec River. The four amendments being proposed would result in additional license requirements designed to improve downstream and upstream fish passage at each of the projects. FERC's proposal for the relicensing of the Shawmut Project would authorize the continued operation of the dam for up to 50 years and would include new

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[38] Based on the average number of eggs stocked and survival estimates provided by NEFSC (2018).

fish passage measures that were proposed by Brookfield. These measures are described in FERC's BA, as well as the Shawmut DEA, with a revised action filed with FERC in September 2022. The proposal includes operational and structural changes that are designed to improve survival of Atlantic salmon smolts and kelts, as well as upstream passage efficiency for prespawn adults.

FERC has proposed to incorporate fish passage performance standards into the amended licenses for the Lockwood, Hydro-Kennebec, and Weston Projects as well as into the new license for the Shawmut Project. In the context of their proposed actions, performance standards establish targets for the efficacy of upstream and downstream passage that are then incorporated into an adaptive management strategy for avoiding and minimizing effects to Atlantic salmon. In general, performance standards can serve as important benchmarks for monitoring the success or failure of passage modifications at a project. Brookfield has committed to achieving these standards and has proposed measures that they believe are sufficient to do so. If the standards are not achieved after the proposed measures have been implemented, Brookfield has committed to work with us to identify additional structural and operational passage measures based on the study results. They will then construct and implement the new measures and reevaluate with additional studies. This adaptive process will continue until the performance standards have been achieved.

6.2.1 Downstream Fish Passage

The continued operation of the Lockwood, Hydro-Kennebec, Shawmut, and Weston Projects consistent with the terms of the proposed license amendments and new license will still continue to affect migrating salmon by killing, injuring, and delaying smolts and kelts passing downstream through project facilities. Section 4.5.1.1. describes the effects that operating the projects under the current licenses have on migrating salmon. We have estimated that under baseline conditions (e.g., operation of the projects consistent with the terms of their current licenses) the four projects result in the mortality of approximately 47% of all smolts leaving the Sandy River due to both direct and indirect effects. We also have estimated that under baseline conditions approximately 35% of migrating postspawn adults (kelts) are killed when migrating through the four projects. In this section we will analyze how the operation of the projects consistent with the proposed actions, including implementation of the proposed measures at each project, will individually and cumulatively affect smolt and kelt survival in the Kennebec River.

As indicated above, FERC has proposed to amend the licenses for these projects to incorporate a package of fish passage measures (Supplemental SPP, 2022) that are designed to reduce direct and indirect adverse effects to Atlantic salmon, including downstream migrating smolts and kelts. FERC has also proposed cumulative performance standards for smolts (97% survival per dam; measured cumulatively (88.5%) through all four dams). This standard, as defined, would apply to direct mortality, but not indirect mortality (impoundment and hydrosystem delayed mortality). When evaluating the effects of the proposed passage measures in the context of the achievement of the proposed cumulative performance standard, we will consider all direct mortality attributable to the four projects. As such, we will proceed to evaluate the proposal with the understanding that the total mortality associated with dam passage can be represented by a conceptual equation: mortality in the impoundment[39] + direct mortality + hydrosystem delayed mortality in the estuary = total dam-related mortality; and that the proposed performance standard applies only to direct mortality. We consider these sources of mortality below.

In analyzing the effect of the proposed measures, we need to determine how each new measure (i.e., those measures not implemented during the 2012 to 2015 period when the projects were being evaluated) affects direct and indirect (impoundment and hydrosystem delayed mortality) survival as described in section 4. Generally, the proposed measures focus on reducing turbine entrainment and increasing passage over the spillway or through a downstream fish bypass. Therefore, to analyze each passage measure we must first estimate how the measure will change the proportion of fish going to turbine and non-turbine passage routes, and then apply appropriate route specific survival rates as specified by Brookfield's revised analysis filed with FERC in September 2022. The information obtained from the smolt studies in 2012-2015 will be used to estimate both of these factors. As these studies provide specific information on the proportion of fish using each route and the direct survival through each route, it is relatively straightforward to estimate how a given measure could change survival at the project. However, it is less apparent how passage route selection relates to hydrosystem delayed mortality. As we assume it is affected by migratory delay and injury associated with turbine entrainment (BBHP, 2017; Storch et al., 2022; Stich et al., 2015; Stevens et al., 2019), we anticipate that any reduction in entrainment and migratory delay would lead to a reduction in hydrosystem delayed mortality.

In our analysis of the effects of the proposed downstream measures, we will consider two phases; an interim phase that will encompass the period between the issuance of FERC's new and amended licenses and the implementation of all operational and structural measures; and the implementation phase, which will encompass the period between the full implementation of all downstream measures and the expiration of Shawmut's new project license. As we don't have information regarding how Lockwood, Hydro-Kennebec, and Weston will be operating after they undergo relicensing; in our analysis we consider the potential for the effects of those projects to persist throughout a new 50 year license at Shawmut. We anticipate that the interim phase for downstream passage will include the period within three years of FERC's issuance of the new and amended licenses (expected 2023 to 2025[40]), and that the implementation phase will include the period from year four to the expiration of the Shawmut license. Although some measures will be implemented right away (within a year), it will take up to three years for the measures to be in full effect. Therefore, we anticipate that the downstream survival rates for smolts during the three year interim phase will incorporate anticipated increases in survival

[39] Impoundment effects are not considered Effects of the Action (section 6) for the proposed license amendments, but are considered in the Environmental Baseline (section 4). They are considered as effects of the proposed license for Shawmut, however.

[40] Dependent on the timing of FERC's approval.

attributable to the proposed operational measures initiated in year one (i.e., turbine shutdowns and spill prioritization), but will not include the improvements anticipated from the proposed structural measures (e.g., racks, guidance structures, spillway enhancements, new downstream fishways).

6.2.1.1 Weston Project

As described in section 2, FERC and Brookfield propose the following new measures to improve downstream passage for Atlantic salmon at the Weston Project:

- Make fishway improvements including resurfacing the flume (bypass fishway), sealing gaps, and adding a velocity dissipation slope; to be constructed concurrent with the construction of the upstream fishway, to begin within one year after FERC's issuance of the license amendment;
- Automate the left Tainter gate on the North Channel and reprioritize spill flows to direct spill to deeper locations, avoiding ledge outcroppings to the extent possible, within two years after FERC approval;
- Construct and operate a new upstream fish passage facility with an AWS having a 304 cfs capacity and a uniform acceleration weir; to be constructed within one year after FERC approval, and to be operated once volitional fish passage operations are implemented following construction and shakedown of facilities at Lockwood, Shawmut and Hydro-Kennebec;
- Install a 2-inch trash rack overlay at all four units within two years of FERC approval;
- Modify the center stanchion top gates to allow flow conveyance with minimum headpond effects within two years of FERC approval; and
- Conduct a balloon tag study to confirm the appropriate gate prioritization to maximize survival on spill within one year of FERC approval.

Smolts

As detailed in section 4, we anticipate that the operation of the Weston Project currently results in the cumulative mortality[41] of 18.0% of salmon smolts. This estimate includes 9.6% due to

[41] In these analyses, cumulative mortality is multiplicative, rather than additive. It is calculated as (1 - (direct survival x indirect survival (delayed mortality))). This is because the types of mortality happen sequentially. Only those fish that survive the direct effects of passage are exposed to indirect effects (i.e., hydrosystem delayed mortality). As a hypothetical example, if 100 smolts are stocked above a dam and 10% die during passage, only 90 of those fish (90% x 100 fish) survive to the estuary. If another 10% of those fish die due to hydrosystem delayed mortality, 81 fish (90% x 90 fish) successfully migrate through the estuary. Therefore, 90% survival at the dam and 90% survival due to hydrosystem delayed effects results in a cumulative survival of 81% ((90% x 90%) = 81%), and a cumulative mortality of 19% (1-81% = 19%). If cumulative mortality is calculated additively in this scenario, one would incorrectly estimate a mortality rate of 20% (10% direct + 10% HDM), which we know to be incorrect as 81 of 100 smolts hypothetically survived the effects of passage. In the Weston calculation, cumulative survival is calculated as 0.904 x 0.907 = 0.820. We then subtract that result from one to convert it to cumulative mortality (i.e., 1 - 0.820 = 0.180).

direct mortality, and 9.3% due to hydrosystem delayed mortality. To reduce this level of mortality, Brookfield has proposed to modify the current project license to incorporate the above measures.

The smolt survival studies conducted at the Weston Project between 2013 and 2015 indicated that survival through the non-turbine routes (spillway: 84.5%; downstream bypass: 88.9%) is, on average, worse than what was observed for smolts that migrated through the four Francis turbines (97.0%). To address the poor survival through the non-turbine passage routes, Brookfield has proposed to modify the existing bypass sluice to provide better energy dissipation and to automate and prioritize the gates at the north channel spillway to better control the flow. In addition, Brookfield will be conducting an injury/survival analysis of the different spill routes in the north channel (Tainter gates, Obermeyer sections, stanchions) in order to identify the routes that should be prioritized in order to maximize smolt survival. Several of the gates deposit fish onto ledge outcrops in the north channel. Effective prioritization would result in more fish being passed in areas that have the highest anticipated survival. Thus, this operational change should minimize mortality by passing as many fish as possible through the sections that discharge to inundated areas with adequate depths to allow for safe passage. In addition, Brookfield will modify a section of stanchions in the center that will provide another ledge-free spill route.

It was determined during consultation that the spill prioritization and downstream bypass flow evaluated at the Weston Project during the 2013-2015 studies did not reflect how the project was typically operated at the time (when it was owned and operated by Nextera Energy); nor does it reflect how Brookfield has prioritized flow since they purchased the projects. As such, the estimate of direct mortality (9.6%), which is driven by poor survival through the non-turbine routes, was based on an inaccurate operational scenario. Of particular note:

- During the studies, the majority of the spill was passed at the stanchion gates in the north channel, whereas under current prioritization the stanchions are not lowered except under the highest flow conditions;
- During the studies, the amount of flow passed through the bypass sluice was held steady at 6-10% of flow, whereas current protocol maintains a *minimum* of 8% of station flow (440 cfs) in the sluice. Once station capacity has been achieved, Brookfield then prioritizes the sluice over all other non-turbine routes, increasing its flow up to 45% of station flow (2,500 cfs).

The discrepancies between the evaluated and actual flow prioritization affects the estimates of baseline route selection, migratory delay, and survival. In addition, although the study results provide a general understanding of route specific survival, they do not provide clear evidence regarding which section(s) of the spillway are leading to the high rates of mortality. As such, Brookfield has proposed a prioritization sequence that will be refined after a new survival/injury assessment is conducted (Table 25).

Brookfield's initial proposal has grouped the spill routes so that the routes that would discharge fish onto rocks are only utilized at the highest flows when the ledge is inundated. Figure 16 shows the location of the different spillway sections in the north channel in relation to ledge outcrops at lower flows. Substantial outcrops exist below the right (looking downstream) Tainter gate section, the left Obermeyer, and the left stanchion sections. Conversely, ledge free areas exist below the left Tainter section, the right Obermeyer, and the center stanchion sections. Except for the left Obermeyer, all the sections that could potentially deposit smolts onto ledge outcrops will only be used at 8% flow exceedance or above (i.e., river flows that are exceeded 8% of the time during the downstream passage season). Figure 17 shows the conditions in the north channel during a high flow event in September of 2009. At these flows the ledge outcrops are all inundated, although it is unknown by how much and whether the depth is sufficient to prevent impact between fish that travel over the dam and ledge. The left Obermeyer section, which is in a ledgy part of the channel, would be utilized 23% of the time. It is unknown whether the ledge downstream of that section would be exposed at those flows. As indicated, this prioritization scheme will be refined based on the results of a balloon-tag survival/injury evaluation conducted the first year of the SPP. Even absent the data that would be collected during these studies, and the anticipated resulting refinements, the best available information indicates that the proposed scheme should maximize passage through the safest passage routes, while limiting passage through the less safe routes at times when the ledge outcrops are exposed.

Table 25. The proposed initial prioritization for flow management at the Weston Project. We have highlighted the routes that could potentially deposit smolts onto exposed ledge.

Conveyance	Incremental Flow (cfs)	Cumulative Flow (cfs)	Exceedance (%)
Log Sluice (Min Setting)	440	440	100%
Upstream Passage AWS	304	744	100%
Turbines (Operating Capacity)	5,500	6,244	53%
Log Sluice (Max Setting)	2,060	8,304	44%
Right Obermeyer	4,450	12,754	31%
Left Obermeyer	4,450	17,204	23%
Center Stanchion Top Gates (top half of Top Gates)	715	17,919	21%
Left Tainter	5,000	22,919	14%
Right Tainter	5,000	27,919	8%
North Channel Stanchion Top Gates	5,005	32,924	5%
South Channel Stanchion Top Gates	4,620	37,544	2%

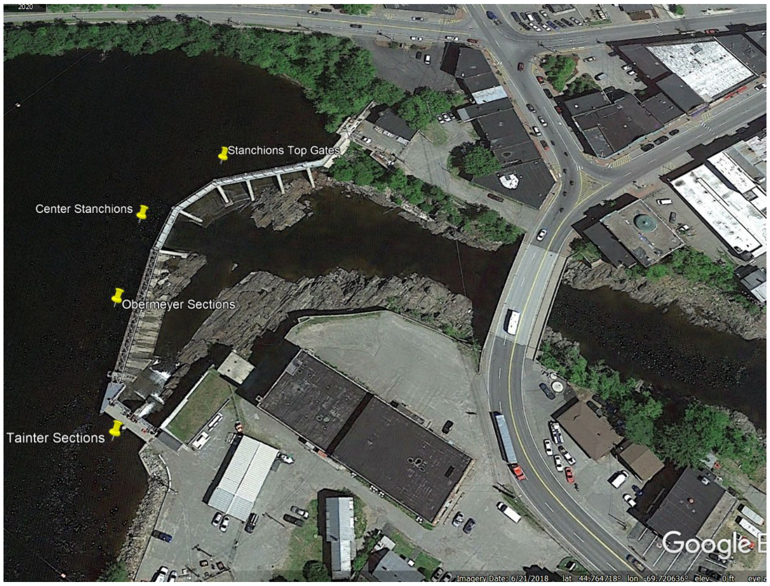

Figure 16. The north channel of the Weston Project at lower flows with the different spillway sections labeled (Google Earth). The ledge outcrops below several of the gates are apparent in this image.

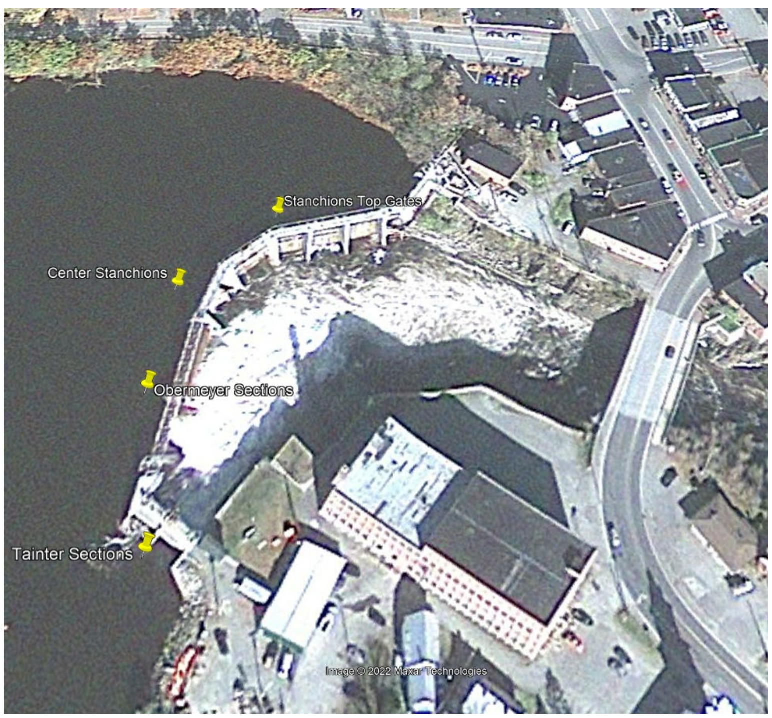

Figure 17. The north channel of the Weston Project at high flows in 2009 with the different spillway sections labeled (Google Earth). At this flow the ledge outcrops are fully submerged.

Until studies are completed, we do not know with certainty how the proposed modifications to the downstream bypass fishway and spillway will affect smolt survival. However, there are a limited number of possible sources of mortality through these routes, and we can ascertain the effect of the measures by evaluating how well they address the most likely causes of mortality. If we determine that the measure will be effective at addressing the most likely cause(s), then it is reasonable to assume that survival through the routes will increase to what is typically documented at similarly low head dams.

As addressed above, the best available information indicates that the prioritization of spill routes, as refined by the proposed field assessment of route specific survival and injury, will address the poor survival through the north channel spillway as documented in the 2013-2015 smolt survival studies (BWPH 2014, 2015, 2016). The available information indicates it is likely that discharging smolts on to the exposed, or inadequately inundated, rocky outcrops downstream of the dam is the primary source of this mortality. Other spillway characteristics, however, such as inadequate plunge pool depths or deteriorated concrete along the spillway face, may also contribute to the mortality. That said, given the documented condition of the north channel spillway, these possible sources of mortality are unlikely to be significant. Except for the rocky outcrops, the channel depth below the primary spill routes (Tainter and Obermeyer gates) appear sufficient for fish passing through this route to avoid impact with the substrate, particularly at high water levels. The spillway below the gates appears rough and could be a source of mortality. If this is the case, it would become apparent during the route specific survival study that will be conducted in the first year of the proposed action; and additional measures would be implemented to address the mortality. However, we anticipate that the short length of the spillway, as well as the amount of water being passed, limits the likelihood that fish would come into contact with it. Therefore, the rocky outcrops are most likely to be the primary threat to salmon in the channel and as the proposed measures will reduce impact with them, they should be effective at reducing the route specific mortality at the Weston Project.

Normandeau Associates provided an estimate of survival with the implementation of the spillway improvement measures (i.e., prioritization) (Supplemental SPP, 9/21/22[42]). They estimated that the proposed measures would increase spillway survival to at least 97.3%, and as high as 100.0%. To estimate the expected survival through the spillway with the proposed measures, we have considered the average spillway survival for salmon observed at other projects. The average spillway survival for salmonids at 18 projects (including nine in the GOM DPS) is 97% (Alden Research Laboratory, 2012; BBHP, 2017, 2017b, 2018, 2019; BWPH, 2016, 2019). Therefore, we anticipate that the proposed measures will lead to a spillway survival of at least 97%.

Survival rates through downstream fishways are typically much higher than through turbines (Alden Research Laboratory, 2012; BBHP, 2017, 2017b, 2018, 2019; BWPH, 2016, 2019). As

[42] FERC Accession #: 20220921-5117

above, to estimate the expected survival through the bypass with the proposed measures, we have considered the average bypass survival for salmon observed at other projects. The average bypass survival for salmonids at 13 projects (including seven in the GOM DPS) is 98% (Alden Research Laboratory, 2012; BBHP, 2017, 2017b, 2018, 2019; BWPH, 2016, 2019). Therefore, the best available information indicates that with the proposed modifications that survival at the Weston sluice will be increased to at least 98%. As with the spillway, there is uncertainty regarding the extent to which the proposed measures address the source of mortality. However, the remedy is more apparent at the bypass sluice as it does not have multiple passage alternatives with varying degrees of risk. As the proposed measure will significantly increase the flow through the sluice while smoothing out the surface and dissipating energy, it is anticipated that the survival rates will mirror what has been observed at other projects. Therefore, the best available information indicates that the proposed measures will lead to an average bypass survival of 98%.

In addition to the measures to improve the safety of the non-turbine routes, FERC and Brookfield have proposed measures that will reduce turbine entrainment at the Weston Project:

- First, they have proposed to maintain the existing flow through the downstream log sluice, which differs substantially from what was evaluated during the 2013-2015 smolt survival studies. During those studies the flow through that route was limited to 8% of station flow (i.e., 440 cfs) throughout the evaluation. However, since Brookfield purchased the project they have been prioritizing the sluice as flows increase beyond turbine capacity, up to 45% of station unit flow (2,500 cfs). In their analysis, Brookfield indicates that the sluice is operated at capacity 45% of the time during the downstream passage season for smolts. At 8% flow the bypass passed 43% of the smolts that approached the project. It is anticipated that this proportion will increase with the significant increase in passage flow.
- Second, they have proposed to construct a new upstream fishway at the Project that will have an auxiliary water supply (AWS) intake in the project forebay between the turbine intakes and the downstream passage sluice. This AWS, which passes approximately 5.5% of station capacity (304 cfs), will double as a downstream fishway and will correspondingly be fitted with a uniform acceleration weir (UAW) to improve attraction. The location of this fishway inside of the existing guidance boom will provide an alternative safe passage option for fish that swim underneath the boom and should therefore decrease turbine entrainment.
- Third, they have proposed to install full-depth 2-inch clear spaced overlay racks in front of the turbine intakes to eliminate turbine entrainment of adult Atlantic salmon and American shad. Although the racks are not intended to eliminate smolt entrainment, as they are physically capable of swimming between 2-inch racks, it is likely that the racks will act as a behavioral deterrent to some degree.

The best available information indicates that these measures will increase the bypass efficiency for fish that enter the south channel, but would not affect the proportion of fish that pass over the north channel spillway, as it is located upstream of the powerhouse and downstream bypass.

Although we do not have empirical data that indicates the degree to which bypass efficiency would increase, we expect that it will increase to at least 70%, which is at the upper range of bypass efficiency rates that were observed at the four projects during the 2012-2015 smolt survival studies. This equates to a 23% entrainment rate when you include the fish that pass via the spillway. Given the increase in downstream passage flow through the existing sluice, as well as through the new AWS fishway, a 12% increase in average passage efficiency (the average bypass efficiency in the 2013-2015 studies was 58%) is a conservative estimate of how passage route selection could change at the project.

Given the anticipated improvement in survival through the downstream bypass and spillway, as well as the anticipated increase in bypass efficiency, the best available information indicates that the average direct survival of smolts at Weston would increase to 97.5%. We estimate this by multiplying the expected passage route utilization by the route specific survival routes discussed above and then summing them (Table 26).

Table 26. The calculation of anticipated smolt survival at the Weston Project based on changes in route utilization and survival caused by the proposed measures.

Passage Route	Utilization (U)	Survival (S)	U x S
Francis Units	23.0%	97.0%	22.3%
Spillway	24.3%	97.0%	23.6%
Bypass	52.7%	98.0%	51.6%
Survival (Sum)			97.5%

As indicated in section 4, we consider the causative factors for hydrosystem delayed mortality to be migratory delay and sublethal injury. In our analysis above, we describe how both turbine and non-turbine routes contribute to sublethal injury given the relatively poor survival through those routes. As we have described, the best available information indicates that the proposed measures will improve survival through those routes to what is typical for Atlantic salmon smolts for bypass and spillways at other projects (i.e., 97% spillway survival, 98% bypass survival). The reduction in turbine entrainment also reduces the potential for injury. Based on these improvements, the best available information indicates that the proposed action will reduce sublethal injury rates from 5.0% to 1.7%.

Similar to injury, the best available information indicates that migratory delay (residence time) will decrease at the project due to the proposed action. During the 2013-2015 smolt studies at the projects, Weston had more migratory delay than any of the other projects (average of 19.2% of smolts took longer than 24 hours to pass the project (16.7% in 2013, 3.4% in 2014, 37.5% in 2015)). Delay was particularly excessive in 2015, when flows in the river were quite low, and significantly lower in 2014 when river flows were high. Normandeau Associates presented information on route specific delay in their 2014-2016 study reports (BWPH 2013-2016). There wasn't a significant difference in delay between fish that passed via the bypass or turbine routes in 2013 and 2014; although there was in 2015 (BWPH, 2016). In that year, the median delay for fish that passed through the turbines was eight times higher than what was experienced by fish that passed through the bypass. This is likely attributable to the much lower flow in the river that year. The proposed action will lead to additional flow through the sluice, which should increase attraction to that route. Brookfield has also proposed to install a new downstream fishway (associated with the AWS) that will attract fish that swim underneath the guidance boom. Both of these measures should lead to increased attraction to non-turbine routes, which will lead to reduced migratory delay. To estimate that reduction, we recalculated the average delay at the project assuming that the 2015 delay estimate was the same as what was observed in 2013, a similarly low flow year. We do this as 2015 was the only year when there was a significant difference between the route specific delay (delay through turbines was 8x higher). As increasing attraction to non-turbine routes would reduce the proportion of fish passing through the turbines (where delay was extreme), we expect that this would reduce migratory delay at the project overall. As 2015 was the only year where there was a significant difference in route specific delay, it is the only year that we adjusted to develop an estimate. Adjusting the 2015 delay from 37.5% to 16.7% reduced the average delay to 12.3%. Therefore, the best available information indicates that once the improvements are implemented, approximately 12.3% of smolts will take longer than 24 hours to pass the dam, with 87.7% passing within 24 hours of approaching the dam.

As indicated in section 4, we assumed that hydrosystem delayed mortality at the Weston Project was approximately 9.3% based on baseline project specific estimates of migratory delay and sublethal injury. To estimate the potential reduction in this mortality caused by the proposed action, we determined the proportional difference between injury and delay under the baseline and proposed action scenarios and applied that change to the 9.3% assumed delayed mortality described above. As such, because the best available information indicates an estimated 66% reduction in injury (i.e., ((5.0%-1.7%)/5.0%=66.0%), we would anticipate a similar reduction in the component of delayed mortality attributed to injury. Similarly, the best available information indicates that there will be an estimated 36% reduction in migratory delay (i.e., (19.2%-12.3%)/19.2%=36%), therefore we would anticipate a similar reduction in that component of hydrosystem delayed mortality. Therefore, the best available information indicates that Weston's total contribution to hydrosystem delayed mortality in the estuary is reduced from 9.3% to 4.8%.

Based on the above analysis the best available information indicates that the proposed action will reduce cumulative mortality at the project from 18.0% to 7.2% (Table 27). Although spill reprioritization may lead to immediate increases in survival, it will take time to evaluate the spill route specific survival rates, and to implement the proposed operational and structural improvements. As such, to be conservative, we anticipate that survival at the Weston Project during the downstream interim phase may not differ significantly from what has been described in the environmental baseline. Once improvements are implemented, we expect 2.5% of smolts passing the Weston project to die as a direct result of dam passage, with 97.5% surviving. Of the surviving smolts, 4.8% will die later, for a total cumulative mortality of 7.2% (Table 27).

Table 27. Summary of smolt mortality at the Weston Project under the existing and proposed action scenarios.

Source of Mortality	Environmental Baseline	Interim (Y 1 - 3)	Implementation (Y 4 - Exp)
Direct	9.7%	9.7%	2.5%
Hydrosystem Delayed	9.3%	9.3%	4.8%
Cumulative	18.0%	18.0%	7.2%*

*Cumulative survival is multiplicative, not additive, as only smolts that survive direct effects are exposed to HDM. Therefore, it is calculated as 0.975 x 0.952 = 0.928. We then subtract that result from one to convert it to cumulative mortality (i.e., 1 - 0.928 = 0.072).

Migratory delay of smolts within 200 meters of the Weston Project varies by year, with an average of 19.2% (range: 3.4% to 37.5%) of fish taking more than 24 hours to pass the project (Table 20). This is the level of delay we anticipate during the interim phase. As indicated above, Brookfield and FERC have proposed measures that the best available information indicates will reduce migratory delay at the project. Therefore, the best available information, as described below, indicates that for the duration of the interim and implementation phases an average of 19.2% and 12.3%, respectively, of smolts will continue to be harassed at the Weston Project.

We do not know, specifically, what amount of delay in a given river will lead to reduced fitness, increased predation rates, or an increase in hydrosystem delayed mortality. The threshold of effect likely varies significantly by river flow and temperature. Regardless, we expect that 24 hours per dam provides adequate opportunity for smolts to locate and utilize well-designed downstream fishways at hydroelectric dams. A 24-hour period would allow these migrants an opportunity to locate and pass the fishway during early morning and dusk, a natural diurnal migration behavior of Atlantic salmon. We can reasonably expect that passage times in excess of 24 hours per dam would result in unnatural delay for migrants, in addition to an increased energetic cost and stress, which could potentially lead to increased predation and may also lead to reduced fitness in the freshwater to saltwater transition.

NMFS Interim Guidance on the ESA Term “Harass” (PD 02-110-19; December 21, 2016) provides for a four-step process to determine if a response meets the definition of harassment. The Interim Guidance defines harassment as to "[c]reate the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering." The guidance states that NMFS will consider the following steps in an assessment of whether proposed activities are likely to harass: 1) Whether an animal is likely to be exposed to a stressor or disturbance (i.e., an annoyance); and, 2) The nature of that exposure in terms of magnitude, frequency, duration, etc. Included in this may be type and scale as well as considerations of the geographic area of exposure (e.g., is the annoyance within a biologically important location for the species, such as a foraging area, spawning/breeding area, or nursery area?); 3) The expected response of the exposed animal to a stressor or disturbance (e.g., startle, flight, alteration [including abandonment] of important behaviors); and 4) Whether the nature and duration or intensity of that response is a significant disruption of those behavior patterns which include, but are not limited to, breeding, feeding, or sheltering, resting or migrating,

Here, we carry out that four-step assessment for harassment. We have established that all outmigrating smolts will encounter the dam, which will result in a disruption of their downstream migrations (step 1) and that 19.2% and 12.3% of smolts will be delayed for more than 24 hours during the interim and implementation phases, respectively (step 2). We have established the expected response of the exposed smolts (step 3): individual smolts delayed more than 24 hours during their downstream migration will need to expend additional energy searching for a passage route; this is expected to result in physiological stress and will increase the time the individual is exposed to predators; this delay is also expected to affect an individual's ability to successfully make the transition to saltwater. Finally, we establish that the nature and duration of the response is a significant disruption of migration (step 4). Based on this four-step analysis, we find that individual smolts delayed for more than 24 hours on their downstream migration are likely to be adversely affected and that effect amounts to harassment. Therefore, we anticipate that an average of 19.2% and 12.3% (construction and implementation phases, respectively) of salmon smolts that pass the project will be exposed to significant delay (i.e., take more than 24 hours to pass the dams), which we consider to meet the definition of harassment.

NMFS considers "harm" in the definition of "take" as "an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering" (50 CFR §222.102). As discussed above, harm associated with delay will be considered in our analysis of the cumulative effects of passage inefficiencies at all four dams, which is addressed below.

Adult salmon (Kelts)

In section 4.5.1, we indicated that the racks in front of the turbines at the Weston powerhouse are large enough for Atlantic salmon kelts to become entrained. In our environmental baseline analysis, we anticipated that 15% of kelts would be killed at the project, which we expect to continue through the interim phase (i.e., until the new racks are installed). The proposed installation of 2-inch racks will exclude 100% of adult salmon from passing the project through the turbines. In addition, the new AWS fishway will provide a safe route of egress for kelts that sound beneath the guidance boom. These modifications will lead to a significant reduction in adult Atlantic salmon mortality at this project. There is potential that kelts, as with smolts as described above, can experience mortality when passing a dam via non-turbine routes. This mortality can be caused by impact with rock or other substrate downstream of the dams, or else with part of the dam structure itself. In their analysis of dams on the Penobscot River, Alden Research Laboratories (2012) indicate that:

> The primary factors affecting fish survival [at a dam spillway] will be discharge, velocity of spill, location and angle of spill striking dam face, dam material coarseness, presence of rocks or walls, turbulence in stilling basin or plunge pool, and the distribution of flow across the downstream face of the dam. However, detailed information describing these parameters is not readily available for Penobscot River hydro projects. Larinier (Larinier, 2000) indicated that spillways are considered the safest downstream passage route for dams with heights of about 30 ft (10 m) and less, as long as water depth at the base of the dam is sufficient and no rocks, baffles, or other structures are present in the flow path.

As described previously, there is significant ledge below the dam at the Weston Project, and the project head is just over 30 feet. As such, some mortality is expected. However, as the proposed action will prioritize flow to ledge-free areas, and as many kelts would be attracted to the increased flow in the log sluice and the new AWS fishway, the mortality associated with spillway passage is expected to be minimal. Based on similar conditions in the Penobscot, Alden (2012) anticipated that kelt survival past projects that do not allow for turbine entrainment (due to narrow space racks) would be approximately 97%. Consistent with these assumptions, we anticipate that a small proportion (up to 3%) of salmon kelts could still be killed due to passage at the Weston Project. As such, the best available information indicates that the proposed action would lead to the mortality of 3% of kelts annually for the duration of the implementation phase.

6.2.1.2 Shawmut Project

License Amendment

The proposed license amendment would allow for the continuation of status quo operation of the downstream fish passage facility at the Shawmut Project until the issuance of the new license. Smolt survival and delay at the project under these conditions were evaluated between 2013 and 2015 (BWPH 2014-2016).

Brookfield's supplement to the SPP does not specifically indicate which measures would be considered as part of the amendment, rather than as part of the relicensing. However, they indicate that they will reprioritize spill flows to avoid ledge outcroppings the first fish passage season after the issuance of this Opinion, which presumably means throughout the interim phase. Additionally, in the original SPP proposal, they have proposed to lower 4 sections of hinge boards adjacent to the canal headworks for the Atlantic salmon smolt migration season (April 1 to June 15) to provide approximately 560 cfs of spill flow and to provide this supplemental flow from May 1 to May 31, annually. As such, we consider that these changes will be implemented in the interim period before a new license is issued.

Smolts

Over the three years of study, approximately 39% of smolts passed the project via the downstream bypass, 27% passed via spill, 12% passed via the Francis units, and 22% passed via the propeller units (Supplemental SPP, 9/21/2022). The average survival rates for the bypass, spillway, and propeller units were not meaningfully different (i.e., 86.8%, 87.7%, and 88.4%, respectively) although survival rates through the Francis units were noticeably lower (i.e., 84.5%). During the interim period prior to license issuance, Brookfield has proposed to reprioritize flows along the spillway to avoid ledge outcrops; this is not expected to change the utilization rates of these routes. It is unknown what proportion of the fish that passed the spillway in the 2013-2015 studies may have impacted the ledge along the eastern bank of the river, although it is expected to be low (see analysis below in the relicensing section). Similarly, given that the route specific survival of fish that passed through the lowered flashboards during the 2015 study was essentially the same as through the other routes, and as we don't expect a significantly higher proportion of fish to use that route with the lowering of an additional board, we do not expect that this measure will lead to a meaningful increase in direct survival. Therefore, we anticipate that even with flow reprioritization and the lowered flashboards, the existing mortality rate of 12.9% will persist through the interim period prior to license issuance. As no changes are expected to injury or delay rates, we do not anticipate any reduction from the hydrosystem delayed mortality rate discussed in section 4 (i.e., 7.6% at Shawmut). As such, we anticipate that during the interim period prior to license issuance, up to 19.5% of Atlantic salmon smolts that pass the Shawmut project will be killed.

Kelts

As detailed in section 4, the operation of the Shawmut Project is currently leading to the estimated mortality of 9% of salmon kelts. Reprioritizing spill flows and lowering boards for the month of May will not meaningfully increase protection of kelts above the baseline condition and, therefore, we anticipate that this level of mortality will continue until measures required by the new license are implemented.

<u>Relicensing</u>

The proposed action includes improvements to downstream passage at the Shawmut Dam that are expected to increase the proportion of fish that pass the project via non-turbine routes, and to improve survival through those routes. The proposal includes the following measures:

- Within 2 years of license issuance:
    - Install 1 inch overlays at the current intakes of the Units 1 – 6 Powerhouse;
    - Install a 2 inch trash rack overlay at the Unit 7 & 8 Powerhouse for the protection of kelts;

    - Install a floating guidance boom at the current intakes of the Unit 7 & 8 Powerhouse;
    - Install a floating guidance boom outside of the gate structure;
    - Resurface and smooth the spillway concrete below the hingeboards and the log sluice; and
    - Install a uniform acceleration weir at the Tainter gate within 2 years after FERC license issuance.
- Construct and operate a new upstream fish passage facility with an AWS having a 340 cfs capacity and a uniform acceleration weir construction to begin within one year of FERC approval; to be operated once volitional fish passage operations are implemented following construction and shakedown of facilities at Lockwood, Weston and Hydro-Kennebec;
- Construct a new downstream fish passage flume downstream of the forebay Tainter gate concurrent with the construction of the upstream fishway;
- Reprioritize spill flows to direct spill to avoid ledge outcroppings to the extent possible beginning the first downstream passage season following issuance of the Biological Opinion; and
- Implement nighttime shutdowns of Units 7 & 8 from 8 pm to 8 am for 4 weeks (up to 5 weeks) during the smolt migration period, which is generally targeted for the last week of April to the last week of May, with the start date to be determined in consultation with NMFS and MDMR based on smolt trapping information or migration model following completion of the spillway improvements.

The proposed action also includes a passage standard of 97% for Atlantic salmon smolts. This is a different standard than the cumulative standard proposed for all four projects, as it requires the individual project survival >97% regardless of what happens at the other projects. Brookfield will evaluate smolt passage for three years to verify that they have achieved the standard. If the passage standard is not met within this timeframe, then additional measures will be implemented and evaluated.

Smolts

As detailed in section 4, we anticipate that the operation of the Shawmut Project is currently leading to the cumulative mortality of 19.5% of salmon smolts. This estimate includes 12.9% due to direct mortality, and 7.6% due to hydrosystem delayed mortality[43]. To reduce this level of mortality, Brookfield has proposed the improvements described above as part of their new license. As indicated in section 4, based on the results of the 2013-2015 studies conducted by Normandeau Associates, we do not expect that any dam-related mortality will occur in the Shawmut impoundment (BWPH, 2014-2016).

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[43] Cumulative survival is multiplicative as only smolts that survive direct effects are exposed to HDM. Therefore, it is calculated as 0.871 x 0.924 = 0.805. We then subtract that result from one to convert it to cumulative mortality (i.e., 1 - 0.805 = 0.195).

The smolt survival studies conducted at the Shawmut Project between 2013 and 2015 indicated that survival through the non-turbine routes (spillway: 87.7%; downstream bypass: 86.8%) is, on average, as low as through the turbine routes (Francis units: 84.5%; propeller units: 88.4%). As such, there are currently no safe downstream passage routes at the Shawmut Project. To address this, the proposed license will include measures that would increase survival through both the spillway and the downstream bypass, as well as to reduce turbine entrainment.

The documented poor survival of smolts over the spillway is inconsistent with spillway survival that has been documented for salmon at other hydro projects, both in the GOM DPS, and on the west coast (Alden 2012). The 2013-2015 studies did not provide information regarding the specific spillway routes used by smolts passing at the Shawmut Dam, and therefore, the relative survival experienced through the hinge board sections, the log sluice, or any of the three bladder sections was not documented. However, Normandeau Associates conducted a retrospective analysis where they estimated the flows that were occurring when each individual smolt passed the project, and correlated that information with the routes that would have been operated given the prioritization at the time (Trested, D., Normandeau Associates, August 24, 2022; Figure 18). Using Normandeau's analysis, we estimated the proportion of mortality that occurred when each of the different spillway routes were in use (Table 28). This estimate does not indicate specifically where the mortality occurred as multiple routes were operating concurrently. For instance, both the hingeboards and the first bladder section were operating when 60% of the mortality occurred. However, the analysis allows us to narrow down the list of possible sources of mortality. It is less likely that the second and third bladder sections, or the overtopped boards, were the cause of the mortality, as they were only operating when a smaller proportion of the mortality events occurred (at times when spill was also occurring at the other routes). It is more likely that the mortality occurred at the other routes (i.e., the sluice, the hinge board sections, and the first bladder section), as they were all operating when a large proportion of the mortality occurred.

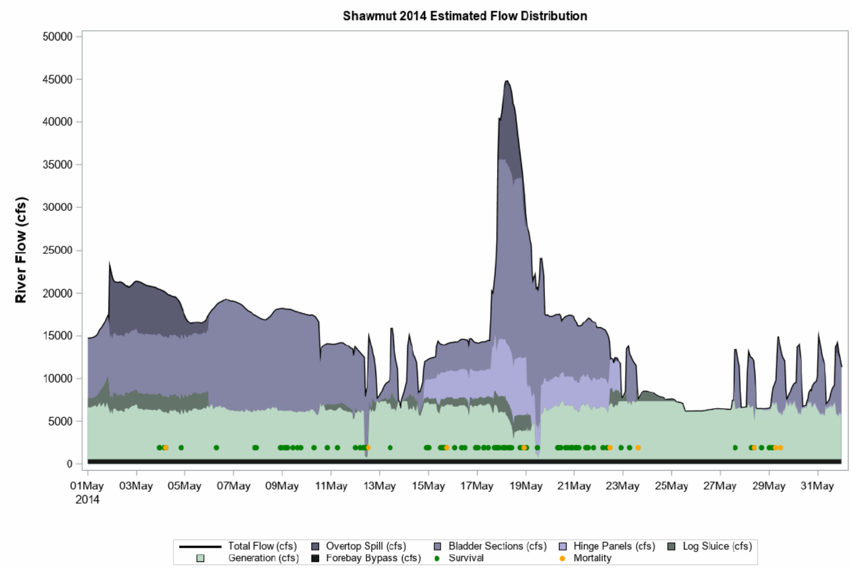

Figure 18. An example of the analysis conducted by Normandeau Associates to estimate which spillway routes at the Shawmut Project were leading to mortality. This example considers the 2014 results, but the analysis was conducted for 2013 and 2015, as well.

Table 28. The approximate proportion of spillway mortality that occurred during the 2013-2015 smolt survival studies when each of the different spill routes were being operated. This analysis was based on Normandeau Associates' spill route analysis, an example of which is shown in Figure 18.

Spillway Route	Proportion mortality while operating
Sluice	42%
Hingeboards	58%
Bladder 1	62%
Bladder 2	27%
Bladder 3	27%
Overtop	15%

The condition of the concrete in the log sluice (operates from 1 to 1840 cfs) and along the spillway below the hinged flash boards (140 cfs per board; 7,000 cfs when all 50 are in use) is severely deteriorated (Figure 19). These sections are anticipated to be *at capacity* (i.e., passing as much water as physically possible) 43% and 26% of the time during the downstream passage season, respectively (Table 29). However, these routes also operate at lesser amounts of flow (i.e., below capacity) as river flows increase. For instance, the hinge boards are not operated all at once; rather sections of boards are opened sequentially until all 50 have been lowered, when they are passing 7,000 cfs combined. Similarly, the sluice is operated *up to* 1,840 cfs, but will also pass lower amounts of water as the river flow increases or decreases. The rough surfaces likely contribute to poor survival of fish that pass via those routes, particularly at lower flows when fish are more likely to come into contact with the concrete. The likelihood of mortality and injury increases at lower flows due to the potential for insufficient depth to adequately cushion fish passing via those routes. Rubber dam 1, a section of spillway which also shows some deterioration, is operated either in the up or down position (i.e., it is not metered), which means it is either passing 0 cfs or 7,000 cfs. Given the substantial amount of flow passing this section when it is operated, it is less likely that fish would contact the spillway surface. Given this, and the fact that it will only be operated 15% of the time under the new prioritization, it is less probable that the route leads to a significant amount of mortality. Therefore, we expect that by implementing measures to fix the spillway at the hinge boards and the log sluice, the proposed action correctly targets the most likely location of mortality at the spillway.

We recognize that there is little information to indicate precisely why fish are dying when passing over the spillway. However, there are only a few likely sources of this mortality. It is probable that mortality is occurring due to fish impacting some hard surface; such as rock outcrops, the dam structure itself (including the spillway), or the river substrate if the plunge pool is not sufficiently deep.

Unlike Weston, there are few rocks downstream of the Shawmut dam, with the only observable outcrop occurring along the eastern river bank downstream of rubber dam 3. That section of the spillway is only operated at the highest flows (Table 29; only 4% exceedance) according to the proposed prioritization, when much of the ledge is inundated. Rubber dam 3 was only being operated when 27% of the spill mortalities occurred (when spill was also occurring at all the other routes as well). Given that, it is unlikely to be a significant source of mortality.

There are times when the depth of the water immediately downstream of the spillway may be insufficient. For instance, in Figure 19 which shows a small section of the spillway downstream of the hinge boards, the water depth appears to be quite shallow. However, shallow conditions are less likely to occur during the April-June smolt passage season when flows in the river tend to be much higher. For example, that photograph was taken on August 1, 2022, when river discharge at the North Sidney stream gauge was approximately 2,400 cfs (median flow for that date is around 4,500 cfs)[44]. In contrast, the median discharge at that flow gauge during the fish passage season (April 15-June 15) ranges between 7,000 and 20,000 cfs. According to the USFWS Fish Passage Design Guidelines (2019), “plunge pool depth must be 25% of the equivalent fall height or 4 feet, whichever is greater”. Based on the height of the spillway (24-feet), a plunge pool of at least 6-feet should be sufficient. Given the expected flows in the river

[44] USGS. National Water Information System: Web Interface. Water Data for the Nation. https://waterdata.usgs.gov/me/nwis/uv/?site_no=01049265&PARAmeter_cd=00065,00060

at the time that salmon smolts are passing the spillway, it is likely that water depths would exceed this depth. Therefore, we do not anticipate that smolts are being killed due to impacts with the substrate below the spillway.

As it is less likely that fish are striking rocky outcrops or the riverbed below the spillway, we conclude that smolt mortality at the spill routes is most likely caused by contact between the fish and the deteriorated concrete on the spillway below the hinge boards and the sluice. As such, we expect the proposed measures (the resurfacing of 350-feet of spillway and the sluice, as well as the prioritization of these routes) will increase survival at these routes to what would be expected at a typical spillway. Therefore, we anticipate that the proposed action will increase survival through the spillway to the average spillway level of 97%.

Figure 19. Deteriorated concrete along the spillway below the hinge boards at the Shawmut Dam.

Table 29. The proposed initial prioritization for flow management at the Shawmut Project.

Conveyance	Incremental Flow (cfs)	Cumulative Flow (cfs)	Exceedance (%)
Tainter Gate	600	600	100%
Sluice Gate	35	635	100%
Upstream Passage AWS	340	975	100%
Turbines (Operating Capacity)	6,755	7,730	48%
Log Sluice	1,840	9,570	43%
Hinge Boards (Min Setting)	7,000	16,570	26%
Rubber Dam #1	7,000	23,570	15%
Rubber Dam #2	7,000	30,570	8%
Rubber Dam #3	7,000	37,570	4%
Hinge Boards (Max Setting)	3,050	40,620	2%

Similar to the poor survival over the spillway, the low survival through the Tainter gate bypass (i.e., 86.8%) during the 2013-2015 studies was unexpected. Based on information from other projects in the GOM DPS and elsewhere, we anticipate that survival through a well-designed downstream fishway should be 98% on average. (Alden Research Laboratory, 2012; BBHP, 2017, 2017b, 2018, 2019; BWPH, 2016, 2019). The cause of the poor downstream survival at the bypass at Shawmut is unknown; however, flow over the sharp crested weir appears to impact a concrete apron and a wall, which suggests it could be a cause of injury and mortality to fish passing through this route. Brookfield's proposal includes a new downstream fishway that will incorporate a uniform acceleration weir and a flume that guides fish to the tailrace of the Unit 7 - 8 Powerhouse. This should significantly reduce the potential for impact with project structures and, therefore, improve survival. In addition, they are proposing to install a new downstream fishway as part of the AWS system at the new upstream fishway, which is being constructed outside of the power canal on the outboard side of the Unit 1 - 6 Powerhouse. As both of these fishways have been designed in coordination with agency and consulting fish passage engineers we anticipate that survival will be consistent with what has been observed at other projects. Therefore, the best available information indicates that survival through the new downstream bypasses will be approximately 98%.

In addition to implementing measures to improve smolt survival through non-turbine routes, Brookfield is proposing measures at the Shawmut Project to reduce turbine entrainment and to guide fish to those downstream routes. Among the measures, Brookfield has proposed to install two 10-foot deep floating guidance booms; the first would extend from the western bank upstream of the headworks at an angle to the new downstream and upstream fishway on the outboard side of the Unit 1 - 6 Powerhouse (Figure 20; green line); and the second would be installed within the power canal in front of the Unit 7 - 8 Powerhouse (blue line). Guidance booms are not 100% effective at excluding fish. The 10-foot depth of the panels mean that they aren't effective at excluding or guiding species that migrate low in the water column (e.g., eels), and that even fish that travel near the surface are able to sound under the boom. However, guidance booms have been successfully used for surface oriented fish, such as juvenile Atlantic salmon (average 59% effective; range 58-60% effective) (BWPH 2014-2016), and adult alewives (average 58% effective; range 32%-84%) (BWPH 2016b, BWPH 2017b).

Figure 20. A Google Earth image of the Shawmut Project. The approximate location of the two guidance booms are depicted as a green and blue line; the approximate location of the new downstream bypass fishways are shown as orange triangles; the approximate extent of spillway resurfacing is shown in purple.

Angled full depth racks have the potential to provide a higher rate of exclusion for salmon smolts (mean 93%; range 88%-100%) (BBHP, 2015, 2016, 2017b, 2018, 2019; Harbicht et al., 2022; Nettles & Gloss, 1987; Tomanova et al., 2021). However, at powerhouses with high velocities, full depth structures with narrow rack spacing may result in the impingement of fish against the racks (Tomanova et al., 2021; USFWS, 2019), which can result in injury and mortality. According to the USFWS Fish Passage Design Guidelines (2019), velocities upstream of full-depth guidance structures should not exceed two feet per second (fps) due to the potential for impingement. Similarly, Tomanova et al. (2021), studying Atlantic salmon passage at hydro projects on the Ariege River in France, indicated that velocities with narrow, full depth racks should be kept below 1.6 fps for the same reason. In 2011, the Licensee hired a consultant to model alternative designs for full depth structures at the Shawmut Project to determine the feasibility of a full depth structure in relation to the velocity threshold (Blue Hill Hydraulics, Inc., personal communication, 2011). The modeling indicated that all of the full depth rack structures led to velocities upstream of the racks in excess of the two foot per second threshold. Brookfield's analysis (according to FERC's DEA for Shawmut) confirms an approach velocity at the Unit 7 - 8 Powerhouse of 3.5 fps. Therefore, we conclude that installing full depth racks would lead to the impingement of certain species and life stages of anadromous fish, including salmon smolts.

Although floating guidance booms are less likely to impinge fish, when by themselves they are much less effective than full depth structures (59% versus 93%). To account for their lower efficiency at Shawmut, Brookfield will install two of them to double the efficiency for fish that otherwise would have passed through the Unit 7 and 8 Powerhouse (which entrained twice as many smolts as the Unit 1 - 6 Powerhouse in the 2013-2015 studies). They will also install uniform acceleration weirs at both of the new downstream bypasses to increase bypass efficiency. To further reduce turbine entrainment of salmon smolts, Brookfield will conduct nighttime (12 hour) shutdowns at the Unit 7 and 8 Powerhouse for four or five weeks (or a sufficient amount of time to encompass 97% of the smolt run) during the smolt migration period. Additionally, they will install 1-inch spaced racks at the Unit 1 - 6 Powerhouse[45]. We estimate that all of these measures combined will reduce entrainment such that no more than approximately 3%[46] of smolts pass through the turbines. It is important to note that the entire package of measures is expected to result in an entrainment rate of Atlantic salmon smolts that is similar to what would be expected if full depth angled racks were installed, with significantly less risk of impingement, and therefore, would have higher overall survival compared to installation of full depth angled racks at this project.

The best available information indicates that mortality rates are generally higher through the turbines than through spillways and dedicated downstream bypasses (as described in section 4); however, when the turbines are not operating the sources of mortality through this passage route are eliminated. During the smolt migration period, Brookfield's proposal indicates that they will shut down turbines for 12 hours at night (8pm to 8am) for 4 weeks (28 days) at the Unit 7 - 8 Powerhouse at the Shawmut Project. They have estimated that 97% of the run would pass the project during that period and have proposed to shut down turbines at night for an additional week (total of 35 days) if smolt trapping in the Sandy indicates that 50 or more smolts per day could still be migrating through the river. Although the smolt run has historically occurred between mid-April and mid-June on the different rivers monitored, there is variability in the timing of the initiation of smolt migration and in the duration of the run (USASAC 2016-2022). As the proposed shutdown window is only 28-days long, such variability will significantly affect

[45] 1-inch racks were considered at the Unit 7 - 8 Powerhouse as well, however, it was determined that the velocities, which are in excess of two fps, could lead to impingement of salmon and alosines. 2-inch racks were proposed instead, which, although ineffective at excluding juvenile salmon, will exclude larger fish (adult salmon and shad) from being entrained in the turbines.

[46] Assumptions: Route utilization rates are based on 2013-2015 studies. 73% of fish approach the power canal, whereas the rest pass via spill. Each boom has an assumed 58% guidance efficiency, which is the average efficiency at Lockwood, Hydro-Kennebec, and Weston in the 2012 to 2015 studies. The UAWs increase bypass efficiency by 15% (Haro et al. 1998). The analysis assumes 40% of smolts pass at night, per Brookfield's analysis. This is likely an underestimate; however, it is consistent with what was observed in the 2013-2015 studies. We assumed that the 1-inch overlays at the Unit 1 - 6 Powerhouse would reduce entrainment by 43%, which is the proportional difference between the study results at the project (BWPH 2013-2015) with the existing 1.5-inch racks (11.6%) and the average 6.6% entrainment rate observed at the Orono A and Stillwater A powerhouses on the Penobscot River between 2014 and 2018 once perpendicular 1-inch racks were installed. This is more conservative than the 93% reduction assumed by Brookfield in their analysis, but is more appropriate as the existing powerhouse already has 1.5-inch racks that likely provide some behavioral deterrent effect.

the percentage of the run that is protected by these shutdowns. Brookfield has proposed that "the start date [would] be determined in consultation with NMFS and the Maine Department of Marine Resources (MDMR) based on smolt trapping information or migration model". Although smolt trapping may allow for an accurate estimate of the start of the run, we do not anticipate that traps will be operated in the Sandy River in most years. The decision of where and when to operate traps is made by the fisheries agencies based on management and assessment priorities. As such, we expect that in many years the determination of the start date will be informed by a migration model. Therefore, we consider the effectiveness of the shutdown proposal under two conditions; one when trapping is occurring and another when it is not.

If smolt trapping is underway, we would expect the proposed shutdown window to begin the day that the first smolt is captured in the trap in the Sandy River. As indicated in Table 13, the total run duration on the Sheepscot varied between 21 and 37 days (average 28 days) between 2015 and 2019; and 48 (2022) and 53 days (2021) in the Sandy River (average 51 days) (USASAC 2021, Noll, J., MDMR, personal communication, 11/30/2022). The longer duration in the Sandy is likely due to the larger size of the watershed, which leads to some smolts needing to travel further, requiring more time. It is also likely that the streams in the headwaters (which tend to be at higher elevation) warm more slowly in the spring, which leads to fish initiating their migration at different times in different parts of the watershed. Regardless of the cause, it is apparent that the Sandy has a longer run duration than the smaller Sheepscot River. Given this longer duration, it is possible, but unlikely, that 97% of the run would pass during a 28-day or 35-day shutdown window. MDMR has provided us information on the timing of smolt captures from the traps in the Sandy River in 2021 and 2022 so that we can estimate the proportion of smolts that would be protected by the proposed shutdown window (Table 30). It should be noted that as fish were monitored at the trap location rather than at the dams, which are further downriver, the proportion protected by the shutdowns would be slightly lower than what is shown in Table 30 (Frechette, D. MDMR, personal communication, 11/14/2022). This is attributable to the additional time it would take for smolts to migrate the distance between the Sandy and the dams. For example, according to their modeling, MDMR indicated that 3% fewer fish would pass Lockwood within 28-days than would pass Weston (Frechette, D. MDMR, personal communication, 11/14/2022).

Table 30. The proportion of the smolt run that migrated out of the Sandy River within different hypothetical protection windows in 2021 and 2022. The duration is the number of days after the day of first capture at the rotary screw traps, and the proportions indicate the portion of the total smolt run that passed during that time frame. The last row indicates the number of days it took to pass 100% of the run (recorded at the trap) in 2021 and 2022, respectively.

Duration	2021	2022
28-days	82.2%	44.0%

35-days	95.9%	88.2%
42-days	99.4%	99.7%
48/53-days	100.0%	100.0%

This information indicates that it is highly unlikely that 97% of the run will pass within four weeks of the first capture date and that a four week shutdown would protect only 44-82.2% of the run. Even if the trigger for the one week extension occurs[47], it is unlikely that 97% would be reliably achieved, and more likely that 88.2-95.9% of the run would be protected. However, greater than 99% of the run passed within six weeks (42 days) of the first capture date in both 2021 and 2022; thus, we expect that a six week period of night time shutdowns would reliably protect more than 97% of the outmigrating smolts as long as the initiation of shutdowns coincides with the initiation of the run.

As indicated above, we do not anticipate that trapping will occur in most years, and we will need to rely on a smolt migration model to determine the date for initiating shutdowns. MDMR and NOAA's Northeast Fisheries Science Center have developed a model to predict the timing of the smolt run based on air temperature (Frechette et al., 2022). Because we consider it the best available information, we expect that this is the model that will be used to predict the appropriate time to initiate turbine shutdowns. As it is a model, and therefore based on numerous assumptions, it will not predict the initiation date of the run with the same level of accuracy as real-time trapping. The model assumes that a minimum of 54-days would be needed to protect 100% of the smolt run. Correspondingly, it assumes that approximately 80%, 96%, and 99% would pass within 28-days, 35-days, and 42-days, respectively (Frechette D., MDMR, personal communication, 12/2/2022). These proportions are dependent on the accuracy of the predicted start date of the run. MDMR has provided a comparison between the observed (trap results) and expected (model predicted) dates of first capture on the Sandy River in 2021 and 2022 to help us understand how accurate the predictions would likely be in the future when the traps are not in place. They have indicated that in 2021 the expected initiation date was six days later than what was actually observed; and that in 2022 the expected date was 13 days later than what was actually observed (Frechette D., MDMR, personal communication, 12/2/2022). Frechette et al. (2022) notes that despite the discrepancy between the observed and modeled dates in 2021 that, "approximately 99% of the Sandy smolt wave would have passed all four of the dams during the suggested 54-d protective window" (Frechette et al. 2022). Therefore, it is likely that a 28 or 35 day shutdown would protect a smaller proportion of the run. As such, we expect that the proportions indicated in Table 30 are the *maximum* proportion of what would be protected with a

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[47] The proposed trigger for the extra week of shutdowns is the capture of enough smolts to indicate that 50 or more smolts are still migrating in the river. This is not a reasonable trigger as the extrapolation from trap catch to migrating smolts is not made in real time; and it could be months before such an estimate is available. However, we anticipate that some alternative trigger (based on the number of fish captured, rather than the extrapolated estimate) could be agreed upon.

modeled start date, and that it would likely be lower. As noted above, Brookfield is proposing to implement night time shutdowns that are of sufficient duration to encompass 97% of the period that the smolt run passes all four projects. Brookfield has estimated that a four or five week shutdown period would be sufficient to reach this goal; however, it appears that this will not be long enough. As such, we assume that FERC will condition the license to require the shutdowns meet the 97% goal, rather than the four to five weeks that Brookfield has described[48]. As such, in this analysis we assume that whether trapping is occurring or not, Brookfield will conduct the shutdowns that are of sufficient duration to encompass the period that 97% of the smolt run passes all four projects.

Given the anticipated improvement in survival through the downstream bypass and spillway, as well as the anticipated increase in bypass efficiency, we estimate that the average direct survival of smolts at Shawmut will increase to 97.4%. We estimate this by multiplying the expected passage route utilization by the route specific survival rates discussed above and then adding them together (Table 31).

Table 31. The calculation of anticipated smolt survival at the Shawmut Project based on changes in route utilization and survival caused by the proposed measures.

Passage Route	Utilization (U)	Survival (S)	U x S
Francis Units	1.7%	84.5%	1.4%
Propeller Units	1.3%	88.4%	1.1%
Spillway	27.2%	97.0%	26.4%
Bypass	69.8%	98.0%	68.4%
Survival (Sum)			97.4%

As indicated in section 4, we consider the causative factors for hydrosystem delayed mortality to be migratory delay and sublethal injury. In our analysis above, we indicate that both turbine and non-turbine routes contribute to sublethal injury given the relatively poor survival through those routes. As we have described, we anticipate that the proposed measures are expected to increase survival through the spillway and bypass to what is typical for Atlantic salmon smolts at low head dams. The potential for a reduction in turbine entrainment also reduces the potential for injury. Based on these improvements, we anticipate that the proposed action could reduce sublethal injury rates from 6.9% to 0.5% (Table 32).

Table 32. The calculation of sublethal injury at the Shawmut Project. The baseline utilization rates are from BWPH's Supplemental SPP. Injury rates are based on the 1-hour injury rates estimated in FPL Energy (2013), but have been modified as described in the text.

[48] Incorporated as a term and condition (#3b) in section 10 of this Opinion.

Baseline Condition	Francis	Kaplan	Non-turbine	Injury (Sum)
Utilization	11.6%	21.1%	66.7%	
Utilization x Injury Rate	2.8%	1.6%	2.5%	6.9%
Proposed Condition				
Utilization	1.7%	1.3%	97.0%	
Utilization x Injury Rate	0.4%	0.1%	0.0%	0.5%

Similar to injury, we expect migratory delay (residence time) will decrease at the project due to the proposed action. During the 2013-2015 smolt studies at the projects, the presence of the Shawmut dam led to migratory delay greater than 24 hours for an average of 8.5% of migrating smolts. Several of the measures could reduce delay, such as the installation of guidance structures and uniform acceleration weirs, as well as the shutdown of the turbines at the Unit 7 - 8 Powerhouse. The shutdown of these turbines for 12-hours a day will divert the 2,600 cfs of flow that would otherwise go through the turbines to the spillway, which would increase attraction to that route particularly in low flow years. On the Penobscot River, Black Bear Hydro has implemented a spill program 24 hours (spill 20-50% of river flow, not complete shutdowns) a day during a portion of the smolt migration period. Monitoring conducted between 2016 and 2018 indicated that delay was substantially reduced with this measure, with an average of 2.4% of smolts per project taking longer than 24 hours to pass (residence time; time measured from when the smolts approach within 200 meters upstream of the project to when they pass it) (BBHP, 2018). As the Unit 1 - 6 Powerhouse will still be operating, we anticipate that some delay will occur, but that, like on the Penobscot, it will be significantly reduced. Lacking project specific information, we assume that the average amount of delay (2.4%) seen at the Penobscot between 2016 and 2018 is a reasonable estimate of what would occur at Shawmut with the shutdown of one of the powerhouses. The installation of guidance structures and UAWs at the bypass structures is expected to further reduce that delay. Haro et al. (1998) documented significant reductions in migration time when comparing a sharp-crested weir to a uniform acceleration weir. In their study, they documented that while a sharp crested weir only passed 0.7% of Atlantic salmon smolts within 10 minutes of approach, a UAW passed 38.3% (Haro et al., 1998). This represents a substantial increase that would likely make a difference in delay, particularly when combined with a guidance boom. As we anticipate that the proposal will lead to approximately 70% of smolts passing one or the other of the downstream bypass fishways, we assume that none of these fish will take longer than 24 hours to pass the project. Therefore, we will focus the analysis of the nighttime shutdowns at the Unit 7 and 8 Powerhouse on the remaining 30% of smolts. The proposal for Shawmut requires shutdowns for 12 hours a day, and Brookfield estimates that during the 2013 to 2015 smolt survival studies approximately 40% of smolts passed the project at night. We therefore consider that 60% of the smolts pass during the day at this project. This is unusual, as smolts are known to migrate primarily at night in freshwater (Kocik et al., 2009). This could be an effect of tagging and handling, or else delay at the project may have led to a large portion of fish passing during the day. Regardless, we include this proportion in our analysis as it is the best available information on run timing at this project. Given the timing of the project shutdown at the Unit 7 - 8 Powerhouse, the 40%/60%

(night/day) timing distribution, and information on the existing and potential delay expected when significant spill is provided (as on the Penobscot), we estimate that the nighttime shutdowns (in combination with the guidance structures and UAWs) will reduce the percentage of smolts that take more than 24 hours to pass the project from 8.5% to 1.8% (Table 33).

Table 33. The calculation used to estimate the reduction in delay (residence time) that would be caused by the proposed action.

Passage Route	% of Smolts (S)	% Delayed (D)	S x D
Bypass	70%	0%	0%
Nighttime (spill)	12%	2.4%	0.3%
Daytime (spill + turbine)	18%	8.5%	1.5%
Total (Sum)			1.8%

As indicated in section 4, we assumed that hydrosystem delayed mortality at the Shawmut Project was approximately 7.6% based on project specific estimates of migratory delay and sublethal injury. To estimate the potential reduction in this mortality caused by the proposed action, we determined the proportional difference between injury and delay under the baseline and proposed action scenarios and applied that change to the 7.6% assumed delayed mortality described above. As such, because the best available information indicates an estimated 93% reduction in injury (i.e., (6.9%-0.5%)/6.9%=93.0%), we would anticipate a similar reduction in the component of delayed mortality attributed to injury. Similarly, the best available information indicates that there will be an estimated 79% reduction in migratory delay (i.e., (8.5%-1.8%)/8.5%=79%), therefore we would anticipate a similar reduction in that component of hydrosystem delayed mortality. Therefore, we determine that Shawmut's total contribution to hydrosystem delayed mortality in the estuary is reduced from 7.6% to 0.9%.

Based on the above analysis, we anticipate that the proposed action will reduce cumulative mortality at the project from 19.5% to 3.4% (Table 34). Although reprioritization may lead to immediate increases in survival, it will take time to implement the other proposed operational and structural improvements. As such, we anticipate that survival at the Shawmut Project during the downstream interim phase (Year 1-3) may not differ significantly from what has been described in the environmental baseline.

Table 34. Summary of smolt mortality at the Shawmut Project under the existing and proposed action scenarios.

Source of Mortality	Environmental Baseline	Interim (Y 1 - 3)	Implementation (Y 4 – Y 50)

Direct	12.9%	12.9%	2.6%
Hydrosystem Delayed	7.6%	7.6%	0.9%
Cumulative	19.5%	19.5%	3.4%*

*Cumulative survival is multiplicative, not additive, as only smolts that survive direct effects are exposed to HDM. Therefore, it is calculated as 0.974 x 0.991 = 0.966. We then subtract that result from one to convert it to cumulative mortality (i.e., 1 - 0.966 = 0.034).

If the project performance standard for smolt survival is not met after the proposed measures have been implemented, then Brookfield will implement additional measures that will be informed by study results and developed in consultation with the agencies. These measures could include measures that will further improve survival over the spillway (such as resurfacing additional sections of the dam, or excavating a deeper plunge pool), or further reduce turbine entrainment (such as expanding the duration of shutdowns, or conducting shutdowns at the Unit 1 - 6 Powerhouse). These measures would further reduce the number of fish that are entrained in the turbines and would increase the efficiency of the downstream fishway; both of which would contribute to increased survival.

Under current operating conditions, migratory delay of smolts within 200 meters of the Shawmut Project varies by year, with an average of 8.5% of fish taking more than 24 hours to pass the project. This is the level of delay we anticipate during the interim phase (years 1 to 3). As indicated above, Brookfield will implement measures that are expected to reduce migratory delay at the project. We anticipate that for the duration of the implementation phase an average of 1.8% of smolts will continue to take more than 24 hours to pass the Shawmut Project; as explained above, we have determined that this adverse effect meets the definition of harassment but does not meet the definition of harm.

As indicated above, we anticipate that the proposed action will reduce residence time at the Shawmut Project. However, the proposed modifications will not affect the rate of movement through the 19-km impoundment; effects to the movement of smolts through the impoundment (i.e., the excess time it takes to pass through this stretch of the river compared to how long it would take if the dam was not there) are effects of the continued existence of the dam as will be authorized by a new license for the project. As described in section 4, we have estimated that the Shawmut impoundment contributes an additional 8.6 to 14.0 hours of delay on average. This will increase the proportion of fish that are delayed by more than 24 hours at the project. However, the study results do not indicate what proportion of smolts would be exposed to this additional amount of delay.

Kelts

In section 4, we indicated that the racks in front of the turbines at the new Shawmut powerhouse are large enough for Atlantic salmon kelts to become entrained (i.e., adult salmon can pass through the racks and be entrained in the turbines). In our analysis, we concluded that 8% of kelts are killed at the project as a result of turbine entrainment under baseline conditions, and we expect that to persist through the interim phase. The installation of 2-inch racks within three years of license issuance will exclude 100% of adult salmon from passing the project through the turbines. In addition, the new downstream fishways will provide a safe route of egress for kelts. These modifications will result in a significant reduction in adult Atlantic salmon mortality at this project. Consistent with assumptions made by Alden Research Laboratories (2012), we anticipate that a small proportion (up to 3%) of salmon kelts could still be killed due to the effects of passage at non-turbine routes. As such, the best available information indicates that the proposed action will result in mortality of 8% and 3% of kelts annually during the interim and implementation phase, respectively.

6.2.1.3 Hydro-Kennebec Project

As indicated in section 2, Brookfield has proposed new measures at the Hydro-Kennebec Project that will be implemented within two years of FERC approval:

- Install a new, relocated downstream entrance with a uniform acceleration weir;
- Remove internal weirs and smooth downstream flume;
- Relocate the fish boom, connect directly to the relocated entrance and eliminate the gap; and
- Install a 2-inch trashrack overlays in front of the turbine intakes.

Additional measures include:

- Operate the new upstream fish passage facility with an AWS/flume having a 200 – 400 cfs capacity once volitional fish passage operations are implemented following construction and shakedown of facilities at Lockwood, Shawmut and Weston;
- Implement nighttime shutdowns from 8 pm to 8 am for four weeks (up to five weeks) during the smolt migration period, generally targeted for the last week of April to the last week of May, with the start date to be determined in consultation with NMFS and MDMR based on smolt trapping information or a migration model beginning with the first downstream passage season after issuance of this Biological Opinion; and
- Conduct a survey of the bypass reach ledges for perched pools and modify the ledges as necessary to provide opportunities for egress; to be implemented within one year of FERC approval.

Smolts

As detailed in section 4, we anticipate that the operation of the Hydro-Kennebec Project is currently leading to the cumulative mortality of 10.4% of salmon smolts (excluding mortality attributed to the impoundment, which was addressed in the environmental baseline). This estimate includes 7.0% due to direct mortality and 3.7% due to hydrosystem delayed mortality[49]. To reduce this level of mortality, Brookfield will implement the improvements described above as part of their proposed SPP.

Of the measures designed to reduce turbine entrainment, the shutting down of the project turbines for 12 hours a night (8 pm to 8 am) for 4 or 5 weeks will likely be the most effective. As indicated previously, the effectiveness of turbine shutdowns is dependent on timing them so that they coincide with the actual run in the river. Brookfield has proposed to use information from smolt trapping or a migration model to determine the appropriate time to initiate shutdowns. We anticipate that in most years traps will not be operated in the Sandy, and that the DMR and NMFS smolt run timing model will be used to inform the initiation of shutdowns. As described in the Shawmut analysis, a four week shutdown that begins on the date predicted by the model is unlikely to protect >97% of the smolt run, which is the objective described by Brookfield. For our analysis, we assume that whether trapping is occurring or not, Brookfield will conduct shutdowns that encompass the period that 97% of the smolt run passes all four projects, which is consistent with the assumptions made by Brookfield in their analysis.

The analysis provided by Brookfield indicates that in the 2012-2014 studies 72% of study smolts passed Hydro-Kennebec during nighttime hours, and that 97% of smolts passed within a four week period. If the shutdowns are implemented for a duration that encompasses 97% of the run, we anticipate that at least 70% (97% that pass during the weeks that the turbines are shut down at night x 72% that pass at night) of the smolt run would be protected if the measure is implemented as proposed. As such, 70% of the smolts would pass via the spillway, the new AWS fishway, or the redesigned bypass.

The remaining 30% of smolts (those that pass during the day or outside of the shutdown period) could be entrained through the project turbines. During the 2012-2014 studies, approximately 28% of all the study smolts went through one of the two turbines; with 22.6% going through unit 1 (next to the downstream bypass), and 5.5% going through unit 2 (next to the shoreline)[50]. The existing floating guidance boom has a 5-foot gap immediately upstream of the unit 1 intake, which likely explains the significantly higher entrainment rate (Figure 21). Brookfield's analysis assumes that the proposal to reset the guidance boom to close the gap will reduce unit 1 entrainment to what was observed at unit 2. This is likely a conservative estimate as the repositioned entrance, increased flow, and the installation of a uniform acceleration weir would likely attract a higher percentage of migrants to the bypass from what was observed in the 2012-

[49] Cumulative survival is multiplicative as only smolts that survive direct effects are exposed to HDM. Therefore, it is calculated as 0.930 x 0.963 = 0.896. We then subtract that result from one to convert it to cumulative mortality (i.e., 1 - 0.896 = 0.104).

[50] Utilization rates differ from what was presented in Table 5 of Brookfield's September 21, 2022 filing, as we adjusted them so that they added up to 100%. Although unexplained, we assume that Brookfield included all smolts that approached the project in the denominator, even those for which a passage route could not be ascertained. In our recalculation, we only included smolts that had an assigned passage route.

2014 studies. In addition, it is possible that some of the smolts that used unit 2 also passed through the gap. Therefore, we anticipate that applying the 5.5% unit 2 entrainment rate to unit 1 provides a conservative estimate of entrainment at the Hydro-Kennebec project and that the actual entrainment rate may be even lower.

To determine the effect of the proposed measures, we first need to estimate how they will change passage route selection at the project. For this analysis, we estimated route selection for the 30% that approach the project when the turbines are operating by assuming that fish that would have gone through the turbines, but are deterred by the proposed measures, will pass via the bypass. This is because the fish will still be attracted to the powerhouse on the east side of the river but will be diverted to the bypass (just to the right of the powerhouse) due to the guidance boom, the UAW, and the additional attraction flow (Figure 21). Conversely, when estimating route selection for the 70% of smolts that pass when the turbines aren't operating, we assumed that the fish that would have gone through the turbines would pass via the spillway due to the 12 hour nighttime shutdowns. This is because those fish won't be attracted to the powerhouse (as the turbines aren't operating) and will instead be attracted to the substantial flow passing the spillway.

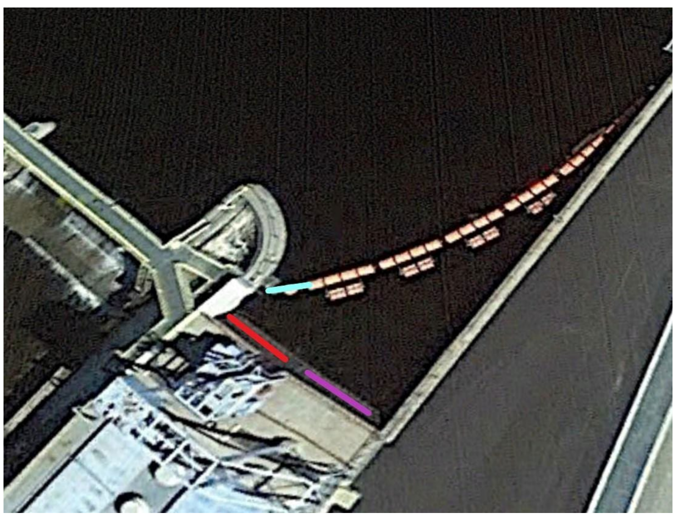

Figure 21. The floating guidance boom at Hydro-Kennebec has a 5-foot gap (light blue line) that exists immediately upstream of the intake to unit 1 (red line).

In order to estimate project survival under these day and night scenarios, we need to determine how the route survival rates will be affected by the proposed action. The proposal to change the position of the bypass entrance and the removal of baffles should improve survival through that route. The existing entrance is at a 90 degree angle from the discharge flume, which potentially leads to fish impacting the wall of the concrete plunge pool. Moving the entrance away from the intakes and eliminating the angle should reduce this source of mortality. The survival through the bypass during the studies averaged 94.5%, and ranged between 88.2% and 98.6% (FERC Accession # 20220921-5117). Lacking certainty on how significant the improvement will be, we will assume that bypass survival will increase to what is typically observed at other projects (98%) (Alden Research Laboratory, 2012; BBHP, 2017, 2017b, 2018, 2019; BWPH, 2016, 2019), which is a modest improvement that is at the upper range of what was observed during the studies. We do not expect changes to the survival of any of the other routes.

Given these assumptions, we anticipate that 95.1% of fish that pass when the turbines are operating (30% of the time) will survive, and that 97.7% will survive when they aren't operating due to nighttime shutdowns (70% of the time). Therefore, we estimate that the weighted project survival will be 96.9% (i.e., (30% x 95.1%) + (70% x 97.7%)) (Table 35).

Table 35. Analysis of the anticipated survival of Atlantic salmon smolts at the Hydro-Kennebec Project with the implementation of the proposed measures.

	Daytime (30% Passage)			Nighttime (70% Passage)		
Passage Route	Utilization (U)	Survival (S)	U x S	Utilization (U)	Survival (S)	U x S
Unit 1	5.5%	89.7%	4.9%	0.0%	89.7%	0.0%
Unit 2	5.5%	69.4%	3.8%	0.0%	69.4%	0.0%
Spillway	31.5%	97.5%	30.7%	59.6%	97.5%	58.1%
Bypass	57.5%	96.8%	55.7%	40.4%	98.0%	39.6%
Survival (Sum)			95.1%			97.7%
Weighted Survival	**96.9%**					

As indicated in section 4, we consider the causative factors for hydrosystem delayed mortality to be migratory delay and sublethal injury. In our analysis above, we indicate that turbine passage is expected to contribute to sublethal injury. As we have described, we anticipate that the proposed measures will reduce the proportion of fish that pass via the turbine units. Given the analysis above, we anticipate that turbine entrainment will be reduced from 28% to approximately 3%. The reduction in turbine entrainment also reduces the potential for injury. Based on these improvements, we anticipate that the proposed action would reduce sublethal injury rates from 2.1% to 0.2% (Table 36).

Table 36. The calculation of sublethal injury at the Hydro-Kennebec Project. The baseline utilization rates are from BWPH's revised analysis. Injury rates are based on the 1-hour injury rates estimated in FPL Energy (2013; 7.5% 1-hour injury rate for Kaplan units).

Baseline Condition	Units	Non-turbine	Injury (Sum)
Utilization	28.1%	71.9%	
Utilization x Injury Rate	2.1%	0.0%	2.1%
Proposed Condition			
Utilization	3.3%	96.7%	
Utilization x Injury Rate	0.2%	0.0%	0.2%

Similar to injury, we expect migratory delay (residence time) will decrease at the project due to the proposed action. During the 2013-2015 smolt studies at the projects, an average of 7.3% of migrating smolts took longer than 24 hours to pass Hydro-Kennebec. Several of the proposed measures are expected to reduce delay, such as the installation of guidance structures and uniform acceleration weirs, as well as night time shutdowns of the turbines at the powerhouse. Shutting down the two Kaplan turbines for 12-hours a day will divert between 3,100 cfs to 7,922 cfs of flow to the spillway (operating range between 1,550 and 3,961 cfs a piece), which would substantially increase attraction to that route particularly in low flow years. We have estimated that 70% of smolts would pass the project when the turbines are shut down, and that 30% will pass during the day when the turbines are operating. As 100% of river flow would be passing over the spillway or the downstream fishway for 12-hours per day, fish that approach during the day would be unlikely to be delayed a full 24 hours. Therefore, we do not anticipate that any smolts will be delayed by more than 24 hours under the proposed measures.

As indicated in section 4, we assumed that hydrosystem delayed mortality at the Hydro Kennebec Project was approximately 3.7% based on project specific estimates of migratory delay and sublethal injury. To estimate the potential reduction in this mortality caused by the proposed action, we determined the proportional difference between injury and delay under the baseline and proposed action scenarios and applied that change to the 3.7% assumed delayed mortality described above. As such, we assumed that since we estimate a 91% reduction in injury (i.e., (2.1%-0.2%)/2.1%=90.5%), we would anticipate a similar reduction in the component of delayed mortality attributed to injury (i.e., ~0.2%). Similarly, we would anticipate a 100% reduction to the component attributable to migratory delay. Therefore, we assume that Hydro Kennebec's total contribution to hydrosystem delayed mortality in the estuary is reduced from 3.7% to 0.2%.

Based on the above analysis we anticipate that the proposed action will reduce cumulative mortality at the project from 10.4% to 3.3% (Table 37). Although the turbine shutdowns will lead to immediate increases in survival, it will take time to implement the other proposed operational and structural improvements. As such, we anticipate that survival at the Hydro-Kennebec Project during the downstream interim phase (Year 1-3) will lead to a direct mortality rate of 4.7% and an indirect mortality rate (excluding impoundment mortality) of 0.5%.

Table 37. Summary of smolt mortality at the Hydro-Kennebec Project under the existing and proposed action scenarios.

Source of Mortality	Environmental Baseline	Interim (Y 1 - 3)	Implementation (Y 4 - Exp)
Direct	7.0%	4.7%	3.1%
Hydrosystem Delayed	3.7%	0.5%	0.2%

Cumulative	10.4%	5.2%	3.3%*

*Cumulative survival is multiplicative, not additive, as only smolts that survive direct effects are exposed to HDM. Therefore, it is calculated as 0.969 x 0.998 = 0.967. We then subtract that result from one to convert it to cumulative mortality (i.e., 1 - 0.967 = 0.033).

Migratory delay of smolts within 200 meters of the Hydro-Kennebec Project varied in 2013 and 2014, with 7.3% (range: 6.3% to 8.2%) of fish taking more than 24 hours to pass the project on average (BWPH 2014, 2015). The proposal to conduct nighttime shutdowns (as well as modifying the downstream guidance boom, installing a uniform acceleration weir, increasing bypass flow, and relocating the bypass entrance) should reduce migratory delay. Based on the assumptions described above, we believe that it is reasonable to assume that the proposal will eliminate smolt delay (i.e., > 24 hour residence time). Therefore, we anticipate that with the implementation of the proposed action, no smolts will be harassed due to delay associated with the proposed action at the Hydro-Kennebec Project.

Kelts

In section 4, we indicated that the racks in front of the turbines at the new Hydro-Kennebec powerhouse are large enough for Atlantic salmon kelts to become entrained (i.e., adult salmon can pass through the racks and be entrained in the turbines). In our analysis, we concluded that 10% of kelts would be killed at the project as a result of turbine entrainment under baseline conditions, and we expect that to persist through the interim phase. The installation of 2-inch racks within three years of license issuance will exclude 100% of adult salmon from passing the project through the turbines. In addition, the modified downstream fishway will provide a safe route of egress for kelts that are attracted to it. These modifications will result in a significant reduction in adult Atlantic salmon mortality at this project. Consistent with assumptions made by Alden Research Laboratories (2012), we anticipate that a small proportion (up to 3%) of salmon kelts could still be killed due to the effects of passage at the project spillway. As such, the best available information indicates that the proposed action will lead to the mortality of 10% and 3% of kelts annually during the interim and implementation phase, respectively.

6.2.1.4 Lockwood Project

As described in section 2, the downstream passage proposal at Lockwood maintains the status quo operation and maintenance of the bypass gate and floating guidance boom in the power canal throughout the downstream passage season. Brookfield has proposed the following new measures:

- Within two years of FERC approval:
  - Install a 2-inch trash rack overlay at Unit 7 (Units 1-6 already have 2-inch racks); and
  - Install a uniform acceleration weir at both the downstream fishway and the forebay surface sluice.

- Implement nighttime shutdowns from 8 pm to 8 am for four weeks (up to five weeks) during the smolt migration period, which is generally targeted for the last week of April to the last week of May, with the start date to be determined in consultation with NMFS and MDMR based on smolt trapping information or migration model beginning the first downstream passage season after issuance of this Biological Opinion.

Smolts

As detailed in section 4, we anticipate that the operation of the Lockwood Project is currently leading to the cumulative mortality of 7.6% of salmon smolts (4.3% due to direct mortality, and 3.5% due to hydrosystem delayed mortality)[51]. To reduce this level of mortality, Brookfield has proposed the new measures described above as part of their proposed SPP.

Of the proposed measures designed to reduce turbine entrainment, the shutting down of the project turbines for 12 hours a night (8 pm to 8 am) for four or five weeks will likely be the most effective. As indicated previously, the effectiveness of turbine shutdowns is dependent on timing them so that they coincide with the actual run in the river. Brookfield has proposed to use information from smolt trapping or a migration model to determine the appropriate time to initiate shutdowns. We anticipate that in most years traps will not be operated in the Sandy, and that the DMR and NMFS smolt run timing model will be used to inform the initiation of shutdowns. As described in the analysis for Shawmut above, a four week shutdown that begins on the date predicted by the model is unlikely to protect >97% of the smolt run as predicted by Brookfield. However, for our analysis, we assume that whether trapping is occurring or not, Brookfield will conduct shutdowns that encompass the period that 97% of the smolt run passes all four projects.

The analysis provided by Brookfield indicates that 75% of study smolts passed Lockwood during those hours during the 2013-2015 studies, and that 97% of smolts passed within a four week period. Therefore, considering the percentage of smolts that are expected to pass at night and the implementation of night time shutdowns hat overlap with the period when 97% of the smolt run occurs, we anticipate that at least 73% (97% x 75%) of the smolt run will be protected through implementation of this measure. Therefore, 73% of the smolts are expected to pass at night via the spillway, or one of the downstream bypass fishways with the added uniform acceleration weirs. The remaining 27% of smolts (those that pass during the day or outside of the shutdown period) could potentially be entrained through the project turbines. During the 2013-2015 studies, approximately 15% of all the study smolts went through one of the seven turbines; with approximately 7% going through the Francis units (units 1-6), and 8% going through the Kaplan

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[51] Cumulative survival is multiplicative as only smolts that survive direct effects are exposed to HDM. Therefore, it is calculated as 0.967 x 0.965 = 0.924. We then subtract that result from one to convert it to cumulative mortality (i.e., 1 - 0.924 = 0.076).

unit (unit 7)[52]. The remaining 85% went either through the downstream bypass (26%) or the spillway (59%). We assume that this is the route distribution that will apply to the 27% of the smolts that pass when the turbines are operating. For the 73% of smolts that pass at night when the turbines are shut down, we assume that smolts that would have passed through the powerhouse will instead be passed via spill. This is due to the resulting shift of flow (and therefore attraction) from the power canal to the spillway. We can estimate the survival at the project with the implementation of the proposed action by applying the average route survival rates to the expected route utilization rates during both day and night, and then applying the appropriate weights (Table 38).

Table 38. Analysis of the anticipated survival of Atlantic salmon smolts at the Hydro-Kennebec Project with the implementation of the proposed measures.

	Daytime (27% Passage)			Nighttime (73% Passage)		
Passage Route	Utilization (U)	Survival (S)	U x S	Utilization (U)	Survival (S)	U x S
Francis	6.9%	85.5%	5.9%	0.0%	85.5%	0.0%
Kaplan	8.0%	88.1%	7.0%	0.0%	88.1%	0.0%
Spillway	59.2%	97.3%	57.6%	74.5%	97.3%	72.5%
Bypass	25.9%	97.1%	25.1%	25.9%	97.1%	25.1%
Survival (Sum)			95.7%			97.6%
Weighted Survival	**97.1%**					

As indicated in section 4, we consider the causative factors for hydrosystem delayed mortality to be migratory delay and sublethal injury. In our analysis above, we indicate that turbine passage likely contributes to sublethal injury. As we have described, we anticipate that the proposed measures will reduce the proportion of fish that pass via the turbine units. Given the analysis above, we anticipate that turbine entrainment will be reduced from 15% to approximately 4%. The potential for a reduction in turbine entrainment also reduces the potential for injury. Based on these improvements, we anticipate that the proposed action could reduce sublethal injury rates from 2.2% to 0.7% (Table 39).

Table 39. The calculation of sublethal injury at the Lockwood Project. The baseline utilization rates are from BWPH's revised analysis. Injury rates are based on the 1-hour injury rates estimated in FPL Energy (2013; 1-hour injury rate for 7.5% for Kaplan units and 23.8% for Francis units).

Baseline Condition	Francis	Kaplan	Non-turbine	Injury (Sum)
Utilization	6.9%	8.0%	85.1%	
Utilization x Injury Rate	1.6%	0.6%	0.0%	2.2%
Proposed Condition				
Utilization	1.9%	2.2%	95.9%	
Utilization x Injury Rate	0.5%	0.2%	0.0%	0.7%

[52] Utilization rates differ from what was presented in Table 7 of Brookfield's September 21, 2022 filing, as we adjusted them so that they equaled 100%.

Similar to injury, we expect migratory delay (residence time) will decrease at the project due to the proposed action. During the 2013-2015 smolt studies at the projects, Lockwood led to migratory delay greater than 24 hours for an average of 6.3% of migrating smolts. Some of the proposed measures are expected to reduce delay, such as the installation of uniform acceleration weirs, and the shutdown of the turbines. The shutting down of the units for 12-hours at night will divert up to 4,300 cfs of flow to the spillway, which should substantially increase attraction to that route. We have estimated that 73% of smolts would pass the project when the turbines are shutdown, and that 27% will pass during the day when the turbines are operating. As 100% of river flow would be passing over the spillway or the downstream fishway for 12-hours per day, fish that approach during the day would be unlikely to be delayed a full 24 hours. Therefore, we do not anticipate that any smolts will be delayed by more than 24 hours under the proposed measures.

As indicated in section 4, we assumed that hydrosystem delayed mortality at the Lockwood Project was approximately 3.5% based on project specific estimates of migratory delay and sublethal injury. To estimate the potential reduction in this mortality caused by the proposed action, we determined the proportional difference between injury and delay under the baseline and proposed action scenarios and applied that change to the 3.5% assumed delayed mortality described above. As such, we assumed that since we estimate a 72% reduction in injury (i.e., (2.2%-0.6%)/2.2%=72%), we would anticipate a similar reduction in the component of delayed mortality attributed to injury (i.e., ~0.4%). Similarly, we would anticipate a 100% reduction to the component attributable to migratory delay. Therefore, we assume that Lockwood's total contribution to hydrosystem delayed mortality in the estuary is reduced from 3.5% to 0.4%.

Based on the above analysis we anticipate that the proposed action will reduce cumulative mortality at the project from 7.6% to 3.3% (Table 40). Although the turbine shutdowns will be implemented immediately, it will take time to implement the other proposed operational and structural improvements. However, as the anticipated gains in survival at the project are attributed primarily to the turbine shutdowns, we anticipate that survival during the interim phase will not differ from what is expected during the implementation phase.

Table 40. Summary of smolt mortality at the Lockwood Project under the existing and proposed action scenarios.

Source of Mortality	Environmental Baseline	Interim (Y 1 - 3)	Implementation (Y 4 - Exp)
Direct	4.3%	2.9%	2.9%
Hydrosystem Delayed	3.5%	0.4%	0.4%
Cumulative	7.6%	3.3%	3.3%*

*Cumulative survival is multiplicative, not additive, as only smolts that survive direct effects are exposed to HDM. Therefore, it is calculated as 0.971 x 0.996 = 0.966. We then subtract that result from one to convert it to cumulative mortality (i.e., 1 - 0.967 = 0.033).

Migratory delay of smolts within 200 meters of the Lockwood Project varies by year, with 6.3% (range: 3.1% to 9.5%) of fish taking more than 24 hours to pass the project on average (BWPH 2014-2016). The proposal to conduct nighttime shutdowns (as well as installing two uniform acceleration weirs) is expected to reduce migratory delay. Based on the assumptions described above, it is reasonable to conclude that the proposal will eliminate smolt delay (i.e., > 24 hour residence time). Therefore, we anticipate that with the implementation of the proposed action, no smolts will be harassed due to delay associated with the proposed action at the Lockwood Project.

Stranding

In the last few years, approximately 100,000 smolts have been stocked below the Lockwood Project annually. Operation of the Lockwood Project could affect any Atlantic salmon smolts stocked downstream of the project, particularly during flashboard replacement and/or during and after spill events, by inadvertently trapping or stranding them in the various pools downstream of the project. On June 15, 2021, following flashboard replacement, MDMR documented the stranding of 23 juvenile salmon (Noll, J., MDMR. Personal communication, June 17, 2021). To reduce the potential effects of stranding on Atlantic salmon and other fish species, Brookfield will continue monitoring downstream pools after significant spill events and during flashboard replacement and will collect any stranded Atlantic salmon and release them back into the river. Monitoring actions following each significant spill event will be recorded.

Flashboard replacement is scheduled to occur after June 15; at this time of year, Atlantic salmon smolts migrating from habitat upstream of the Lockwood Dam are anticipated to be in the estuarine or marine environment. Based on information from the NEFSC, we would anticipate that 5-10% of the smolts could holdover in the freshwater environment rather than outmigrating to the ocean (John Kocik, NOAA's Northeast Fisheries Science Center, personal communication, October 6, 2021). These juvenile salmon may find refuge in nearby tributaries and leave the river the following year. This behavior is likely a result of these fish not being physiologically prepared for the transition to salt water. Based on this information, we expect that the 23 smolts that were stranded in the pools on June 15, 2021 were stocked hatchery smolts that were holding over in the river. Therefore, in years when smolts are stocked downstream of the project, we would expect some of these smolts to be stranded. Given the stranding event in 2021, we anticipate that as many as 0.023% (23 out of 100,000 stocked) of any smolts stocked downstream of the Lockwood Project could become stranded in the pools downstream of the dam annually.

Stranding delays migration, exposes individuals to greater predation risk, increases injury rates due to contact with the ledges, and increases stress due to handling and transport. Additionally, because stranding pools warm more rapidly than free-flowing water, stranding pools can induce stress, and increase energy expenditure in juvenile salmon. As indicated, by mid-June we would expect that all naturally reared or wild smolts to have emigrated from the river. Juveniles stranded after this point are likely stocked fish that are not emigrating in that year. Thus, any delay associated with stranding after mid-June is unlikely to make a difference in the timing of their migration. However, the mainstem Kennebec River is not suitable habitat for rearing in the summer, and these fish would need to locate suitable cold-water habitat downstream of the Lockwood Dam. In spite of Brookfield's existing plan to address stranding at Lockwood, it is evident that certain stranding pools are occasionally too large to safely rescue stranded salmon. Therefore, we assume that any individuals that are unable to be rescued die from either predation or exposure to unsuitable thermal conditions. According to MDMR, they were finding approximately 10 smolts per pool during the stranding event in 2021. We expect that Brookfield should be able to survey nearly all stranding pools. However, we estimate that no more than one pool a year will not be adequately surveyed, and therefore, we would assume that the smolts in that pool could die. As such, of the 0.023% of smolts that are stocked below Lockwood that are stranded during flashboard replacement, we expect that up to 0.010% (i.e., 10 smolt mortalities per 100,000 stocked) will be killed, and that 0.013% (i.e., 13 per 100,000 stocked) will experience injury or disruptions to migration and rearing. We expect that this will only occur in years that supplementation of smolts occurs downstream of the Lockwood Project.

Here, we carry out the four-step assessment for determining if the stranding of juvenile salmon that does not result in mortality meets the definition of harassment. We have established that during the term of the action, some juvenile salmon are likely to be exposed to the effects of stranding in years when stocking occurs downstream of the Lockwood Project (step 1). We expect that some stocked juveniles will hold over in the river after being stocked in the river, and may be subject to the effects of stranding as they attempt to locate suitable habitat for holding and rearing (step 2). We have established the expected response of the exposed juveniles (step 3). Stranded individuals are potentially subjected to greater predation risk as they are trapped in the pools, and are stressed and potentially injured due to handling and transport. Additionally, because stranding pools warm more rapidly than free-flowing water, stranding pools can increase energy expenditure in juvenile salmon. These effects could reduce the potential for stranded fish to successfully locate suitable cold water rearing habitat. Finally, we establish that the nature and duration of the response is a significant disruption of migration and rearing (step 4). Based on this four-step analysis, we find that in years when stocking occurs, 13 out of every 100,000 stocked juveniles are likely to be adversely affected and that effect amounts to harassment. As we expect the duration of the stranding event to be short (only when flashboards are being replaced, and only until they can be successfully rescued by Brookfield or MDMR staff), we do not anticipate that the effect stranding leads to "harm" of the individual fish (i.e., we do not anticipate that this disruption of behavior will lead to mortality).

Kelts

In section 4, we indicated that the racks in front of the turbines at the Kaplan unit (unit 7) are large enough for Atlantic salmon kelts to pass through. The racks at the Francis units currently have 2-inch rack spacing that exclude adult salmon. In our analysis, we concluded that 8% of kelts are killed at the project as a result of turbine entrainment under baseline conditions, and we expect that to persist through the interim phase. The installation of 2-inch racks within three years of license issuance will exclude 100% of adult salmon from passing the project through the turbines. In addition, the improved downstream fishways (new UAWs) will provide a safe route of egress for some kelts. These modifications will result in a significant reduction in adult Atlantic salmon mortality at this project. Consistent with assumptions made by Alden Research Laboratories (2012), we anticipate that a small proportion (up to 3%) of salmon kelts could still be killed due to the effects of passage at the project spillway. As such, the best available information indicates that the proposed action will result in the mortality of 8% and 3% of kelts annually during the interim and implementation phase, respectively.

6.2.1.5 Summary of Downstream Passage Effects to Atlantic Salmon

Smolt Survival

Operation of the projects consistent with the proposed actions will reduce turbine entrainment and therefore reduce both direct and indirect mortality of smolts in the Kennebec River. Table 41 indicates the reduction in cumulative mortality we would expect under the interim and implementation phases given the proposed measures. Our analysis indicates that proposed measures will reduce the cumulative mortality associated with dam passage in the lower Kennebec River from approximately 47%, under baseline conditions, to 40% during the interim phase, and 16% during the implementation phase. In addition to the proposed structural and operational measures, Brookfield has proposed to adaptively manage these projects to achieve an 88.5% cumulative *direct* survival (11.5% mortality; does not incorporate indirect mortality) through the four hydro projects. Our analysis indicates that direct mortality will be reduced to approximately 11% from 30% (baseline). Therefore, we expect that the proposed measures would result in achievement of the proposed performance standard for direct survival. However, we anticipate that mortality associated with the indirect effects of dam operation (e.g., hydrosystem delayed mortality) will still occur at the projects. We have estimated that HDM will be reduced by approximately three-quarters (from approximately 24% (baseline) to 6% (implementation phase)), largely due to the expected reduction in turbine entrainment and migratory delay.

Table 41. The cumulative effect of all four hydro projects on outmigrating juvenile Atlantic salmon. Indirect mortality only considers hydrosystem delayed mortality.

Project	Interim Phase (Y 1-3)			Implementation Phase (Y 4-50)		
	Direct	Indirect	Cumulative	Direct	Indirect	Cumulative
Weston	9.7%	9.3%	18.0%	2.5%	4.8%	7.2%

Shawmut	12.9%	7.6%	19.5%	2.6%	0.9%	3.4%
Hydro-Kennebec	4.7%	0.5%	5.2%	3.1%	0.2%	3.3%
Lockwood	2.9%	0.4%	3.3%	2.9%	0.4%	3.3%
Cumulative	27.2%	17.8%	40.2%	10.6%	6.3%	16.2%

*Cumulative mortality rates are calculated by converting the project mortality rates to survival rates and then multiplying them by each other.

Migratory Delay of Smolts

In section 4.5.1.2., we describe the ongoing migratory delay currently caused by Lockwood, Hydro-Kennebec, Shawmut, and Weston (Table 20). This analysis focuses on delay that occurs within 200 meters upstream of each project, as the available information indicates that this delay is influenced by the operation of the project, and therefore is an effect of the action under consultation. In the project specific analyses above, we carried out our four-step assessment to determine that delay of greater than 24 hours meets the definition of harassment, and concluded that on average 6.3%, 7.3%, 8.5%, and 19.2% of smolts at the Lockwood, Hydro-Kennebec, Shawmut, and Weston Project, respectively, will be harassed during the interim phase (years 1 through 3) as a result of delay greater than 24 hours. We likewise determined that 0%, 0%, 1.8%, and 12.3% of smolts at the Lockwood, Hydro-Kennebec, Shawmut, and Weston Project, respectively, will be harassed as a result of delay greater than 24 hours during the implementation phase.

In section 4, we described how migratory delay can lead to smolts missing their physiological smolt window and result in increased exposure to predation (Blackwell & Juanes, 1998; Budy et al., 2002; McCormick et al., 1998). The annual median residence time (i.e., defined as the amount of time it takes a smolt to pass the project once it comes within approximately 200 meters of the dam) varied significantly at each project during the studies that were conducted between 2012 and 2015 (Table 20). The available information indicates that the proportion of fish that take longer than 24 hours to pass increases as the amount of flow going over the spillway decreases. The turbine shutdowns at Lockwood, Hydro-Kennebec and Shawmut will substantially increase spill at these projects at the time of day we generally expect most of the smolts to be passing the projects. Despite the relatively low night time passage rate observed at the Shawmut Project during the 2013-2015 smolt studies (which was likely related to delay effects associated with the dam), it is expected that a significant majority of smolts pass during the nighttime hours (Kocik et al., 2009). In addition, new and improved guidance structures (Shawmut and Hydro-Kennebec), the installation of new bypass routes (Weston and Shawmut) and uniform acceleration weirs (all four projects), as well as increased bypass flows (Weston, Shawmut, and Hydro-Kennebec) are all expected to further reduce migratory delay of smolts at the projects. Therefore, we anticipate that residence time at each project will be reduced.

Brookfield has not proposed a project specific performance standard for migratory delay. Rather, they have proposed a *cumulative* 96 hour downstream delay standard. They have proposed to implement this as follows:

> Within each study year following the implementation of the downstream fish passage facilities and measures proposed for Lockwood, Hydro-Kennebec, Shawmut and Weston, residence time for each individual test smolt will be calculated as the duration of time from first detection at the point 200 meters upstream of each dam to a point downstream of each dam. The cumulative residence time for all smolts determined to have passed downstream at all four projects will be calculated as the sum of the four residence duration values. Achievement of the downstream salmon smolt timing goal will be based on a three-year average equal to or greater than ~~96%~~ 97% of individuals passing through all four projects with a cumulative project residence time of no more than 96 hours (Pg 6-3 of the Biological Assessment; and corrected by K. Maloney, Brookfield, personal communication. March 11, 2022).

As described in section 4, Brookfield has provided analysis for 2013-2015 that indicates that of the fish that survive passage through all four dams, on average, 5% (range: 0% (2014) to 13% (2015)) took longer than 96 hours cumulatively. Achieving the proposed standard would reduce this to less than 3%. Although we have estimated reductions in project specific delay, we have yet to estimate how the cumulative delay might be impacted by the proposed measures. As we would expect cumulative delay to be strongly correlated to the average project specific delay, we can estimate the scale of the reduction that might be expected. The average per dam delay (i.e., residence time > 24 hours) at the four projects is approximately 10.5% under baseline conditions (i.e., ((6.3% + 7.3% + 8.5% + 19.2%)/4 dams = 10.5%)). In contrast, the estimated average per dam delay after all the measures based have been implemented is 3.5% (i.e., ((0% + 0% + 1.8% + 12.3%)/4 dams = 3.5%)). This constitutes a 67% reduction in the average delay per project (i.e., (10.5% - 3.5%)/10.5% = 67%), meaning that the proposed measure estimate is one-third of the baseline estimate. If we apply this same reduction to the average cumulative delay of 5%, then we can estimate that it will be reduced to 1.7% (i.e., 33% x 5% = 1.7%). Therefore, given the anticipated reductions in project specific delay explained above, we expect that the cumulative delay standard will be met.

This analysis does not consider delay associated with the reduced rate of movement through the project impoundments during the term of any amended license, as those effects are considered to be part of the Environmental Baseline. However, as explained previously, effects on movement due to the Shawmut impoundment are effects of the continued operation of the project under the terms of a new license. In section 4, we have estimated that a reduction in the rate of movement of smolts through the Shawmut impoundment could add 11 hours to the average migration time we would expect absent the dam. Based on information provided by Brookfield on cumulative delay (Table 21), we indicated that delay that was estimated in the Weston and Shawmut impoundments would add approximately 3% to the cumulative delay attributable to the dams.

The Weston impoundment is not considered an effect of the action, although the Shawmut impoundment is. As such, and as we estimated that the two impoundments lead to a similar amount of delay, the best available information indicates that the Shawmut impoundment will contribute an additional 1.5% to the overall cumulative mortality associated with the four dams, for an estimated total of 6.5% (i.e., 5% + 1.5% = 6.5%) during the interim phase, and 3.2% (i.e., 1.7% + 1.5% = 3.2%) during the implementation phase. This additional delay is not considered in the cumulative delay standard proposed by Brookfield, but can still contribute to the risk of hydrosystem delayed mortality.

As described above, we have determined that smolts that take longer than 24 hours to pass any individual dam will be harassed. However, most of the smolts that are harassed due to delay at a project appear to move quickly past the other projects, such that the proportion of fish that are actually exposed to a cumulative delay of more than 96 hours is relatively small (as described above, 6.5% during the interim phase, 3.2% during the implementation phase). NMFS considers "harm" in the definition of "take" as "an act that actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering" (50 CFR §222.102). We have determined that delay of greater than 96 hours (cumulative at 4 dams) would significantly disrupt the behaviors of individual smolts. Migratory delay of this extent can lead to salmon smolts missing the physiological smolt window (i.e., the period when an individual smolt's condition is optimal for making the freshwater to saltwater transition), which would require that they overwinter in the river, rather than outmigrating to the ocean, which increases the risk of predation. Fish that are actually killed as a result of this delay in the river upstream of Lockwood have already been considered as mortalities in the above direct mortality analyses. As indicated, fish that do not die in the river but are delayed by more than 24 hours at a single dam are included in our estimates of harassment. However, fish that exceed the cumulative threshold of 96 hours have a higher risk of dying later in their migration in the estuary and marine environment, and we therefore consider them harmed. As such, we consider that 6.5% and 3.2% of the salmon smolts in the river will be harmed due migratory delay caused by the four dams, as well as the Shawmut impoundment.

We consider fish that actually die in the estuary due to the cumulative effects of delay and injury at the four lower Kennebec River dams as hydrosystem delayed mortality. As indicated in the sections above, the proposals for each project will reduce hydrosystem delayed mortality by reducing delay and injury associated with dam passage. Given our lack of understanding regarding precisely how a reduction in these factors relates to a reduction in delayed mortality, we have conservatively assumed that the proposal will lead to a reduction in the effect proportional to the reduction in delay and injury. Using this approach, we anticipate that total hydrosystem delayed mortality will be reduced from 24% under baseline conditions to approximately 18% during the interim phase, and 6% in the implementation phase (Table 41). Although we expect a reduction in delayed mortality with the implementation of shutdowns in year 1, the full benefit of the proposal won't be realized until the implementation phase, starting in year 4.

Kelt Survival

As indicated in the Environmental Baseline, all four of these projects are expected to kill adult postspawn Atlantic salmon (kelts) under existing conditions as the spacing on the trash racks are such that we do not expect full exclusion. Based on our analysis, we anticipate that 85%, 92%, 90%, and 92% would be expected to survive passage at the Weston, Shawmut, Hydro-Kennebec, and Lockwood Projects, respectively, during the three year interim phase. This equates to a cumulative survival through the four projects of 65%. We anticipate that the installation of racks at the turbines at all four projects will eliminate turbine entrainment of adult salmon, which will significantly reduce mortality. We assume that a small amount of mortality (<3%) could still occur at each project due to effects associated with passage through the non-turbine routes. As this is consistent with assumptions made by Alden (2012), we believe it is the best available information regarding the potential mortality of kelts through non-turbine routes. Therefore, we anticipate that following implementation of the measures included in the proposed actions, 89% of outmigrating adult salmon will survive passage through all four dams.

6.2.2 Upstream Fish Passage

The Shawmut and Weston Projects currently lack upstream passage facilities for diadromous fish; the proposed action includes construction of new fishways at these projects. The construction of new fishways at the Shawmut and Weston Projects and an additional fishway at the Lockwood Project will provide swim through access to approximately 70,000 rearing habitat units in the Merrymeeting Bay SHRU. In addition to the 37,105 habitat units available in the Sandy River, the new upstream fishways will provide access to 32,739 habitat units between the Hydro-Kennebec Project and the impassable dams in Madison (Wright et al. 2008). This habitat is primarily located in Martin Stream, Wesserunsett Stream and Carrabassett Stream, tributaries of the Kennebec River. Salmon need swim-through passage at all four of the lower Kennebec dams to access the spawning and rearing habitat in the Sandy River. We assume that until the fishways at all four projects are operational and have demonstrated safe, timely, and effective passage, as determined by achieving efficiency and delay standards, with the exception of any fish used for testing, prespawn Atlantic salmon will not have access to mainstem habitat in the Kennebec River upriver of the Lockwood Project. The existing trap and truck operation will continue to provide interim upstream passage for Atlantic salmon by transporting them above the currently impassable dams to the habitat in the Sandy River.

Since the construction of the fish trap at the Lockwood Project in 2006, the number of captured prespawn salmon has ranged in numbers from 5 to 60 fish (average= 29). As we have estimated that the Lockwood trap is only 67% effective at capturing salmon, we expect that under current conditions an additional 14 salmon (i.e., (29/0.67) - 29 = 14) on average return to the Kennebec annually and occur river downstream of the dam but do not enter the Lockwood trap. Following the interim period, all migrating adult Atlantic salmon in the mainstem will be affected by the projects as they will be trapped and potentially delayed by the dam and its fish passage facilities. These effects are considered below.

Lockwood Project

Brookfield conducted upstream passage studies at the Lockwood Dam in 2016 and 2017. The study demonstrated an average 79% fishway efficiency, however adult salmon experienced significant migratory delay, ranging between 0.7 to 123.0 days, with median delays of 9.9 and 16.0 days in 2016 and 2017, respectively (BWPH, 2017; BWPH, 2018). Additional upstream studies performed by Rubenstein (2021) resulted in lesser demonstrated efficacy of the fishway. Pooling the results of these studies results in an average fishway efficiency of 67% (range=45-89%). Rubenstein (2021) documented similar passage delays with medians of 16 days and 18 days in 2018 and 2019, respectively[53].

As part of the proposed action, Brookfield will construct a vertical slot fishway in the "bypassed reach," an area downstream of a spillway section of the dam that exhibits demonstrable attraction to salmon (Figure 22); this new fishway was designed in consultation with NMFS, USFWS, and Maine DMR. The design and location of the fishway were selected after review of the BWPH (2017) and BWPH (2018) upstream passage studies and an engineering alternatives analysis that produced several fishway designs for consideration, including vertical slot, ice harbor, and nature-like fishways designs.

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[53] For both Brookfield and Rubenstein studies, fishway efficiency and delay were calculated using a mark-recapture radio telemetry method, where salmon were captured and marked at the Lockwood Dam and then released at a location downstream of the dam. The Rubenstein studies released tagged salmon at a boat launch located approximately 14 km downstream of Lockwood dam, whereas the Brookfield studies released tagged salmon at a boat launch approximately 1.9 km downstream of the dam. Brookfield calculated passage as the percentage of fish that approached within 200m of Lockwood and were subsequently recaptured at the fishway. Rubenstein calculated passage efficiency as the percentage of fish that traveled to within the immediate vicinity of the dam and were subsequently recaptured at the fishway.

Figure 22. The Lockwood Project with the approximate location of the proposed fishway outlined in red.

On April 15, 2020, following design consultations, Maine DMR filed a letter with FERC concluding that the proposed bypass fishway would not be passable for a portion of the Atlantic salmon upstream migration period.[54] Maine DMR stated that it was particularly concerned that at low flows, salmon would "not be attracted into the bypass, because most flow [would] be discharged from the powerhouse." However, Maine DMR stated that it was unable to determine

[54] FERC Accession #: 20200422-5224

at what discharges the bypass would go from being passable to being impassable. It appears that Maine DMR's primary concern regarding upstream passage at the project was that the existing fish lift would become inoperable after construction and operation of the new bypass fishway. However, the SPP filed by Brookfield does not propose any such discontinuation of fish lift operation, unless the discontinuation of the lift is determined reasonable after efficiency studies and consultation with the resource agencies. As such, we consider the proposed action to include operation of both fishways, until or unless the bypass fishway demonstrates achievement of the proposed performance and delay standard.

Located on the Penobscot River, which is approximately the same size as the Kennebec, the West Enfield Project's vertical slot fishway is similar in design to the proposed bypass fishway at the Lockwood Project. Lacking project specific information at Lockwood, we determined that the vertical slot fishway at the West Enfield Project would be a reasonable proxy for expected efficacy of the proposed Lockwood bypass fishway (93%)[55]) (Petersen, 2022)). As Maine DMR indicates, we do not have the information, such as flow-habitat modeling, to affirmatively estimate how often during the passage season the proposed bypass fishway would be expected to attract upstream migrants. In general, we would expect that during periods of very low flow, where there is little attraction to the bypassed reach, there would be continued attraction to the powerhouse, where the current fish trap would maintain operation. Existing information appears to corroborate this expectation– after flashboards were installed in the bypassed reach: 1) residence time of salmon in the bypassed reach correspondingly decreased; and 2) in 2016, the recapture rates of salmon at the fish lift increased (BWPH, 2017; BWPH, 2018). Furthermore, studies demonstrated that salmon are highly attracted to the Lockwood bypassed reach where the new fishway will be located. In 2016, 83% of tagged salmon reached the upper portion of the bypassed reach. In the 2017 upstream passage study, all radio-tagged salmon spent some period of time within the upper section of the bypassed reach. Therefore, we expect that almost all upstream migrating salmon would have an opportunity to pass the new bypass fishway, while the existing fish trap would provide upstream access to any remaining salmon attracted to the powerhouse area or during any low flow periods where the bypass may be inaccessible.

Given the above, we estimate that the overall efficacy of upstream passage at Lockwood, with the operation of both fishways, would be approximately 98%. We assume that 93% of salmon would successfully pass the bypass fishway and the remaining 7% of fish would pass via the existing fish lift with a 67% fishway efficiency (i.e., 93% + (7% x 67%) = 98%).

As explained above, Brookfield will continue to operate the Lockwood fish lift/trap and truck until completion of the bypass fishway and effectiveness testing of all four upstream fishways. Brookfield's proposed effectiveness testing would require tagging at least 200 adult salmon to determine the cumulative performance and delay at all four lower Kennebec River dams. As we analyze in further detail in the below *Performance Standard/Migratory Delay* section, we expect

[55] Represents a pooled average over a six-year period (2014-2020)

that the Lockwood Project will provide upstream passage for Atlantic salmon in the Kennebec River via trap and truck for a 10 year interim phase. During that period, we expect that approximately 67% of adult returns will be trapped at the project and transported to the Sandy River upstream of all four dams, and that 33% will fail to pass.

Although no studies have looked directly at the fate of fish that fail to pass through Lockwood's upstream fish passage facilities, we convened an expert panel in 2010 to provide the best available information on the fate of fish that failed to pass upstream fishways on the Penobscot River. The panel was composed of state, federal, and private sector Atlantic salmon biologists and engineers with expertise in Atlantic salmon biology and behavior at fishways. The group estimated a baseline mortality rate of 1% for Atlantic salmon that fail to pass a fishway at a given dam on the Penobscot River (NMFS, 2012). Therefore, assuming a similar effect occurs at the fish trap at Lockwood, 1% of the Atlantic salmon that fail to pass the Project may die. Salmon will also experience negative energetic effects associated with a delay in passage, as we analyze in further detail above. Therefore, it is assumed that of the Atlantic salmon that are motivated to pass upstream of the dams, 67.0% will pass successfully, 0.3% (1% x 33% failing to pass) will be killed, and 32.7% (99% x 33% failing to pass) will spawn in downstream habitat or stray to another watershed, such as the Androscoggin or Sebasticook.

Hydro-Kennebec, Shawmut, and Weston Projects

No upstream passage studies have been conducted at the Hydro-Kennebec Project, and the proposed fish lifts at the Shawmut and Weston Projects have yet to be constructed; therefore, passage efficiencies at these facilities are unknown. However, we have information regarding the upstream efficacy of other dams within the GOM DPS. As discussed above, the Lockwood Dam fish lift demonstrated an average 67% efficiency. Upstream passage studies were conducted on the Milford Project fish lift on the Penobscot River using radio telemetry in 2014 and 2015 (BBHP, 2015, 2016). Results of those studies demonstrated high average passage efficiency (>95%). Using an acoustic telemetry sampling technique, Peterson (2022) also performed upstream passage studies between 2014 and 2020. That study found a 92% passage efficiency (range= 82-100%). Shepard (1995) found that the average passage efficiency at the West Enfield fish lift on the Penobscot River was 89%, whereas Peterson (2022) documented an average passage rate of 93% (range= 64-100%). Dams within the DPS have demonstrated relatively efficient passage and moderate passage delays without the benefit of any adaptive management that could improve passage efficiencies and delay. Keefer et al. (2021) noted that the passage efficiency for Pacific salmonids at eight dams on the Columbia River were consistently among the highest recorded for any migratory species, averaging 97% (0.966), which the study attributed in large part to salmonid life history traits and a “sustained adaptive management approach to fishway design, maintenance, and improvement.” Brookfield is proposing to adaptively manage the lower Kennebec River fishways in consultation with us, Maine DMR, and USFWS. Additionally, Brookfield has not proposed any limitations on the type and scope of adaptive improvements that could be necessary to achieve its proposed passage efficiency and delay standards. Therefore, we assume that adaptive management performed in conjunction with any evaluations of upstream passage will result in the achievement of passage effectiveness and timing consistent with its proposed standards within 10 years following construction of the fishways and that by year 11, fish will be able to swim through the fishways at all four projects (implementation phase).

In 2017, two tagged salmon were found in the Lockwood headpond/Hydro-Kennebec tailrace, likely having ascended the bypass reach of the Lockwood Dam during a high flow event prior to flashboard replacement.[56] Those salmon were captured in the Hydro-Kennebec fish lift and transported to the Sandy River. After consultation with resource agencies, Brookfield agreed to install and monitor four underwater cameras to determine when on-demand operation of the Hydro-Kennebec fish lift would be necessary to capture salmon, in the event that they were observed in the vicinity of the fish lift.[57] Brookfield proposes to continue camera observations and to attempt to capture any observed salmon for transport to the Sandy River. Adult salmon ascending the bypass reach of the Lockwood Dam appears to be a low-probability event, with two adults documented to have done so in four years of monitoring. Monitoring the Hydro Kennebec fishway and operating it to pass any observed salmon was demonstrably effective and we have no reason to conclude that it will not continue to be effective in ensuring any salmon that do ascend the Lockwood bypass are able to access upstream habitat. Therefore, we expect that in the rare event that salmon enter the Hydro-Kennebec fish lift in the interim period, they will be safely trapped and transported to the Sandy River by truck. Effects of such handling and transport are addressed above.

6.2.2.1 Effects of Trapping and Handling

As explained above, any Atlantic salmon adults that enter the existing Lockwood fish lift will be captured, held in a tank, and transported upstream to the Sandy River. Trapping, handling and trucking fish causes them stress. The primary contributing factors to stress from handling are differences in water temperatures (between the river and wherever the fish are held), dissolved oxygen conditions, the amount of time that fish are held out of the water, and physical trauma. Stress on Atlantic salmon increases rapidly from handling if the water temperature is too warm or dissolved oxygen is below saturation. Fish that are transferred to holding tanks can experience trauma if care is not taken in the transfer process, and fish can experience stress and injury from overcrowding in traps that are not emptied on a regular basis.

All migrating adult Atlantic salmon in the Kennebec River that are passed at the Lockwood Project during the first 10 years will be affected as they will be trapped, handled, and trucked to the Sandy River. The effect that the trapping and trucking of fish has on passage effectiveness and migratory delay is addressed in section 4. However, here we consider the additional effects of handling and associated marking/monitoring (e.g., biological sampling, fin clip/punch, scale sample) and trucking on migrating Atlantic salmon.

[56] FERC Accession #: 20190321-5041
[57] FERC Accession #: 20200319-5031

MDMR maintains a database of adult Atlantic salmon mortalities attributable to trapping and trucking from the Veazie fish trap (Penobscot River). Between 1978 and 2011, the median mortality rate for adult Atlantic salmon trapped at the Veazie Dam on the Penobscot River was 0.07%. MDMR has indicated that no mortalities have occurred as a result of trapping and trucking at the Lockwood Project (Ledwin, S., MDMR, personal communication, 6/17/21)). Given the small number of salmon being trapped at the Lockwood Dam under baseline conditions (average of 29 in the last 10 years), and the low incidence of mortalities related to trapping and trucking overall within the DPS, we do not anticipate that this mortality rate equates to any fish being killed due to effects of trapping and trucking over the period when these activities will occur. We do not anticipate any additional injury or stress associated with marking and/or biological sampling that will take place in association with this handling.

Here, we carry out the four-step assessment for determining harassment. We have established that during the term of the action, prespawn adult salmon will encounter the trap at the Lockwood Dam and will be exposed to the effects of trapping, handling, and trucking, which constitutes a disruption of their upstream migrations (step 1). We expect that 100% of these fish will be subject to the effects of trapping, handling, and trucking as they migrate to spawning habitat upstream of the dams (step 2). We have established the expected response of the exposed adults (step 3). As discussed, salmon that are handled and translocated could fall back in the river or hold in place for some amount of time prior to continuing their migration. This can lead to migratory delay, increased energy costs, and an increased potential for predation. Minor injuries (such as scale loss) may expose fish to increased rates of infection, and could make the fish less fit for migration and spawning. Finally, we establish that the nature and duration of the response is a significant disruption of migration (step 4). Based on this four-step analysis, we find that 100% of prespawn adults that are captured at the Lockwood Dam are likely to be adversely affected and that effect amounts to harassment. For the reasons described above (i.e., the relatively short distance to spawning, rearing, and resting habitat), we do not anticipate that the effect of trapping, handling, and trucking leads to "harm" of the individual fish (i.e., we do not anticipate that this disruption of behavior will lead to mortality). Any affected fish will have ample time to recover from the passage experience prior to migrating the short distance to habitat in the Sandy River to spawn. As we anticipate that the continued operation of the Lockwood fish lift and trap and truck passage program will be necessary to achieve the proposed passage efficiency and delay standard, we anticipate that this source of harassment will remain during the 10 year period that the trap and truck operations continue.

6.2.2.2 Effects of Stranding

Migrating adult Atlantic salmon can be inadvertently trapped or stranded in the various pools on ledges located in the bypass reach downstream of the Projects, particularly during flashboard replacement and/or during and after spill events.

Lockwood

Over a reporting period of 10 years, an average of one salmon has been rescued on these ledges, with a high of four salmon reported in 2019 (USASAC 2013-2022). To reduce the potential effects of stranding on Atlantic salmon and other fish species, the Licensee proposes to continue monitoring downstream pools after significant spill events and during flashboard replacement, collect any stranded Atlantic salmon and release them back into the river, and provide flow into larger, inaccessible pools to maintain water quality suitable for salmon. The Licensee will record its monitoring actions following each significant spill event.

For both adult and juvenile salmon, stranding delays migration, exposes individuals to greater predation risk, increases injury rates due to contact with the ledges, and increases stress due to handling and transport. Additionally, because stranding pools warm more rapidly than free-flowing water, stranding pools induce stress and increase energy expenditure. Existing protocols to monitor stranding pools and rescue stranded salmon have prevented mortality, however, rescued salmon have been documented to have sustained injuries, and were subject to other stressors outlined above. Here, we carry out the four-step assessment for determining if the stranding of adult salmon meets the definition of harassment. We have established that during the term of the action, prespawn adult salmon could be exposed to the effects of stranding, which constitutes a disruption of their upstream migrations (step 1). We expect that some fish will be subject to the effects of stranding as they migrate to spawning habitat upstream of the dams (step 2). We have established the expected response of the exposed adults (step 3). Stranded salmon can be injured, stressed, and are delayed in their upstream migration. This can lead to increased energy costs, and an increased potential for predation. Minor injuries (such as scale loss) may expose fish to increased rates of infection, and could make the fish less fit for migration and spawning. Finally, we establish that the nature and duration of the response is a significant disruption of migration (step 4). Based on this four-step analysis, we find that an average of one salmon a year is likely to be adversely affected and that effect amounts to harassment. For the reasons described above, we do not anticipate that the effect stranding leads to "harm" of the individual fish (i.e., we do not anticipate that this disruption of behavior will lead to mortality).

Hydro-Kennebec, Shawmut, and Weston

To reduce the potential effects of stranding on Atlantic salmon at the Hydro-Kennebec Project, the Licensee proposes to conduct a survey of ledge conditions in the spillway to determine if there are any perched pools that present a risk of stranding. If perched pools are found, the Licensee will modify the ledge and/or provide flow to allow for fish egress.

Given that adult Atlantic salmon do not currently have consistent access to the Hydro-Kennebec, Shawmut, and Weston Dams, we have no information to assess the current risk of stranding at those Projects. Therefore, we assume that these projects will present a similar risk for stranding as the downstream Lockwood Project, described above. As we establish in that analysis, we find that for each of the three Projects (Hydro-Kennebec, Shawmut, and Weston) an average of one salmon a year are likely to be adversely affected and that effect amounts to harassment. For the reasons described above, we do not anticipate that the effect stranding leads to "harm" of the individual fish (i.e., we do not anticipate that this disruption of behavior will lead to mortality).

As described above, we use the expert panel's baseline mortality rate of 1% per dam to estimate the effect to salmon that fail to pass at each of the four projects. As indicated, we expect that during the 10-year interim phase, 0.33% of salmon that fail to pass Lockwood will die. Under current passage numbers, we would expect this to lead to the mortality of one salmon (i.e., (14 salmon per year x 10 years) x 0.33% = 0.5 salmon, rounded up to 1 salmon). During the remainder of the term, we expect that all four projects will be achieving the proposed performance standard (implementation phase). It is assumed that of the Atlantic salmon that are motivated to pass the Lockwood, Hydro-Kennebec, Shawmut, and Weston Projects, 15% will not successfully pass upstream of the Weston Project and 1% of the fish that fail to pass each project will likely die. Because of the near absence of suitable spawning habitat in river reaches between both the Lockwood and Hydro-Kennebec Projects, and Hydro-Kennebec and Shawmut Projects, we assume that salmon that fail to pass Hydro-Kennebec will fall back downstream, through the Lockwood Project in search of suitable habitat. Salmon that fail to pass Shawmut will fall back downstream through both the Hydro-Kennebec and Lockwood Projects and therefore would be subject to project-specific adult (kelt) mortality rates as estimated above. Given the availability of suitable habitat (~ 5,500 units of Class 1 habitat (derived from Wright et al. 2008)) between the Shawmut and Weston projects, we assume that salmon that fail to pass the Weston dam, would not fall back below Shawmut. Therefore, during the implementation phase, we estimate that 0.5% of adults that fail to pass upstream of all four lower Kennebec dams will die (Table 42).

Here, we carry out the four-step assessment to determine whether the failure to pass salmon leads to harassment. We have established that prespawn migrating adult salmon in the action area will encounter the dam(s) and that they will cause a disruption of their upstream migrations (step 1) and that 32.7% of adults in the interim phase and 14.6% of adults in the implementation phase will be blocked from passing the projects, respectively (step 2). We have established the expected response of the exposed adults (step 3): individual adults blocked from migrating upstream will stray to downstream habitat where they may spawn in less suitable habitat. Finally, we establish that the nature and duration of the response is a significant disruption of migration (step 4). Based on this four-step analysis, we find that individual adults blocked from continuing their upstream migration are likely to be adversely affected and that effect amounts to harassment. Therefore, we anticipate that up to 32.7% of migrating adults during the interim phase, and 14.6% of adults during the implementation phase will be blocked from accessing spawning habitat in the Sandy River and will need to locate alternative habitat, which will lead to potential spawning delay, which we consider to meet the definition of harassment.

Table 42. Summary of upstream passage effects on adult salmon during the Interim and Implementation Phases. The proposed passage standard is an average of 96% per dam, which means that each specific

dam could be higher or lower than 96%, as long as the average is 96%. For this reason, these project specific estimates are approximate and may vary slightly.

	Interim Phase (Year 1-10)			Implementation Phase (Year 11-Exp)		
Project	Passage	Mortality	Harassment	Passage	Mortality	Harassment
Lockwood	67.0%	0.3%	32.7%	96.0%	0.0%	4.0%
Hydro-Kennebec	NA	NA	NA	96.0%	0.2%	3.8%
Shawmut	NA	NA	NA	96.0%	0.3%	3.7%
Weston	NA	NA	NA	96.0%	0.0%	4.0%
Total	67.0%	0.3%	32.7%	84.9%	0.5%	14.6%

6.2.2.3 Effects of Passage

Passage Effectiveness

Brookfield has proposed to achieve a standard for safe, timely, and effective upstream passage of Atlantic salmon defined as a cumulative ("end-of-pipe") passage rate of at least 84.9% (i.e., average of 96% survival per dam) and a cumulative upstream passage time of no more than 192 hours (i.e., average of 48 hours per dam) past all four lower Kennebec Projects. As we previously described, upstream fishways are proposed for construction at Lockwood (a second upstream fishway), Shawmut, and Weston. A state of the art fish lift was installed at the Hydro Kennebec project in 2017. As we analyze in further detail below, we have no empirical information to evaluate the safety, timeliness, and effectiveness of these conceptual upstream passage facilities at each project; however, information is available to help us make informed conclusions about their likely safety and effectiveness.

In its August 25, 2021 Motion to Intervene, the Kennebec Coalition suggests that there is no evidence that fishways can ever consistently achieve the performance standard that Brookfield is proposing for Atlantic salmon on the lower Kennebec River.[58] We acknowledge that numerous studies demonstrate that fishways rarely achieve passage effectiveness greater than 90% for any species (i.e., attraction effectiveness x passage effectiveness) (Bunt et al., 2012; Hershey, 2021; Noonan et al., 2012). Hershey (2021) conducted a meta-analysis of overall passage effectiveness at 75 different fishways as described in 60 peer-reviewed papers. That analysis indicated that large diadromous species (considered 10 different species, including Atlantic salmon) have an average passage effectiveness (% attraction x % passage) of only 63% (Hershey 2021). However, projects in the GOM DPS have demonstrated much higher effectiveness for Atlantic salmon (e.g., Milford Project, Veazie Project, Great Works Project, and West Enfield Project). Izzo et al. (Izzo et al., 2016) evaluated Atlantic salmon passage at the Milford project in 2014 and 2015 and documented passage rates of 95% and 100%, respectively. Although median rates were lower, Holbrook et al. (2009) similarly documented passage rates as high as 100%, 95%, and 100% at the Veazie, Great Works, and Milford Projects on the Penobscot, respectively

[58] FERC Accession #: 20210825-5088

(Holbrook et al., 2009). Peterson (2022) estimated the pooled average at Milford and West Enfield over six years (2014-2016, 2018-2020) to be 92% and 93%, respectively (Peterson, 2022). While the Milford and West Enfield projects on the Penobscot have not yet achieved the 95% efficiency and 48 hour delay standards set at those projects, they have demonstrated these relatively high efficiencies without the benefit of any specified adaptive management protocol. Recent information bolsters these findings, suggesting that when managing for salmonid species, sustained adaptive management can render consistently high passage performance through multiple dams (an average of 97% effectiveness) (Keefer et al., 2021).

Migratory Delay of Adult Salmon

Rubenstein (2021) demonstrated that upstream passage delays could convey effects upon Atlantic salmon. Specifically, passage delay was directly linked to thermal experience and energy loss. In the Kennebec River, Rubenstein found that at Lockwood, with a median passage delay of 16-18 days[59] (range= 13-30 days), salmon lost between 2.1-38.3% of their original endogenous fat reserves (pooled average of 16.4%). As a consequence of these energetic effects, Rubenstein's work suggests that migratory delay due to dam passage may result in broader demographic effects by reducing the number of salmon that are able to spawn successfully, or to return to spawn again in subsequent years (iteroparity). In a model that utilized Kennebec River temperature data (which is significantly cooler than the Penobscot) and delay information from the Milford Project on the Penobscot, Rubenstein demonstrated that the energetic effects to salmon due to migratory delay at one dam could result in 10.5% of adults dying before spawning and only 13.6% of adults surviving after spawning. To put this into context, the model results for a free-flowing (i.e., no dams) river indicated that 7% of salmon could die due to energetic effects before spawning, and that 17.4% would survive after spawning (Rubenstein, 2021). This effect would be even worse with multiple dams with similarly high rates of delay. Rubenstein's study demonstrates that dam passage delays directly affect the physiological condition of adult salmon. These energetic effects can result in injury to salmon, via depletion of energy reserves that could result in a reduced likelihood of successful spawning or repeat spawning. As indicated above, river temperature was an important variable in determining energetic effects. Rubenstein noted that the model predicted significantly less delay-related mortality on the Kennebec when compared to the Penobscot due to the Kennebec's cooler river temperatures throughout peak summer months. It should also be emphasized that while the model used Kennebec-specific temperature data, Rubenstein derived passage delay information for model simulations by selecting a random length of delay from an array of delays reported in previous studies (from 2014 to 2019) at the Milford Dam on the Penobscot River, where passage delay ranged from 0-155 days with an average of 12 days delay (BBHP, 2015, 2016; Peterson 2022). Brookfield is proposing to meet or exceed a standard for passage delays of 48 hours or less at each dam (192 hours cumulative). As Rubenstein assumed an average delay per dam that is essentially six times what has been proposed by Brookfield (12 days per dam versus 2 days per

[59] Delay was estimated using a radio-telemetry tagging and recapture method, where salmon were caught at the Lockwood dam, tagged, and then released at a site located approximately 14 km downstream of the dam.

dam), it is reasonable to expect that prespawn mortality attributable to migratory delay will likely be substantially lower. As described above, Rubenstein's model indicated that migration through a free-flowing river would lead to a prespawn mortality rate of 7%, and that this estimate would increase by 2.5% (to 10.5%) with a single dam with delay rates similar to the Milford Dam (average of 12 days). Brookfield's proposal would reduce cumulative delay to 8 days, which would suggest that during the implementation phase, prespawn mortality attributable to migratory delay would be negligible.

As indicated in section 4, significant delay of prespawn adult salmon occurs at the Lockwood Project under existing conditions. However, because of ongoing trap and truck operations, salmon are not delayed in passing the other three dams. It will take time to construct and evaluate the new fishways, and therefore, we anticipate that trap and truck operations will persist through the interim phase (year 1 to year 10) of the action. We expect that the delay observed during Brookfield's studies will persist, and therefore, the median delay will be between 10 and 18 days (BWPH, 2017; BWPH, 2018; Rubenstein, 2021), and 65% of the fish will be delayed in excess of 192 hours due to dam effects (BWPH, 2017; BWPH, 2018). Brookfield has proposed to install swim through fishways at all four projects and operate them to achieve a cumulative delay standard of 192 hours (48 hours per dam). When the projects achieve this standard, we expect a significant reduction in the energetic effects of dam passage. Although greater than what would be expected without dams, an average delay of only 48 hours per dam would allow the majority of salmon to access the Sandy River prior to mainstem temperatures exceeding the stress threshold for Atlantic salmon (20°C). As indicated in Figure 12, the average temperature in the mainstem Kennebec only exceeds 20°C in the months of July, August, and September. Trap data at the Lockwood Project over the last five years (2018-2022) indicates that on average 84% of Atlantic salmon that are trapped at the project are passed prior to June 30[60]. The 16% of salmon that enter the river after July 1 could be exposed to adverse temperature conditions that would likely accelerate the rate of energy depletion if they were delayed by greater than 192 hours due to dams. There are cool water tributaries located downstream of Lockwood that can be used as thermal refuge for salmon (additionally, upstream tributaries will be made available with the restoration of passage at the four dams). As the proposal limits the duration of delay to no more than 192 hours cumulatively for all four dams, (i.e., eight days), we expect that the achievement of this standard will allow adult prespawn salmon to access the abundant spawning and rearing habitat in the Sandy River in a timely manner with insignificant effects to their energy reserves.

Given the available information regarding migratory delay at dams, we expect that limiting delay to less than 192 hours at four dams will be challenging. As indicated previously, although the information suggests it is possible for salmon to pass dams quickly, most studies indicate delay rates regularly exceed 48 hours. Passage at the Milford Project ranged between 0.1 days and 16.1 days in 2014; and in 2015 it ranged between 0.1 days and 35 days (average of 10.5 days)

[60] According to the weekly fishway reports submitted to the agencies by Brookfield.

(BBHP, 2015, 2016). Similarly, Peterson (2022) indicated that median annual delay at Milford between 2014-2016 and 2018-2020 ranged between 4 and 14 days. The yearly pooled median passage time for adults at the West Enfield or Howland Dam ranged from 1.1 days to 3.1 days over four years of study, while the total range of individual passage times over this study period was 0.9 days to 61.1 days (Shepard, 1995). However, Pacific salmon on the Columbia River have been documented passing multiple dams with far less delay. Keefer et al. (2004) evaluated upstream migration rates of over 12,000 adult Chinook salmon and steelhead, and documented that most fish successfully passed the dams in the Columbia River in less than two days. They indicate that fish that took longer than two days are likely individuals that fell back over the dams after passage and were forced to reascend fishways, and/or had strayed to thermal refugia temporarily (Keefer et al., 2004). We note that some of the dams in Keefer's study have more than one fishway, which likely provides more opportunities for fish to pass and therefore leads to reduced passage delay.

Brookfield has proposed to adaptively manage fish passage in the lower Kennebec River to achieve both efficiency and delay performance standards. These standards may not be achieved immediately with the construction of the proposed fishways, and additional operational and structural modifications (such as increasing attraction flow, installing additional entrances, or constructing new fishways) may be necessary in order to achieve the standards. As previously explained, we expect that it will take up to ten years for the upstream passage standards to be achieved. During this period, we anticipate that salmon will continue to be trapped and transported to the Sandy River from the trap at the Lockwood Project. As such, we anticipate that during the interim phase 35% of the prespawn adults that are captured in the Lockwood trap will successfully be transported above the four dams to the Sandy River in less than 192 hours. The remaining 65% will still be successfully transported to the Sandy River, but will be either be harassed or harmed due to the effects of excessive delay. The best available information suggests that the risk of delay is exacerbated by warm temperatures, as under those conditions adult Atlantic salmon are more likely to deplete their energy reserves and either spawn in suboptimal habitat, or die before or after spawning. Therefore, to distinguish between the proportion of fish that we expect to be harmed and harassed, we will consider excessive delay that occurs prior to July 1 to be harassment, and delay that occurs after July 1 to be harm. As estimated above, 16% of the salmon run occurs in the months of July-September. Of these 16%, we expect that 65% will be delayed by more than 192 hours. As such, we estimate that 10% (i.e., 16% of the run x 65% excessive delay = 10%) of the salmon run will be harmed during the interim phase, and that 55% of the run will be harassed. With full implementation of the proposed measures and any new measures required by the adaptive management process designed to insure achievement of the proposed delay standard, we expect that the effects of upstream migratory delay on prespawn salmon will be insignificant by the end of the interim phase.

Here, we carry out the four-step assessment for determining harassment detailed in section 6.2.2.1. We have established that all prespawn adult salmon will encounter the Lockwood Dam during the interim phase and that the dams will result in a disruption of their upstream migrations (step 1). We expect that 55% of prespawn adults that are successfully transported upstream of the four dams to the Sandy River will be delayed by more than 192 hours during the interim phase prior to the performance standard being achieved (year 10 of the license) (step 2). We have established the expected response of the exposed adults (step 3). Individual adults delayed more than 192 hours (48 hours per dam) during their upstream migration will need to expend additional energy, which will reduce the energy reserves available for successful spawning. Finally, we establish that the nature and duration of the response is a significant disruption of migration (step 4). Based on this four-step analysis, we find that individual prespawn adults delayed for more than 192 hours when average water temperature is less than 20℃ are likely to be adversely affected and that effect meets the definition of harassment. Therefore, prior to the implementation of improved fish passage and verification of the performance standards (within 10 years of the license being amended), we anticipate that up to 55% of salmon adults that pass the Project will be exposed to significant delay (i.e., take more than 192 hours to pass upstream of four dams), which we consider to meet the definition of harassment. After the attainment of the performance standard (year 10 to license expiration) we expect that the amount of delay will be diminished, such that no adults will take more than 192 hours to pass the Project (cumulative at four dams).

As defined above, we consider "harm" in the definition of "take" as "an act which actually kills or injures fish or wildlife. We have determined that migratory delay of greater than 192 hours would significantly disrupt the behaviors of individual adults. Although delay can potentially impair essential behavioral patterns to the point that injury or mortality could occur as a result (e.g., an adult could die either before or after spawning because of the energy loss associated with migratory delay), we do not anticipate that to occur to all fish that are delayed by more than 192 hours. Although spawning habitat in the Sandy is a significant distance from the Lockwood Dam, during the interim phase, the trap and truck operation will result in salmon being transported and released into cold water spawning habitat in the Sandy within hours of being trapped. Additionally, most of the salmon delayed at Lockwood will approach the project prior to temperatures exceeding the threshold of effect (above which the probability of energy depletion and mortality increases), and those that do not will be able to access cool water habitat in the tributaries downstream of the project (e.g., Bond, Togus, Seven Mile, Messalonskee, Outlet Stream, Sebasticook). Despite these mitigating conditions, there is potential that the significant delay caused by passage inefficiencies could disrupt the behaviors of adult salmon to the extent that they fail to spawn or die. Given this potential, we expect that delay of 10% of prespawn adults by more than 192 when attempting to pass above the four projects to get to the Sandy River will meet the definition of "harm".

<u>Monitoring</u>

Brookfield proposes to determine achievement of its proposed performance standard via testing of at least 200 adult salmon, motivated to migrate upstream of the Weston Project, following the construction and implementation of the upstream passage facilities and measures proposed for the Lockwood, Hydro-Kennebec, and Weston Projects, as well as those proposed and anticipated for the Shawmut Project. Brookfield will implement an "adaptive management framework" for any additional potential operational and/or structural measures should testing determine that the performance standard has not been achieved. In its SPP, Brookfield acknowledged that it "[does] not anticipate that there will be enough adult salmon available in the initial years of the SPP to conduct a quantitative evaluation of upstream passage efficiency for the new facilities." The 10-year (2011-2020) average number of naturally-reared or wild adults returning to the Kennebec River is 29 (CMS, 2021). Beginning in 2021, the USFWS partnered with the Maine DMR for a limited multi-year program to stock approximately 100,000 salmon smolts into the Kennebec River annually. As a result of this effort, we do expect a short-term enhancement of adult returns to the Kennebec River through approximately the 2026 passage season.[61] In its SPP, Brookfield noted that it could support egg, fry, or smolt stocking in the Sandy River and would "consider modifying the SPP to appropriately include such efforts as "measures" to be undertaken as part of the SPP." In its supplement, Brookfield proposes to offset the costs of production of smolts to be stocked upstream of the Weston Project for the purpose of producing approximately 200 motivated prespawn adults to evaluate the effectiveness of the proposed new fishways. We expect that Brookfield's proposal would help ensure the resources are available to raise additional hatchery fish to be stocked into the Kennebec River and that therefore, sufficient fish will be available for Brookfield y to perform an adequate evaluation of the safety, timeliness, and effectiveness of its proposed upstream fishways. These studies will also provide a source of baseline data to inform any necessary adaptive management of those fishways.

Citing the uncertainty surrounding the availability of adequate numbers of returning adults to support efficiency and delay testing at all four of the projects, Brookfield's June 1, 2021 SPP included a proposal to conduct up to two years of "qualitative" studies to evaluate the effectiveness of the upstream passage through all four Projects, utilizing up to 20 adult Atlantic salmon each year. Using returning salmon in these qualitative studies would subject them to additional stressors, including delay, handling, and surgical procedures, as well as subjecting them to upstream fish passage at new, untested facilities, each with unknown effects on passage efficacy and delay. As described above, Brookfield's more recent September 21, 2022 modified proposal substantially reduces the uncertainty surrounding the ability to perform efficiency and delay testing. The "qualitative" studies that Brookfield proposes may provide generalized descriptive information surrounding the use of upstream passage facilities by Atlantic salmon. However, the sample size proposed (< 20 salmon per study) would likely have limited value in determining critical information such as passage route selection, fishway efficacy/mortality, and passage delay– particularly in light of Brookfield's proposal to perform a more rigorous cumulative upstream passage study. The additional measures included in Brookfield's modified proposal that provide certainty for an evaluation of upstream fishway passage render any sort of

[61] Using information derived from USASAC 2021, in addition to naturally-reared and/or wild adult returns, we estimate that approximately 130 additional adult salmon will return to the Kennebec each year as a result of the temporary Kennebec smolt stocking program. However, we note that any estimates of adult returns are highly variable.

"qualitative" evaluation of the four dams unnecessary. However, we note that Brookfield is proposing to install a second fishway at the Lockwood facility to improve documented poor performance of the existing upstream fishway (described in greater detail below). Given that the Lockwood Project is the first dam on the mainstem Kennebec, the success of the second fishway in ameliorating the upstream passage performance issues at the dam will be instrumental in demonstrating the feasibility of achieving the proposed cumulative upstream standards. For this reason, we expect that a smaller-scale study focused on evaluating the passage efficacy of the Lockwood facility immediately following the construction of the bypass fishway would provide real benefits within the context of the proposed adaptive management framework, described below. Given that the study would be limited to the evaluation of a single facility, an adequate sample size could be as few as 20 individuals. Given the average number of adult returns (29) to the Kennebec, the Licensee would likely have the ability to perform the study in advance of the smolt supplementation effort related to the larger, cumulative upstream study.

Adaptive Management

Performance criteria coupled with adaptive management are considered key components to achieving highly effective fish passage (Keefer et al., 2021; Silva et al., 2017). For the lower Kennebec Projects, Brookfield has proposed an adaptive management "framework" that outlines possible categories of operational and structural modifications that could be implemented at all four dams, in consultation with resource agencies, to help ensure the achievement of proposed performance standards. Brookfield's proposed adaptive management of its upstream fishways include the development and implementation, in consultation with NMFS, of "additional operational or infrastructure measures, as reasonable and practicable, that are likely to meet or exceed the upstream performance standard." As such, we conclude that Brookfield's proposal does not preclude *any* modifications necessary to achieve its proposed upstream passage standards, including additional fishways– provided that information demonstrates necessity. Therefore, given that the licenses will require that these standards be achieved and given the breadth of the adaptive management protocol, we expect that the proposed actions, combined with effective adaptive management of the fishways will achieve high passage efficiencies and low passage delays consistent with the standards outlined in Brookfield's proposal.

We have determined that it is reasonable to expect that within 10 years following FERC license amendments and issuance of a subsequent license, the upstream standards will be met and compliance will be confirmed. This is based on consideration of the following: time required for construction of the fishways at Lockwood, Weston, and Shawmut following expected FERC approvals in the summer of 2024 (two years, starting in the first full construction season following FERC approval, for a total of 3 years following approvals); a year for facility shakedowns; two years of upstream passage testing; two years for the implementation of adaptive management measures, as needed; and another two years for follow-up passage testing. Concurrent with fishway construction, Brookfield will facilitate the implementation of a multi-year enhanced stocking program to ensure 200+ returning adults that can be used in upstream evaluations at the projects.

The Lockwood trap and truck program currently provides the only upstream passage to spawning and rearing habitat in the Kennebec watershed; it will continue until such time that the new fishways have demonstrated safe, timely, and effective passage (i.e., compliance with the performance standards included in the proposed action). As explained above, we expect this to take up to 10 years. Therefore, we expect that Atlantic salmon will continue to be trapped and trucked from the Lockwood Project to the Sandy River as "interim" passage for the next 10 years. As such, upstream migrating Atlantic salmon would continue to be without swim-through access to upstream spawning habitat on the Kennebec during this time. As we explain in further detail in the above *Lockwood* section, we expect that the current Lockwood fish lift, with an average efficiency of 67% and median passage delay of 10-18 days, will dictate upstream passage efficiency for Atlantic salmon in the lower Kennebec River for the duration of the interim term. After 10 years and for the remainder of the term of the proposed actions, we expect that the upstream standards for survival and delay will be achieved.

6.2.2.4 Summary of Upstream Passage Effects on Adult Atlantic Salmon

We expect that during the 10-year interim phase, 67% of prespawn adults will successfully pass all four dams, but will be harassed due to the effects of trap and truck. Approximately 33% of salmon will fail to ascend the Lockwood fish lift, and will be harassed as they will need to locate alternative spawning and rearing habitat, or else leave the Kennebec without spawning. A small proportion of those (0.3%) may die as a result of forced straying. Of the fish that successfully pass the project, 65% will be significantly delayed (>192 hours), and therefore will be harassed (55%) or harmed (10%) due to the energetic effects of delay. After the measures have been fully implemented and evaluated (by the end of year 10), we expect that the performance standards will have been achieved such that approximately 85% of adult salmon will successfully pass upstream of all four dams in less than 192 hours. The 15% that fail to pass all four dams will be harassed, but are expected to be able to access newly available spawning and rearing habitat in the tributaries. A small proportion of those fish (0.5% total) may die as a result of straying due to their inability to locate suitable habitat.

6.3 Effects of Aquatic Monitoring and Evaluation

Brookfield has proposed studies involving Atlantic salmon at the Weston, Shawmut, Hydro-Kennebec, and Lockwood Projects during the term of the license amendments, as well as the new license for Shawmut. The studies that have been proposed are:

- Upstream:
    - Prespawn adults
        - Up to six years of passage effectiveness studies using up to 200 adult salmon a year trapped at the Hydro-Kennebec and Lockwood fishways, for a total of 1,200 adult salmon.
- Downstream:

- Smolts
  - Brookfield has proposed to conduct three years of smolt survival studies at the four projects with 50 smolts per project per year. We anticipate that approximately 200 smolts will be needed per project per year in order to obtain results with sufficiently low error rates. Brookfield has proposed to conduct adaptive management if the performance standards are not achieved with the initial measures. Therefore, we anticipate that at least six years of studies would be needed, for a total of 4,800 smolts.
  - Injury assessment at each project. Brookfield has proposed to conduct an injury assessment at each project to determine their contribution to hydrosystem delayed mortality. The study design was not specified for this evaluation, but we anticipate it will be a balloon tag study that will assess injury rates through each of the passage routes at each project. In addition, they have proposed a balloon tag study at the Weston spillway routes to help inform prioritization. Given a similar study conducted at the Ellsworth Hydroelectric Project in 2017 (BBHP, 2017; FERC Accession # 20171229-5079), we anticipate that up to 300 fish would be needed per project. It is likely that a surrogate species (such as trout) would be used in these studies instead of Atlantic salmon.
- Kelts
  - Downstream survival studies were required in the ISPP but were delayed due to the lack of a source of study fish. We anticipate that the adult prespawn salmon that will be tagged and used for upstream passage studies will be tracked through their outmigration to provide information on kelt survival at these four projects.

These studies are necessary to monitor the effect of the proposed action, and would not occur but for the proposed action. We anticipate that the effects of handling and tagging will lead to minor injury of every study fish, but that they will recover after a short period and will be able to continue their migration. This conclusion is based on the results of numerous similar studies within the GOM DPS of Atlantic salmon (BWPH 2013, 2014, 2015, 2016; BBHP 2017, 2017b, 2018, 2019). Therefore, we do not believe that these effects will lead to a significant disruption of behavior.

Techniques such as PIT tagging, coded wire tagging, fin-clipping, and the use of radio or acoustic transmitters are commonly used techniques with Atlantic salmon. All sampling, handling, and tagging procedures have an inherent potential to stress, injure, or even kill the marked fish. Telemetry using radio and/or acoustic tags will be the primary technique for the proposed downstream studies.

The method proposed for the downstream passage studies is to surgically implant tags within the body cavities of the smolts. These tags do not interfere with feeding or movement. However, the tagging procedure requires considerable experience and care (Nielsen, 1992). Because the tag is placed within the body cavity, it is possible to injure a fish's internal organs. Infections of the sutured incision and the body cavity itself are also possible (Chisholm & Hubert, 1985; Mellas & Haynes, 1985).

Fish with internal radio tags often die at higher rates than fish tagged by other means because radio tagging is a complicated and stressful process. Mortality is both acute (occurring during or soon after tagging) and delayed (occurring long after the fish have been released into the environment). Acute mortality is caused by trauma induced during capture, tagging, and release. It can be reduced by handling fish as gently as possible. Post-release delayed mortality occurs if the tag or the tagging procedure harms the animal in direct or subtle ways. Tags may cause wounds that do not heal properly, may make swimming more difficult, or may make tagged animals more vulnerable to predation (Howe & Hoyt, 1982; Matthews & Reavis, 1990; Moring, 1990). These effects contribute to post-release handling mortality that is frequently observed in telemetry studies.

All fish used in the proposed study will be handled by one or more people. There is an immediate risk of injury or mortality and a potential for delayed mortality due to mishandling. Those same fish that survive initial handling will also be subject to tag insertion for identification purposes during monitoring activities. It is assumed that 100% of the fish that are handled and tagged will be injured and harmed.

A proportion of the smolts are anticipated to be killed due to handling and tagging. There is some variability in the reported level of mortality associated with tagging juvenile salmonids. We did not document any immediate mortality while tagging 666 hatchery reared juvenile Atlantic salmon between 1997 and 2005 prior to their release into the Dennys River. After 2 weeks of being held in pools, only two (0.3%) of these fish died. Over the same timeframe, we surgically implanted tags into wild juvenile Atlantic salmon prior to their release into the Narraguagus River. Of the 679 fish tagged, 13, or 1.9%, died during surgery (NMFS, unpublished data). It is likely there were delayed mortalities as a result of the surgeries, but this could not be quantified because fish were not held for an extended period. In a study assessing tagging mortality in hatchery reared yearling Chinook salmon, Hockersmith et al. (Hockersmith et al., 2000) determined that 1.8% (20 out of 1,133) died after having radio tags surgically implanted. Given this range of mortality rates, it is anticipated that no more than 2% of Atlantic salmon smolts will be killed due to handling and tagging during the proposed downstream monitoring studies. As monitoring the tagging of up to 4,800 Atlantic salmon smolts, we anticipate that no more than 96 (16 a year) would be killed due to tagging effects.

All adult Atlantic salmon used in the passage studies will be injured due to handling and tagging. However, long term effects of handling and tagging on adult salmon appear to be negligible. Bridger and Booth (Bridger & Booth, 2003) indicate that implanting tags gastrically does not affect the swimming ability, migratory orientation, and buoyancy of test fish. Due to handling and tag insertion, it is possible that a small proportion of study fish may die due to delayed effects. In a study assessing tagging mortality in hatchery reared yearling Chinook salmon, Hockersmith et al. (2000) determined that 2% (28 out of 1,156) died after having radio tags gastrically implanted. Given the size differential between a yearling Chinook and an adult Atlantic salmon, it is expected that this would represent a worst-case estimate of tagging mortality in the adult salmon being used in the passage studies at the Kennebec projects. Given the number of Atlantic salmon being tagged (no more than 1,200), it is expected that up to 24 (four a year) adult Atlantic salmon will be killed as part of the upstream passage studies. Injuries are expected to be minimized by having trained professionals conduct the procedures using established protocols.

6.4 Effects of Habitat Restoration Funding

In addition to operational and structural modifications at the dams, Brookfield has proposed to provide funds for connectivity projects in the Kennebec and Sandy Rivers. These projects would improve fish passage within rearing and spawning habitat within critical habitat in the Kennebec River watershed. The types of project could include culvert upgrades or removals, small dam removal, or fishway construction. Brookfield has proposed to provide $75,000 a year per project for the first 10 years of the SPP, which equates to $3,000,000 total (i.e., $75,000*4 projects*10 years).

These projects would not reduce the effect that the dams have on migrating juvenile or adult salmon, however, they will provide additional opportunities for spawning and rearing and will benefit the species and the functioning of the designated critical habitat. Without knowing where these projects will occur and what they will involve, the effects cannot be established; however, we expect all such projects would have a net benefit. We expect projects carried out with these funds would require permits or authorizations from the U.S. Army Corps of Engineers and/or other federal agencies and that any necessary section 7 consultation would be carried out in the future.

6.5 Effects to Atlantic Salmon Critical Habitat

On August 27, 2019, NMFS and USFWS published a revised regulatory definition of "destruction or adverse modification" (84 FR 44976). As defined, destruction or adverse modification "means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species."

The critical habitat designation for the GOM DPS is for habitats that support successful Atlantic salmon spawning/rearing, and migration. The critical habitat does not include any unoccupied habitat. In order to determine if the proposed action may affect critical habitat, we consider whether it would impact the habitat in a way that would affect its ability to support spawning, rearing, and migration. Specifically, we consider the effects of the project on the physical features of the proposed critical habitat and how these effects impact the conservation value of the habitat. As defined in section 2, the action area of the proposed action includes the mainstem of the Kennebec River from the upper extent of the Weston Dam impoundment downstream to the confluence with the Sebasticook River. The entirety of the action area falls within designated critical habitat.

In this analysis, we consider the consequences of the action on critical habitat in the action area. For each PBF that may be affected by the action, we determine the effects to the feature. In making this determination, we consider the action's potential to affect how each PBF supports the conservation needs of Atlantic salmon in the action area. Part of this analysis is consideration of the conservation value of the habitat and whether the action will have effects on the ability of Atlantic salmon to use the feature(s), temporarily or permanently. Later, in the integration and synthesis section of this Opinion we will consider the effects addressed here on the value of the critical habitat designated for the whole of the DPS.

In the Environmental Baseline, we described a two-step process for characterizing the function of each spawning and rearing PBF that is based: 1) on the presence and potential functional status of the feature, and 2) on the ability of the appropriate life stage of salmon to access and utilize the feature. We determined that PBFs SR 1 – 7, M 2, and M 3 are present in the action area and have the potential to function at a limited capacity due to several of the functional parameters (described in Table 8) being outside of the fully functional range. We further indicated that as the PBFs present upstream of the Lockwood Dam are not accessible, they are not able to realize that potential and therefore currently have low conservation value. We have determined that PBFs M 2 and M 3 are not functioning under existing conditions as upstream passage of salmon and alosines are blocked due to the lack of swim through fishways. We determined the habitat downstream of the Lockwood Project is fully accessible, and, given their status, that the PBFs function at a limited capacity.

All of the PBFs in the action area will be affected by the proposed action, except for M 5 and M 6. M 5 refers to the need for cool water and sufficient flows to stimulate smolt migration in the spring. Given the low suitability of the rearing habitat within the mainstem, we expect that few, if any, smolts are initiating movement in the action area. The majority of smolts will be produced in the Sandy River or other tributaries, which are outside of the action area. Additionally, as the projects operate in run of river mode (inflow equals outflow), and as they don't significantly affect water temperatures in the spring months, the proposed actions will have no effect on PBF M 5, and it will not be considered further. PBF M 6 refers to the need for water chemistry that will support seawater adaptation of smolts. Specifically, this PBF addresses the need for low acidity water as smolts that are exposed to water that is too acidic (low pH) can lose their tolerance for salt water (USOFR, 2009), which would affect their ability to successfully transition to the ocean. We do not anticipate that the proposed action will affect the pH of water in the action area; therefore, the project will have no effect on this feature and we will not consider PBF M6 further.

Below, we analyze the potential effects of the proposed action on the remaining PBFs.

6.5.1 PBFs for Spawning (SR1-SR3)

SR 1: Deep, oxygenated pools and cover (e.g., boulders, woody debris, vegetation, etc.), near freshwater spawning sites, necessary to support adult migrants during the summer while they await spawning in the fall.

PBF SR1 refers to the need for holding and resting areas that prespawn salmon can use during their upstream migration; referring specifically to pools "near freshwater spawning sites". Although spawning habitat has not been mapped between Lockwood and Weston (likely due to the lack of access posed by the dams) we anticipate that there will be cool water areas near groundwater discharge areas or cool water tributaries where adults may hold while they wait to spawn.

As the water temperature in the action area regularly exceeds 20°C in the warm summer months any holding pools that are present have the potential to function at a limited capacity. The proposal to improve fish passage at the four projects will allow this potential to be realized by allowing the appropriate lifestage of Atlantic salmon to access and utilize the habitat. As Brookfield has committed to achieving a cumulative passage performance standard of 85% (96% per dam), the habitat will be considered accessible when those standards have been met. As such, the proposed action will increase the conservation value of the PBF by year 10 of the proposed action. Despite the significant improvement to the conservation value of the PBF, the proposed action will still adversely affect it as it will take 10 years for improvements to be realized, and because even after the standard has been achieved a small proportion of prespawn salmon will still be excluded from accessing upstream habitat.

SR 2: Freshwater sites that contain clean, permeable gravel and cobble substrate with oxygenated water and cool water temperatures to support spawning activity, egg incubation, and larval development.

SR 3: Freshwater spawning and rearing sites with clean, permeable gravel and cobble substrate with oxygenated water and cool water temperatures to support emergence, territorial development and feeding activities of Atlantic salmon fry.

PBF SR 2 and SR 3 refer to the need for appropriate physical conditions to support spawning activity, as well as egg and fry development. Although spawning habitat has not been mapped in the mainstem upstream of Lockwood, the available information indicates that there are some areas that will provide the substrate and cold water conditions necessary for this purpose. In the Environmental Baseline, we have indicated that this feature has the potential to function at a limited capacity due to temperature and depth conditions in the action area, as well as an abundance of nonnative species.

The proposal to improve fish passage at the four projects will not change the potential of the habitat to support egg and fry development; however, it will significantly improve the conservation value of the PBFs upstream of Lockwood by allowing prespawn Atlantic salmon to access and utilize the habitat for spawning. As Brookfield has committed to achieving a cumulative passage performance standard of 85% (96% per dam), the habitat will be considered accessible once that standard has been achieved. As such, the proposed action will increase the conservation value of the PBF by year 10 of the proposed action. Despite the significant improvement to the conservation value of the PBFs, the proposed action will still adversely affect them as it will take 10 years for improvements to be realized, and because even after the standard has been achieved a small proportion of prespawn salmon will still be excluded from accessing upstream habitat.

6.5.2 PBFs for Rearing (SR4- SR7)

Freshwater rearing sites with the space (SR4), habitat diversity (SR5), cool water (SR6), and diverse food resources (SR7) necessary to support growth and survival of Atlantic salmon parr.

PBF SR 4 - 7 describe the physical and biological conditions necessary to support the rearing of salmon parr. Although the Wright et al. (2008) habitat model indicates there is rearing habitat throughout the action area, it has indicated it is mostly class 3 habitat, which means the model predicts that a relatively low proportion of the habitat contains the features necessary to support rearing. In the Environmental Baseline, we have indicated that these features have the potential to function at a limited capacity due to temperature, depth, and fish community conditions in the action area.

The proposal to improve fish passage at the four projects will not change the potential of the habitat to support parr development; however, it will significantly improve the conservation value of the PBFs upstream of Lockwood by allowing prespawn Atlantic salmon to access and utilize the habitat for spawning and rearing. As Brookfield has committed to achieving a cumulative passage performance standard of 85% (96% per dam), the habitat will be considered accessible when this standard has been met. As such, the proposed action will increase the conservation value of the PBFs by year 10 of the proposed action. Despite the significant improvement to the conservation value of the PBFs, the proposed action will still adversely affect them as it will take 10 years for improvements to be realized, and because even after the standard has been achieved a small proportion of prespawn salmon will still be excluded from accessing upstream habitat.

6.5.3 PBFs for Migration (M1 - M4)

M1: Migratory sites free from physical and biological barriers that delay or prevent access of adult salmon seeking spawning grounds needed to support recovered populations

The four dams that are considered in FERC’s proposed action are significant physical barriers that without safe and effective fish passage prevent prespawn salmon from accessing spawning habitat. Salmon cannot currently access the migratory corridor between Lockwood and the

Sandy River, which means that this PBF is not functional. Current management of the Kennebec River relies on the use of the trap and truck operation at Lockwood in order to transport returning adults to spawning habitat in the Sandy River.

The Lockwood fish trap is 67% (pooled average over four year period) effective and causes significant migratory delay (average of 17.3 days). This condition will persist through the interim phase, which means that the lack of swim-through fishways will continue to adversely affect this PBF for the next 10 years.

The proposal to construct new fishways at the Lockwood, Shawmut, and Weston fishways will allow for the functioning of PBF M1 by providing swim-through passage through the system, which directly increases the conservation value of this PBF. Brookfield has proposed to operate the fishways at the four projects to achieve a cumulative upstream passage effectiveness of 85% (i.e., 96% per dam at four dams), at which point the habitat will be considered accessible. As such, the proposed action will allow for the functioning of the PBF by year 10 of the proposed action. Despite the significant improvement to the conservation value of the PBF, the proposed action will still adversely affect it as it will take 10 years for improvements to be realized, and because even after the standard has been achieved a small proportion of prespawn salmon will still be excluded from accessing upstream habitat.

M2: Freshwater and estuary migration sites with pool, lake, and in-stream habitat that provide cool, oxygenated water and cover items (e.g., boulders, woody debris, and vegetation) to serve as temporary holding and resting areas during upstream migration of adult salmon.

PBFs SR1 and M2 both describe the holding and resting areas that prespawn salmon can use during their upstream migration. SR1 refers specifically to pools "near freshwater spawning sites," whereas M2 speaks to the need for holding areas throughout the migratory corridor. As described for SR 1 above, the proposed action will allow for the functioning of PBF M2, and will improve the conservation value of the PBF by year 10 of the proposed action. Despite the significant improvement to the conservation value of the PBF, the proposed action will still adversely affect the PBF as a small proportion of prespawn salmon will still be excluded from accessing it, even with the achievement of the performance standard.

M3: Freshwater and estuary migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation.

In section 4, we described how the presence and operation of the dams in the lower Kennebec does not allow for the functioning of this PBF in the action area as they block upstream and downstream passage of native alosine fish (i.e., river herring and American shad). The four dams kill and injure juveniles and adults as they pass through the turbines, and block access to important spawning habitat for migrating adults in the Kennebec River watershed. The presence or absence of these species is considered to play important roles in mitigating the magnitude of predation on Atlantic salmon smolts and adults from predators such as striped bass, double-crested cormorants, harbor seals, and gray seals, primarily in the estuary (Leach et al., 2022; Saunders et al., 2006).

As indicated above, the proposed downstream and upstream passage measures will likely provide some benefit to the alosine species migrating through the action area. Any of the measures designed to reduce turbine entrainment at the four projects for Atlantic salmon are expected to lead to some improvement in rates of injury and survival for downstream migrants of other species, although lacking adequate baseline information on survival rates at the dams currently, it is not possible to quantify the anticipated improvement in survival.

Lockwood

The proposal at the Lockwood Project to shut down turbines at night for 97% of the smolt outmigration period will have limited benefit for alosines as the timing only minimally overlaps with their outmigration period. Smolts generally leave the system between April 15 and June 15, whereas adult and juvenile river herring leave the system between June 1 and November 30. However, the installation of uniform acceleration weirs (UAW) at both of the downstream bypass fishways is expected to increase attraction to the safer routes of downstream passage for all species. As indicated previously, Haro et al. (1998) conducted studies with juvenile Atlantic salmon and American shad to compare passage rates and timing between a uniform acceleration weir and a sharp crested weir. While they determined that there was a significant increase in passage rate (and reduction in passage time) for Atlantic salmon, no difference was observed for American shad. The authors concluded that this could be because the shad were avoiding both types of weirs, or because they were not motivated to pass downstream (Haro et al., 1998). The USFWS Fish Passage Engineering Design Criteria (2019) acknowledge the potential for avoidance of areas of high acceleration and recommend that “the geometry of a surface level bypass weir should create a uniform spatial flow velocity” (USFWS, 2019). Assuming these (or other appropriate criteria) are applied in the design, we anticipate the UAWs will increase the bypass effectiveness at the Lockwood Project for juvenile and adult alosines.

In addition to the construction of new weirs, Brookfield will be installing racks with 2-inch spacing in front of the Kaplan unit at the project. As the Francis units already have 2-inch rack spacing, the installation of a rack at the Kaplan is expected to further reduce the proportion of adult alosines that are entrained at the project. Specifically, these racks will completely exclude adult American shad from swimming through the turbines at the Lockwood Project because shad will be too large to pass through the openings. In combination with the improved attraction to the two downstream bypass fishways, this should significantly improve survival of that species. However, adult alewives and blueback herring can easily fit through racks with 2-inch spacing. In Table 8 of FERC’s Draft Environmental Analysis for the Shawmut Project, it is indicated that 1.5-inch racks would not exclude adult river herring of any size, and even 1-inch spacing would only screen out the largest adults[62]. This was demonstrated at this project when Brookfield conducted an alewife passage study in 2015 and 36% of the alewives that entered the power canal passed through the Francis units (which currently have 2-inch racks) (BWPH, 2016b). Therefore, we conclude that although the new racks should significantly improve conditions for Atlantic shad at the Lockwood Project, it will not benefit other alosines.

The proposal to construct and operate a new, volitional fish ladder, designed consistent with USFWS fishway design guidelines to accommodate other sea-run fish including alosines, should, when operated with the existing trap, lead to an increase in the number of alosines that migrate above the project. Although uncertain, it is likely that the installation of a second fishway at Lockwood will result in effective upstream passage of alosines.

Hydro-Kennebec

The proposal at the Hydro-Kennebec Project to close the gap in the floating guidance boom, and to install a new entrance (with a uniform acceleration weir) to the new downstream bypass should benefit alosines. The relocated floating guidance boom (which was 84% effective for alewives at this project in the 2016 study (BWPH, 2017b)) should become even more effective when the five foot gap has been closed. In addition, the overlay racks (2-inch spacing) in front of the two turbines are expected to exclude adult American shad from being entrained, which when combined with the improved guidance to the downstream bypass fishway is expected to lead to an improvement in survival. As indicated above, we do not anticipate that these racks will benefit river herring as they can easily pass through 2-inch spacing.

A new fish lift, designed consistent with USFWS fishway design guidelines to accommodate other sea-run fish including alosines, was constructed in 2017. It will be monitored and adaptively managed, as needed, to improve passage of Atlantic salmon. It is expected that modifications that improve passage for Atlantic salmon would benefit other migrating species as well.

Shawmut

The proposed measures at the Shawmut project are expected to offer enhanced protection to American shad and river herring compared to current conditions. As indicated previously, the booms at the Lockwood and Hydro-Kennebec Projects were 32% and 84% effective, respectively, at guiding approaching alewives to the project bypass fishways. Doubling that effectiveness with the installation of a second boom in front of the Unit 7 - 8 Powerhouse would further increase the number of shad and river herring that pass safely downstream of the project. The new bypass entrances will include uniform acceleration weirs, which are expected to increase attraction to the downstream bypasses for alosines. The installation of 2-inch overlay

[62] Based on the body width scaling factors in Smith (1985).

racks at the Unit 7 - 8 Powerhouse is expected to prevent adult American shad from passing through the turbines, but as indicated above, will not physically exclude river herring of any lifestage. The installation of 1-inch racks at the Unit 1 - 6 Powerhouse would physically exclude passage of larger adult river herring, and may also act as a behavioral deterrent for smaller fish. Additionally, the resurfacing of 350-feet of spillway as well as the log sluice in the middle of the dam is expected to improve the safety of spillway passage for all species.

The proposal to construct and operate a new fish lift at the Shawmut Project is expected to increase the number of alosines that migrate above the project. The fishway was designed to effectively pass all anadromous species. The new fishway will be monitored and adaptively managed as needed to improve passage of Atlantic salmon. It is expected that modifications that improve passage for Atlantic salmon would benefit other migrating species as well.

Weston

The proposal to make improvements to increase the safety of the non-turbine passage routes for Atlantic salmon is expected to also improve survival rates for other species. Specifically, the resurfacing of the sluice and the addition of an energy dissipation structure at the base would increase survival through the bypass. Similarly, the gate automation and prioritization of spill (to avoid ledge outcrops) is expected to make those routes safer for all species. Implementation of a minimum flow through the log sluice during the outmigration period for alosines is expected to provide a safe passage route in the south channel, and the construction of a new downstream fishway (associated with the AWS for the new upstream fishway) on the inside of the guidance boom provides a safe route of egress for fish that sound under the boom.

The proposal to construct and operate a new fish lift at the Weston Project is expected to lead to an increase in the number of alosines that migrate above the project. The fishway was designed to effectively pass all anadromous species. The new fishway will be monitored and adaptively managed as needed to improve passage of Atlantic salmon. We expect that modifications that improve passage for Atlantic salmon would benefit other migrating species as well.

Effects of the Dams to PBF M 3 in the Kennebec River

Considering the proposed actions individually and cumulatively, we expect that implementation of the proposed actions will improve abundance and distribution of river herring and American shad in the Kennebec River. However, we anticipate that some proportion of juvenile and adult alosines will continue to become entrained through project turbines where they will be delayed, injured, or killed during their migration. We have limited information regarding the survival of alosines at the four projects. Normandeau Associates has conducted downstream adult alewife studies at the Lockwood and Hydro-Kennebec Projects for Brookfield (BWPH, 2016b, 2017b). Survival estimates from those studies were 96% and 85% at Hydro-Kennebec and Lockwood, respectively. No survival information is available from the Shawmut and Weston Projects. We also have no upstream effectiveness information at the Lockwood Project, and the other three projects either do not yet have fishways or, in the case of Hydro-Kennebec, are not currently accessible to migrating alosines. However, as we have described above, many of the downstream measures that are being implemented at the four projects will improve passage conditions for all species; and the construction of upstream fishways at all four projects will allow swim through access to the action area (as well as to the Sandy River) for alosines for the first time since the construction of the dams in the 19th century. As such, although we expect that the dams will continue to limit the production and distribution of river herring and shad to some extent due to passage inefficiencies, the restoration of access will allow the PBF to function at a limited level. The passage improvements, especially the new fishway, will mean that both salmon and alosines will be swimming through the action area at the same time and, therefore, that herring and shad may act as suitable prey for predators that would otherwise consume salmon. Despite this significant improvement to the conservation value of the PBF, the proposed action will still adversely affect the PBF as it will limit abundance and distribution of alosines in the action area due to passage inefficiencies.

M4: Migration sites free from physical and biological barriers that delay or prevent emigration of smolts to the marine environment.

As described in detail in section 4, the four dams directly and indirectly kill Atlantic salmon smolts during their migration to the marine environment. We have estimated that under baseline operations these four projects currently kill approximately 47% of smolts (measured cumulatively and excluding impoundment mortality) migrating downstream from the Sandy River. Our analysis indicates that the proposed action will significantly reduce overall mortality, but that approximately 16% of the smolts will still be killed. Therefore, as we still anticipate some passage mortality, the functioning of this PBF will continue to be limited. As such, although the implementation of the proposed downstream measures will significantly improve the functioning of this PBF by providing access and substantially minimizing passage inefficiencies by year 3 of the action, the continued operation of the dams will still adversely affect the PBF.

In summary, we anticipate that the PBFs SR 1 - 7 and M 1 - 4 in the action area will continue to have low conservation value during the interim phase due to the lack of fish passage at the four projects. The restoration of access during the implementation phase will allow all of the PBFs to function at a limited capacity in the action area. Once the performance standards have been achieved, the habitat within the action area will also be considered accessible in terms of our recovery criteria as outlined in the 2019 Recovery Plan. Despite the significant improvement in function and accessibility, the proposed action is likely to adversely affect the PBFs for spawning and rearing in the action area, as well as for migration, as the dams will continue to block and hinder upstream passage of a small proportion of salmon, and will continue to delay, injure, and kill a small proportion of outmigrating smolts and kelts.

6.6 Effects of Fishway Construction on Atlantic salmon

This proposed action includes construction activities associated with new upstream fishways at the Lockwood, Shawmut, and Weston Projects; as well as in-water work associated with the installation and implementation of measures to improve downstream survival of smolts and kelts at all four projects. Construction activities may affect Atlantic salmon and could lead to temporary and permanent effects to designated critical habitat for the GOM DPS of Atlantic salmon. The ACOE has proposed to issue section 404 Clean Water Act authorization for the construction of the Lockwood and Weston fishways; however, they have already provided such authorization for the construction of the Shawmut fishway. As the effects of construction of these fishways are effects of the actions under consultation, our analysis below will address the effects of the construction of these fishways.

Fishway construction activities will involve the removal and placement of temporary and permanent fill in the vicinity of the Weston, Shawmut, and Lockwood powerhouses. As described at length previously, these projects are located within designated critical habitat for the GOM DPS of Atlantic salmon and both juvenile and adult salmon could be present in the action area at certain times of year. Prespawn Atlantic salmon are not expected in the vicinity of the Shawmut and Weston Projects at the time of construction, as they are trucked from the Lockwood Project upstream of the dams to the Sandy River.

Although we do not have any construction details for the proposed downstream passage measures (e.g., boom, rack, and entrance weir installation, spillway repairs, new downstream fishway, modified fishway entrances), we anticipate the amount of in-water work will be minimal and that any fill would be temporary. In addition, as these measures will all be implemented upstream of the Lockwood Project, we do not expect that prespawn Atlantic salmon, or either species of sturgeon, would occur in the vicinity of the work. We also anticipate that in-water work would occur during mid to late summer (the low flow period), which is outside of the period when we would expect juvenile salmon to be migrating past the projects.

Species Presence

In-water work at all three projects will not occur between April 15 and June 15 when we could anticipate Atlantic salmon smolts to be migrating through the mainstem of the Kennebec River. Additionally, given the deep water habitat in the vicinity of the projects, we would not expect any eggs, fry, or parr to be present in the project area.

In-water work has been proposed to occur between July 15 and September 30, and between November 8 and March 8. Prespawn adults could be migrating upstream past the Lockwood project between May and October, so could be in the action area when construction occurs in the July 15 to September 30 timeframe. Of the 180 adult Atlantic salmon trapped at the Lockwood Project between 2017 and 2021, 95% were trapped prior to July 15 or after September 30.[63] The remaining 5% passed the project between July 15 and September 30. Given the significant smolt

[63] Based on the weekly fishway reports provided by Brookfield between 2017 and 2021.

stocking effort that commenced in 2020 downstream of Lockwood, we expect that the number of fish will be higher than what was observed up until that point. Given the stocking of approximately 100,000 hatchery smolts and a postsmolt-to-adult return rate of 0.14% (the 10-year average PSAR for 2SW returns on the Penobscot River; USASAC 2022), we would anticipate 140 hatchery adults returning to the Kennebec, in addition to the 29 naturally reared adults that we would expect based on the 10-year average of returns resulting from egg stocking in the Sandy River. We would therefore expect that up to eight salmon (5% x 149 salmon) could occur in the action area downstream of Lockwood between July 15 and September 30. These salmon could spend considerable time downstream of that project (average of 17 days) as they search for an upstream passage route. Postspawn adults (kelts) migrate from their spawning location to the ocean either in the fall after spawning (~20%; November-December), or will overwinter and migrate in the spring (~80%; April to June). Given this, we can assume that 135 postspawn adults could migrate past the projects between April and June, and 34 could migrate in November and December. Kelts are unlikely to stay in the vicinity of any of the projects once they pass downstream, but they could occur upstream of the dam as they search for a safe passage route. Given this analysis, we assume that no more than eight prespawn adults would be in the action area downstream of Lockwood between July 15 and September 30, and that no more than 34 postspawn adults would be migrating past all three projects during the November to April work window.

6.6.1 Weston and Shawmut Projects

Effects of the construction of the fishway at the Weston and Shawmut Projects is likely to be limited to the habitat immediately downriver of the projects. We do not expect prespawn Atlantic salmon to occur in the vicinity of the dams as they will be trucked to the Sandy River from the Lockwood Project when construction is underway. It is possible that juvenile salmon (smolts) could occur at the projects between April and June, and that kelts could be in the area in November-December, and April-June. We anticipate that the in-water work (largely the installation and removal of cofferdams) will occur outside of the smolt migration period, as well as the spring kelt migration period. It is possible that cofferdams could be removed or installed during the fall (November-December) kelt migration period. As indicated above, we anticipate that approximately 34 kelts could be migrating through the action area at this time. These adult salmon could be exposed to the effects of construction as described below. As it is unlikely that they would hold in the area while disturbance from construction was ongoing, there is a low likelihood that a kelt could become entrapped in the cofferdam as it is being constructed. We are not aware of any instance of an adult Atlantic salmon becoming entrapped in a cofferdam at a construction project. The areas to be cofferdammed at these projects are relatively small, and there is sufficient water depth to allow any salmon in the area to evacuate the vicinity before the area is isolated. As such, we do not anticipate salmon will be entrapped at either project during construction. Although it isn't expected, Brookfield has proposed to develop a fish stranding plan with the agencies that will outline the procedure for any fish that become entrapped in a cofferdam. We anticipate that the plan would minimize stress by limiting handling time as well as the time that fish are held out of the water, as well as by using transfer containers with aerated stream water of ambient temperature. Impacts to Atlantic salmon will be further minimized by requiring that only qualified staff handle the fish. Given these minimization efforts, it is not expected that there will be any injury or mortality associated with cofferdam construction.

6.6.2 Lockwood Project

Both juvenile and adult Atlantic salmon (both prespawn and postspawn) could be present in the action area at certain times of year. It is also within designated critical habitat for Atlantic sturgeon and the GOM DPS of Atlantic salmon.

In-water work associated with the fishway construction project has been timed to minimize effects to listed salmon and sturgeon in the action area (Table 2). The construction and removal of in-water access structures and cofferdams will occur between July 15-September 30, or November 8-April 9. All other construction activity (i.e., spillway demolition, bedrock removal, fishway construction) will occur in the dry within the confines of a dewatered cofferdam.

Installation and Removal of Tailrace Cofferdam

Sedimentation and Turbidity

During the Lockwood dam upstream fish passage installation project, several activities associated with construction of the new structure have potential to disturb sediments and increase turbidity. These actions include:

- Construction and removal of cofferdams;
- Dewatering activities; and
- Construction of a fishway access road.

Brookfield is proposing to install either a double sheet pile wall cofferdam or a single concrete wall cofferdam in the tailwater construction area. Because the substrate in the tailwater portion of the project area is predominantly bedrock; sheet piles for cofferdams cannot be driven into substrate as per typical installation. Based on Brookfield's discussions with potential contractors, the downstream cofferdam would either be a double sheet pile wall with gravel or a single concrete wall tensioned to the bedrock. Any in-river rock excavation will occur behind the cofferdam (e.g., hydraulic excavator(s), hoe ram(s), excavator mounted and handheld equipment, diamond saws and/or diamond wires, blasting). Brookfield will remove the downstream cofferdam upon completion of the fishway and associated crest gates, and floodwall construction.

The installation and removal of sheet or concrete piles for the cofferdam will disturb bottom sediments. However, given the rocky substrate and lack of fine sediments in the project area, little increase in sedimentation or turbidity is expected to result from these activities. To further reduce the potential effects from sedimentation and turbidity, Brookfield will place a turbidity curtain around the cofferdam system and an upland silt fence system will be installed around the project access and laydown areas. Pumps will be utilized throughout construction to control water in the construction area and a dewatering siltation basin will be utilized to prevent the potential transport of sediment upon discharge of water into the river.

The installation and removal of the cofferdam will occur outside of the period when we would expect juvenile salmon to be migrating through the action area. As such, effects to juvenile Atlantic salmon from downstream cofferdam construction and removal are extremely unlikely to occur, and are therefore discountable.

As discussed above, adult salmon could be in the project vicinity at the time of cofferdam installation and removal. The only potential for exposure of Atlantic salmon to increased turbidity will be if a prespawn or postspawn Atlantic salmon is present in the portion of the Kennebec River where increased turbidity will be experienced. Turbidity and TSS effects to Atlantic salmon worsen with increased levels of turbidity (Newcombe & Jensen, 1996). Juveniles and adults salmonids show minor physiological stress and sublethal effects at suspended sediment concentrations of 7 mg/L for a six-day exposure and at 55 mg/L for a seven-hour exposure (Newcombe & Jensen, 1996). There are three major categories of biological responses to Atlantic salmon from turbidity effects. The three categories are behavioral responses, sub-lethal effects, and potential mortality, as defined below.

Behavioral response - The range of turbidity releases expected to result in behavioral reactions ranging from a startle response to avoidance.

- 1-20 mg/L for 1 hour
- 1 mg/L for 24 hours

Sub-lethal effects – The ranges of turbidity releases expected to result in sub-lethal effects including stress, reduction in feeding rates, and increased respiration rates.

- 20-22,026 mg/L for 1 hour
- 1 mg/L for 6 days

Potential mortality - A higher range of releases has the potential to result in fish mortality.

- >22,026 mg/L for 1 hour
- 7 mg/L for 30 months

Adult salmon could be migrating through the action area in the mainstem Kennebec River during in-water work. As indicated above, the rocky substrate and lack of fine sediments will substantially limit the potential for significant turbidity. Consistent with the categories above, we expect the anticipated TSS levels (5-10 mg/L above baseline conditions or a maximum temporary exposure of 20 mg/L) to potentially cause a behavioral response. This response would likely include avoidance of the portion of the Kennebec affected over a short period of time. As we expect all turbidity and TSS to quickly dissipate from the water column, we do not expect exposure to 20 mg/L for one hour or longer, and therefore, no sub-lethal effects will occur. Therefore, given the short duration of in-water work that would lead to a sediment release, the ephemeral nature of the stressor, and the limited proportion of the migratory corridor affected we expect any effects to adult salmon migration (i.e., migratory delay due to avoidance of the portion of the river with elevated TSS) to be so small that they cannot be meaningfully measured, detected or evaluated, and therefore, insignificant.

Effects of Demolition, Construction, and Excavation within the Tailrace Cofferdam

Noise and Sedimentation

While the downstream cofferdam will be installed during the time of year when salmon are not expected to occur in the action area, demolition, construction and/or excavation may be ongoing within the cofferdams during this time. While this work will result in noise, we expect minimal transmission of this noise to the underwater area where salmon will be present due to the need for noise to transmit through the steel or concrete walls. The potential for elevated noise to be experienced within the underwater area is further reduced as sound from one environment (air or water) is not easily transmitted across the air-water interface (Akamatsu et al. 2002, as referenced in Popper 2003). Should blasting be required, Brookfield will implement a blasting plan outlining pre-blast surveys and monitoring, blasting procedures and sequencing, and blast vibration and sound pressures.

Ongoing demolition and construction within the downstream cofferdam will include sediment disturbing activities. However, as the joints of the cofferdam are expected to be water tight, we do not expect any increase in suspended sediment outside of the cofferdam. Additionally, we do not expect that the effects of construction and demolition within the downstream cofferdam will affect the ability of any individual salmon from migrating successfully as the upstream fish trap (opposite side of the river) and the downstream fishway (downstream of the cofferdammed area) are not located in the affected area.

Exposure to Concrete-related Toxins

Water exposed to the discharge of concrete fill used in fishway construction may be toxic to aquatic life unless properly cured prior to coming into contact with surface water. Concrete pouring in or near a water body increases the risk of higher pH water from inside the cofferdam structure leaking out into the Kennebec River. Exposure to water with a high pH poses metabolic risks to salmon and sturgeon. As explained above, we expect the joints of the cofferdam to be water tight; therefore, fresh concrete will not come into contact with flowing water. To further reduce the potential for introducing concrete-related toxins into the river during construction activities, Brookfield will require the contractor to adhere to a minimum of five days between adjacent concrete pours, which will limit the amount of curing concrete at any one time. Additionally, the Kennebec River is classified as waters of the United States under Section 10 of the Rivers and Harbors Act; therefore, Brookfield is required to comply with

Section 404(b)(1) of the Clean Water Act.[64] With the protection measures proposed by Brookfield, we consider any exposure of salmon to water with elevated pH levels to be extremely unlikely; therefore, effects are discountable.

Entrapment of Salmon in the Tailrace Cofferdam

As explained above, the downstream cofferdam at Lockwood will be constructed outside of the time of year when juvenile salmon are likely to be present in the action area. As such, there is no potential for them to become entrapped within the cofferdam located in the tailwater area during construction. Additionally, as the downstream cofferdam's steel sheeting will be braced by gravel or concrete piles tensioned to bedrock, all joints will be tightly sealed. As such, we anticipate that adult salmon will be precluded from entering the enclosed cofferdam area.

As explained, there is a chance that a small number of adult salmon could be in the action area during the periods when cofferdams are being constructed (i.e., July 15 to September 30; November 8 to April 9). We anticipate up to eight prespawn salmon could be downstream of the Lockwood project during the summer work window, and up to 34 postspawn adults could be passing through the project during the fall work window. The isolation of riverine habitat within a cofferdam minimizes the overall adverse effects of construction activities on Atlantic salmon and their habitat because it reduces exposure to in-water construction activities. However, isolating the work area within a cofferdam could lead to negative impacts to fish if any are trapped within the isolated work area. Compared to Weston and Shawmut, the area to be cofferdammed at the Lockwood Project includes a significantly larger area in the bypass reach, where adult salmon are stranded on occasion when flows are reduced through the reach. As such, and as there will be upstream migrating adults seeking a way past the dam when the cofferdam is installed (unlike at Weston and Shawmut), it is possible that salmon could become entrapped in the cofferdam. In order to minimize the probability of entrapping an adult Atlantic salmon within the work area, a visual survey of these areas will be conducted by qualified personnel to verify that there are no salmon within the project area prior to and during the installation and removal of any in-water bypass structure, including cofferdams. If Atlantic salmon are found within a cofferdam, they will be removed and returned to the River prior to dewatering. As the cofferdams will be constructed at the end of the upstream migration period when only a small proportion of the salmon run will still be migrating through the mainstem of the Kennebec River, and as construction will occur within the Lockwood bypass reach where there will be minimal flow that would attract fish, it is expected that no more than one adult salmon will be harassed due to capture and handling at the Lockwood Project.

[64] Section 404 of the Clean Water Act (CWA) establishes a program to regulate the discharge of dredged or fill material into waters of the United States. CWA Section 404(b)(1) guidelines establish a framework whereby the U.S. Army Corps of Engineers must determine the basic and overall purpose of a project, the water dependency of a project, evaluate alternatives, and determine the Least Environmentally Damaging Practicable Alternative (LEDPA) (EPA 2022).

Here, we carry out the four-step assessment to determine whether the stranding of adult salmon within a cofferdam leads to harassment. We have established that prespawn migrating adult salmon could occur in the Lockwood bypass reach at the time that the cofferdam is installed to allow for the construction of the new fishway at the Lockwood Project (step 1) and that one adult could become entrapped (step 2). We have established the expected response of the exposed adults (step 3): stranded salmon can be injured, stressed, and delayed in their upstream migration. This can lead to increased energy costs, and an increased potential for predation. Minor injuries (such as scale loss) may expose fish to increased rates of infection, and could make the fish less fit for migration and spawning. Finally, we establish that the nature and duration of the response is a significant disruption of migration (step 4). Based on this four-step analysis, we find that one salmon a year is likely to be adversely affected and that effect amounts to harassment. Brookfield has proposed to develop a fish stranding plan with the agencies that will outline the procedure for any fish that become entrapped in a cofferdam. We anticipate that the plan would minimize stress by limiting handling time as well as the time that fish are held out of the water, as well as by using transfer containers with aerated stream water of ambient temperature. Impacts to Atlantic salmon will be further minimized by requiring that only qualified staff handle the fish. For these reasons, it is not expected that the affected individual will be injured or harmed.

6.6.3 Effects to Atlantic Salmon Critical Habitat

The construction of the fishways will place temporary and permanent fill below the ordinary high water (OHW) line in the Kennebec River. As indicated in section 4, the PBFs for spawning and rearing are present and functioning in the action area at a limited capacity below the Lockwood Project where the new fishway will be constructed. Conversely, the lack of passage into the action area above the Lockwood Dam (including the area in the vicinity of the Shawmut and Weston Projects) means that the habitat has low conservation value.

As indicated, the features for spawning and rearing (SR 1 - 7) have low conservation value in the vicinity of the Weston and Shawmut dams, since prespawn and, therefore, early life stages (eggs, fry, parr) cannot access them. Similarly, the migratory features (M 1 - 3) have low value in the vicinity of Weston and Shawmut under existing conditions, as upstream migrating adults and alosines cannot access the area. The feature requiring downstream passage of smolts (M 4) is functioning at a limited capacity in the vicinity of these projects. However, as in-water work is expected to occur outside of the smolt run, the conservation value of M 4 will be low when the work is being conducted. Given the condition of the features at the time of in-water work, none of the temporary effects (i.e., noise, sedimentation, turbidity) associated with construction will affect any of the PBFs. The construction of the fishways will permanently fill a small amount of habitat that will contain the new fishways themselves. The footprint of the new fishways at Weston and Shawmut occurs in habitat that will become functional with the restoration of access that is expected due to the proposal to provide swim through passage at the downstream Lockwood Project. Given the small footprint of the fishways, as well as the depth and velocities near the dam that make it unlikely to support spawning and rearing, it is anticipated that the permanent fill will have an insignificant effect on the spawning and rearing PBFs. Effects of the operation of the new fishways on Atlantic salmon critical habitat are addressed above.

As indicated, the features for spawning and rearing (SR 1 - 7) and migration (M 1 - 4) function at a limited capacity downstream of the Lockwood Dam, since prespawn and, therefore, early life stages (eggs, fry, parr) can access the area. The in-water work at the project will occur when M 4 (smolt migration) is not functioning, and therefore we do not expect it to be affected. We expect construction activities to cause temporary effects to the migratory PBF by reducing water quality due to increased turbidity and the filling of habitat. As turbidity and sedimentation effects will be of short duration (limited to a few hours after cofferdam installation and removal), and will occur late in the upstream migration season when few adult salmon will be in the vicinity, we anticipate that the effects caused by temporary stressors to the functioning of the PBFs will be insignificant. As with Weston and Shawmut, the permanent fill associated with the installation of a new upstream fishway, will be more significant long term. The bedrock substrate in the bypass reach is not suitable for spawning or rearing, so the permanent loss of that habitat will not affect PBFs SR 1-7. The installation of a fishway within the bypass reach will significantly increase the conservation value of the habitat, which under baseline conditions attracts fish does not allow for passage. Effects of operation of the new fishways on Atlantic salmon critical habitat are addressed above.

6.7 Effects to Shortnose and Atlantic sturgeon

Here, we consider the effects of the operation of the Lockwood project on Atlantic and shortnose sturgeon. Because these species do not occur in the portions of the action area affected by the Hydro-Kennebec, Shawmut, and Weston projects, the Lockwood project is the only part of the proposed actions considered for shortnose and Atlantic sturgeon.

6.7.1 Stranding

Once a year, the impoundment of the Lockwood Project is lowered to a point where the flashboards can safely be replaced, resulting in a short period (a few hours) of receded flows downstream. During these low flow periods, there is potential for sturgeon to become stranded in pools, as evidenced by the capture of a shortnose sturgeon in a pool at the base of the Lockwood Project on May 19, 2003. We are not aware of any stranding of Atlantic sturgeon.

Data from the Holyoke Hydroelectric project on the Connecticut River can help in assessing the likely effects of stranding on sturgeon. Shortnose sturgeon are occasionally stranded following significant changes in flow. Some sturgeon that have been rescued from the pools have been observed to have significant hemorrhaging along the ventral scutes and damage to their fins. If not rescued, these fish would likely have died from these wounds, stress from increased temperature and decreased dissolved oxygen, or a combination of these factors. Since implementing rescue procedures in 1996, there has been no detected mortality of shortnose sturgeon stranded in pools below the Holyoke Dam.

There has been an approved handling and rescue plan in place for both species of sturgeon at the Lockwood Project since 2005. The continued implementation of a Sturgeon Handling and Protection Plan will continue to ensure that any sturgeon that are stranded in isolated pools are relocated in a way that will reduce the likelihood of injury and will eliminate this potential source of mortality in the Kennebec River. While the capture of shortnose and Atlantic sturgeon in nets and the subsequent transport and handling may stress the fish, this stress is not likely to be long lasting and will have no effect on the survival of the fish. Based on the documented stranding of only one shortnose sturgeon (in 2003), we expect stranding to be a rare event and anticipate that no more than one shortnose sturgeon or one Atlantic sturgeon are likely to be exposed to stress and minor injury when they are stranded at the Lockwood Project through the term of the FERC license expiration date. The implementation of a handling plan and the use of proper handling techniques will minimize the potential for major injury. No mortality is expected to occur due to the short time period fish will be caught in the pools and the implementation of proper handling techniques. We do not expect the temporary holding and relocation of a stranded sturgeon to have any impact on its ability to spawn successfully.

6.7.2 Downstream Passage

As explained above, Ticonic Falls represents the historic limit of upstream migration for sturgeon and sturgeon are not known to occur upstream of the Lockwood Dam. As such, no sturgeon are expected to occur upstream of the project, so no sturgeon will attempt to pass downstream of the project.

6.7.3 Upstream Passage

The fishway at the Lockwood project will be operational during the time of year when adult shortnose and Atlantic sturgeon are likely to be present downstream (April to July). Consistent with the Sturgeon Handling Plan, the fishways will be monitored during the time of year that sturgeon may be present and rescue procedures will be implemented to relocate any sturgeon that unexpectedly enter the fishway.

It is unlikely that individuals of either species would be seeking to migrate above the dams, and it is therefore unlikely that they will be caught in the fishways. Since 2006 when the fish lift was constructed at the Lockwood Dam, no shortnose or Atlantic sturgeon have been captured. Data on the effects of the fish lift at the Holyoke Hydroelectric Project on the Connecticut River suggests that fish lifts that successfully attract other species (i.e., shad, salmon etc.) do a poor job of attracting sturgeon without being specifically designed to improve attraction and access. As the fishway at the Lockwood Project is not designed to pass sturgeon, and no sturgeon have been detected in the fishway to date, we expect very few, if any, shortnose or Atlantic sturgeon to enter the fishway. However, we note that a small number of sturgeon have been documented at other fishways in New England where passage attempts are not anticipated (Milford Dam on the Penobscot River, Cataract Dam on the Saco River, West Springfield Dam on the Westfield River). These instances are rare. As such, it is reasonable to expect that no more than one shortnose or one Atlantic sturgeon will become entrapped in the existing or new fishway at the

Lockwood through the term of the FERC license expiration date. We anticipate that these fish would be exposed to stress and minor injury (scale loss and biological sampling) associated with handling consistent with the Sturgeon Handling Plan.

The proposed Sturgeon Handling and Protection Plan includes a condition that requires the licensee to require that all fishway operators are trained in handling sturgeon and that any sturgeon caught in the fishway or trap be removed with long handled nets and returned to the tailrace. This condition would ensure that no shortnose or Atlantic sturgeon are inadvertently passed above the dam, injured, or killed in the process of returning them below the dam.

6.7.4 Effect on Suitable Spawning Habitat

A study conducted by ERC in 2001 in preparation for the relicensing of the Lockwood project, determined that although suitable depths, temperatures and substrates exist within the Lockwood Project waters, suitable spawning area is likely limited by low water velocities, particularly in the bypassed reach. Although any spawning would occur during high spring flows, mean water column velocities within the deeper portions of the bypassed reach are relatively low (<0.5 feet/second) at both leakage and spillage flows, due to the inherent bedrock-ledge hydraulic controls that create the deep backwatered pool that occupies much of the bypassed reach. The only suitable water velocities within the project area are in the tailwaters below the project, but based upon all habitat characteristics, this reach is thought to contain only marginal spawning habitat (ERC, 2001).

There is no information that suggests that the operation of the Lockwood Dam affects the availability or suitability of spawning habitat in the action area. None of the changes at the project associated with the proposed license amendment will affect the suitability of habitat for spawning or rearing.

6.7.5 Effects of Construction of the New Fishway

As noted above, construction of the new fishway will occur within a cofferdam. The work window to construct the cofferdam is in the low flow period of July 15 to September 30 or between November 8 and April 9. If in-water construction of the cofferdam occurs between November 8 and April 9, no shortnose or Atlantic sturgeon are expected to be present in the action area. Based on the known spawning period for shortnose sturgeon, by July 15 any early life stages are likely to have moved downstream out of the action area. However, adult Atlantic sturgeon, eggs, and yolk sac larvae may still be present in the action area into August and early life stages (eggs and yolk sac larvae) may be present into August.

Given the low flow conditions during the summer work window and the location of the planned cofferdam, it is extremely unlikely that adult Atlantic sturgeon would be present in the work area. Therefore, while adult Atlantic sturgeon may be present in the action area during the summer work window, any exposure to effects of cofferdam construction are extremely unlikely to occur. The area where the cofferdam will be constructed is generally scoured bedrock ledge.

Given that eggs and yolk sac larvae are only present in areas with suitable substrate (i.e., with interstitial spaces for hiding), depths, and velocity, which are unlikely to occur in the area where the cofferdam will be constructed, it is extremely unlikely that any early life stages will be exposed to any effects of cofferdam construction. We also do not expect that the presence of the cofferdam during future spawning seasons will have any effect on the ability of sturgeon spawning and rearing to successfully occur in the action area.

As explained above, any turbidity or noise outside of the cofferdam is expected to be minor and temporary and below thresholds of concern; as such, effects to shortnose and Atlantic sturgeon, if any, will be insignificant.

6.8 Effects to Atlantic sturgeon Critical Habitat

As noted above, the action area extends approximately 2,500 feet (0.75 km) into the habitat downstream of the Lockwood Dam. The Kennebec River critical habitat unit extends from the Ticonic Falls/Lockwood Dam downstream to where the mainstem river discharges at its mouth into the Atlantic Ocean; thus, the action area overlaps with only a very small portion of the critical habitat unit.

The Kennebec River in the action area is entirely freshwater (salinity <0.5ppt); therefore, PBF 2 of Atlantic sturgeon critical habitat, or aquatic habitat with a gradual downstream salinity gradient of 0.5 up to as high as 30 ppt and soft substrate (*e.g.,* sand, mud) between the river mouth and spawning sites for juvenile foraging and physiological development, is not present in the action area. The other three PBFs are found in the action area, and we discuss effects of the proposed action on those PBFs below.

PBF 1

Hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0–0.5 ppt range) for settlement of fertilized eggs, refuge, growth, and development of early life stages

In considering effects to PBF 1, we consider whether the proposed action will have any effect on areas of hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0–0.5 ppt range) for settlement of fertilized eggs, refuge, growth, and development of early life stages. Therefore, we consider how the action may affect hard bottom substrate and salinity and how any effects may change the value of this feature in the action area. We also consider whether the action will have effects on access to this feature, temporarily or permanently.

The free-flowing Kennebec River extending from Ticonic Falls at river kilometer 103 to the head of tide at river kilometer 74 is freshwater, where salinity levels are consistent with the requirements of PBF 1. The action area is approximately 27 river kilometers upstream from the typical limit of salt water intrusion, which is in the upper Kennebec Estuary, where the Edwards Dam was located prior to its removal. Within the Kennebec River, PBF 1 occurs where there is hard bottom substrate for settlement of fertilized eggs, refuge, growth, and development of early life stages. From tagging and tracking studies, as well as the collection of shortnose sturgeon eggs and larvae, we know that Atlantic and shortnose sturgeon spawning may occur in the action area below Lockwood Dam at river kilometer 102 (Wippelhauser et al., 2015; Wippelhauser et al., 2017).

We do not have substrate maps for the action area; however, surveys of the entire Edwards Dam impoundment prior to its removal confirm the presence of hard bottom substrate meeting the criteria for PBF 1 in this reach (Stone and Webster Environmental Technology Services, 1995). Based on the limited data available to us, we have a general picture of the substrate in the action area. Habitat meeting the criteria of PBF 1 exists throughout the action area from below the Lockwood Dam (river kilometer 102) downstream as far as the Sebasticook River confluence (river kilometer 101). As discussed in section 4.4, areas directly below the Lockwood Dam consist almost entirely of bedrock and are characterized by a low-gradient back-watered pool with predominantly ledge substrate (FERC, 2005). Downstream from the east spillway section, some of the habitat is rock, cobble, or gravel. These areas with greater prevalence of interstitial spaces likely maintain the most conservation value for Atlantic sturgeon spawning and rearing of early life stages.

Construction activities and operation of the Lockwood Project will have no effect on salinity in the action area. As explained above, the area where the cofferdam will be constructed is largely scoured bedrock without interstitial spaces and therefore has little to no conservation value for Atlantic sturgeon spawning and rearing. With the exception of permanent concrete fills that will be placed over excavated areas where the fishway will be secured, the action will also not affect substrate type or result in a reduction in hard bottom habitat. To further reduce the potential for effects on substrates, Brookfield will maintain prescribed minimum flows during construction and operation of the new upstream fishway. It is possible that in certain operating conditions, flow modifications related to project operations could result in higher velocities that may result in the displacement or movement of gravel and small cobbles. However, given the persistence of sturgeon spawning below the dam throughout its operational life, any effects on substrate are likely limited in time and space and may be within natural variability related to storms and other river conditions. Based on the available information, any effects of construction activities and operation of the project consistent with the terms of the proposed amended license will be so small that they cannot be meaningfully measured, detected, or evaluated and are therefore insignificant. As such, any effects on the function and value of PBF 1 are also insignificant.

PBF 3

Water absent physical barriers to passage between the river mouth and spawning sites

In considering effects to PBF 3, we consider whether the proposed action will have any effect on water of appropriate depth and absent physical barriers to passage (e.g., locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support: unimpeded movements of adults to and from spawning sites; seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary, and; staging, resting, or holding of subadults or spawning condition adults. We also consider whether the proposed action will affect water depth or water flow, as if water is too shallow it can be a barrier to sturgeon movements, and an alteration in water velocity could similarly impact the movements of sturgeon in the river, particularly early life stages that are dependent on downstream drift. Therefore, we consider the effects of the action on water depth and water flow and whether the action results in barriers to passage that impede the movements of Atlantic sturgeon. We also consider whether the action will have effects on access to this feature, temporarily or permanently.

The operation of the Lockwood Project does not result in any barriers to Atlantic sturgeon movement as it is at the upstream limit of the species range in the river and because operations do not result in changes in water flow or water depth that would be a barrier to any Atlantic sturgeon.

Prior to installation of the new upstream fish passage facility, a cofferdam will be installed to create a dewatered work area on the east side of the Lockwood Dam spillway. The area behind the cofferdam will not be accessible to any Atlantic sturgeon for the time it is installed. However, because the downstream cofferdam will temporarily block access to only a small portion of bottom habitat and the cofferdam will be placed at the upstream limit of sturgeon access in the river, the cofferdam will not impede the movement of Atlantic sturgeon. The new fishway will result in new permanent structures in the river; however the fishway will not be a barrier to movement of Atlantic sturgeon in the action area.

Based on the assessment here, any effects of habitat alterations consistent with the terms of the SPPs may have on PBF 3's ability to provide conservation function to Atlantic sturgeon in the action area (i.e., support unimpeded movement of adults to and from spawning sites or the seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary, or impede the staging, resting, or holding of subadults or spawning condition adults) are too small to be meaningfully measured, detected, or evaluated; therefore, the effects are insignificant. As such, any effects on the function and value of PBF 3 are also insignificant.

PBF 4

Water with the temperature, salinity, and oxygen values that, combined, provide for dissolved oxygen values that support successful reproduction and recruitment and are within the temperature range that supports the habitat function

In considering effects to PBF 4, we consider whether the proposed action will have any effect on water, between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that, combined, support: spawning; annual and interannual adult, subadult, larval, and juvenile survival; and larval, juvenile, and subadult growth, development, and recruitment. Therefore, we consider the effects of the action on temperature, salinity and dissolved oxygen needs for Atlantic sturgeon spawning and recruitment. These water quality conditions are interactive and both temperature and salinity influence the dissolved oxygen saturation for a particular area. We also consider whether the action will have effects on access to this feature, temporarily or permanently and consider the effect of the action on the action area's ability to develop the feature over time.

As described above for PBF 3, discharges of water through the Lockwood Dam will remain unchanged throughout construction activities and operation of the new upstream fishway. PBF 4 is present in the action area. The construction activities and operation of the new upstream fishway consistent with the terms of the SPP, will not affect temperature, salinity, or dissolved oxygen in the action area. As such, there are no effects on PBF 4.

Summary of Effects of Proposed Activities

The continued operation of the Lockwood Project, the construction activities, and operation of the new upstream fishway consistent with the terms of the SPP will affect critical habitat below the Lockwood Dam. We have determined that effects to PBF 1 and 3 will be so small that they are not able to be meaningfully measured, detected or evaluated and are therefore insignificant. PBF 4 will not be affected by the proposed action. As such, the proposed action is not likely to adversely affect critical habitat in the action area.

7 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 C.F.R. §402.02). Future Federal actions that are not part of the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. It is important to note that the ESA definition of cumulative effects is not equivalent to the definition of "cumulative impacts" under the National Environmental Policy Act (NEPA) and therefore, consideration of cumulative effects here may not consider the same activities considered in any NEPA document prepared in association with the proposed actions.

Impacts to Atlantic salmon, Atlantic sturgeon, and shortnose sturgeon from non-federal activities are not well documented in the Kennebec River. It is possible that occasional recreational fishing for anadromous fish species may result in the illegal capture of these species. Within the action area, despite strict state and federal regulations, both juvenile and adult Atlantic salmon and adult sturgeon remain vulnerable to injury and mortality due to incidental capture by recreational anglers. Commercial fisheries for elvers (juvenile eels) and alewives may also capture Atlantic salmon, Atlantic sturgeon, and shortnose sturgeon as bycatch. No estimate of the numbers of these ESA-listed species caught incidentally in recreational or commercial fisheries exists; however, we have no information to suggest that effects would be different than what is considered in the Status of the Species and Environmental Baseline sections of this Opinion

Pollution from point and nonpoint sources has been a major problem in this river system, which continues to receive discharges from sewer treatment facilities and paper production facilities (metals, dioxin, dissolved solids, phenols, and hydrocarbons). Atlantic salmon, Atlantic sturgeon, and shortnose sturgeon are vulnerable to impacts from pollution and are likely to continue to be impacted by water quality impairments in the Kennebec River and its tributaries; however, we have no information to suggest that effects would be different than what is considered in the Status of the Species and Environmental Baseline sections of this Opinion.

Contaminants associated with the action area are directly linked to industrial development along the waterfront. PCBs, heavy metals, and waste associated with point source discharges and refineries are likely to be present in the future due to continued operation of industrial facilities. In addition, many contaminants such as PCBs remain present in the environment for prolonged periods of time and thus would not disappear even if contaminant input were to decrease. It is likely that Atlantic salmon, Atlantic sturgeon, and shortnose sturgeon will continue to be affected by contaminants in the action area in the future; however, we have no information to suggest that effects would be different than what is considered in the Status of the Species and Environmental Baseline sections of this Opinion.

Sources of contamination in the action area include atmospheric loading of pollutants, stormwater runoff from development, groundwater discharges, and industrial development. Chemical contamination may have an effect on listed species reproduction and survival. As noted above, impacts to listed species from all of these activities are largely unknown. However, we have no information to suggest that the effects of future activities in the action area will be any different from effects of activities that have occurred in the past.

8 Integration and Synthesis of Effects

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to species as a result of implementing the proposed actions. In this section, we add the *Effects of the Action* to the *Environmental Baseline* and the *Cumulative Effects*, while also considering effects in context of climate change, to formulate the agency's biological opinion as to whether the proposed actions are likely to appreciably reduce the likelihood of both the survival and recovery of any ESA-listed species in the wild by reducing its numbers, reproduction, or distribution. The purpose of this analysis is to determine whether the action, in the context established by the status of the species, environmental baseline, and cumulative effects, is likely to jeopardize the continued existence of the Gulf of Maine DPS of Atlantic salmon, the Gulf of Maine DPS of Atlantic sturgeon, or shortnose sturgeon. We also consider whether the proposed action is likely to result in the destruction or adverse modification of critical habitat designated for the Gulf of Maine DPs of Atlantic salmon and the Gulf of Maine DPS of Atlantic sturgeon.

Below, for the listed species that may be affected by the action, we summarize the status of the species and consider whether the action will result in reductions in reproduction, numbers or distribution of these species and then consider whether any reductions in reproduction, numbers or distribution resulting from the action would reduce appreciably the likelihood of both the survival and recovery of these species, as those terms are defined for purposes of the federal Endangered Species Act. In making those assessments we consider the effects of the action in the context of the Status of the Species, Environmental Baseline, Cumulative Effects, and climate change.

In the NMFS/USFWS Section 7 Handbook, for the purposes of determining jeopardy, survival is defined as, "the species' persistence as listed or as a recovery unit, beyond the conditions leading to its endangerment, with sufficient resilience to allow for the potential recovery from endangerment. Said in another way, survival is the condition in which a species continues to exist into the future while retaining the potential for recovery. This condition is characterized by a species with a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, which exists in an environment providing all requirements for completion of the species' entire life cycle, including reproduction, sustenance, and shelter." Recovery is defined as, "Improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in section 4(a)(1) of the Act."

8.1 Shortnose sturgeon

Based on the number of adults in populations for which estimates are available, there are at least 104,662 adult shortnose sturgeon, including 18,000 in the Saint John River in Canada. The lack of information on the status of some populations, such as that in the Chesapeake Bay, adds uncertainty to any determination on the status of this species as a whole. Based on the best available information, NMFS considers that the status of shortnose sturgeon throughout their range is stable (SNSSRT, 2010). The Schnabel estimate from 1998-2000 is the most recent population estimate for the Kennebec River System shortnose sturgeon population; however, it does not include an estimate of the size of the juvenile population. A comparison of the population estimate for the estuarine complex from 1981 (Squiers et al., 1982) to 2000 (MDMR, 2003) suggests that the adult population grew by approximately 30% between 1981 and 2000. In 1999, the removal of the Edwards Dam on the mainstem of the Kennebec River opened up an additional 29 rkm of habitat, restoring access to the presumed historical spawning habitat. Use of this area has been documented and is considered to have possibly facilitated even further recruitment into this river (Wippelhauser et al., 2015). Tagging and tracking studies indicate that some Kennebec River fish migrate to the Penobscot River but return to the Kennebec River to spawn. It is hypothesized that this may be a result of increased competition for estuarine foraging resources in the Kennebec River due to increased population size (Altenritter et al., 2018). It is currently unknown if the Kennebec River population of shortnose sturgeon is continuing to increase; however, there are no indications that it has decreased from the 1998-2000 population estimate. As such, we consider the population to at least be stable.

Shortnose sturgeon only occur in the portion of the action area downstream of the Lockwood Dam. Adults are present in the spring during spawning and eggs and larvae may also be present in portions of the action area with suitable substrate, depths, and flow. We have determined that shortnose sturgeon may occasionally be stranded in pools below the dam and require rescue and on rare instances may enter the fishway and require removal. We have determined that all effects of the construction of the new Lockwood fishway will be insignificant or extremely unlikely to occur. No injury or mortality of any shortnose sturgeon is anticipated as a result of any of the actions considered here.

No effects to shortnose sturgeon will occur from future operations of the Hydro-Kennebec, Shawmut, and Weston Projects as the effects of those projects do not extend into the portion of the action area where shortnose sturgeon occur. As the Lockwood Project is located at the upstream extent of the historical range of shortnose sturgeon, it is not considered a barrier to upstream migration. We have determined that operations (i.e., the lack of peaking or pulsed flows) of the Lockwood Project that any effects on spawning and rearing downstream of the project will be insignificant. We have determined that the proposed action will affect shortnose sturgeon by resulting in the capture of one adult in the fishway at the Lockwood Project. Additionally, the stranding of one shortnose sturgeon is expected in pools downstream of the Lockwood spillway during the replacement or maintenance of flashboards. Over the terms of the existing license, therefore, it is anticipated that two shortnose sturgeon (one trapped in the fishway, one stranded in downstream pools) would be captured, collected, and handled at the project. The licensee will adhere to the Sturgeon Handling and Protection Plan to ensure that any shortnose sturgeon captured in the fishways, or in isolated pools, are removed promptly and returned safely downstream. It is possible that some captured shortnose sturgeon could experience minor injuries, such as abrasions, due to contact with the concrete surface of the fish lift. Shortnose sturgeon captured or stranded will be temporarily delayed from carrying out spawning activities. However, given that regular monitoring will occur during the spawning season the amount of time that any shortnose sturgeon would spend in the fishways, or in an isolated pool, is short and certainly less than 24 hours. As such, it is extremely unlikely that the fish would miss a spawning opportunity. Similarly, it is unlikely that the temporary capture in the fishways, or in the pools, and subsequent removal and placement back downstream would cause an individual shortnose sturgeon to abandon their spawning attempt. Considering this analysis, the capture of two shortnose sturgeon is not likely to result in any serious injury or mortality or affect the fitness of any individuals, or cause any reduction in the number of eggs spawned or in the successful development of those eggs and larvae. During the construction period for the new fishway, a small (1.7 acres) area of bedrock will be behind the cofferdam and not available for use by shortnose sturgeon. However, given that spawning and rearing is not expected to take place in this area, any effects of the lack of access to this habitat are extremely unlikely to occur. Similarly, we have concluded that any other effects of construction on any life stage of shortnose sturgeon are insignificant or extremely unlikely to occur.

The proposed action is not likely to reduce reproduction of shortnose sturgeon in the action area because: (1) there will be no reduction in the number of spawning adults; (2) there will be no reduction in fitness of spawning adults; (3) there is not anticipated to be any reduction in the number of eggs spawned or the fitness of any eggs or larvae. The action is also not likely to reduce the numbers of shortnose sturgeon in the action area as there will be no mortality of any individuals and no reason shortnose sturgeon would abandon the action area during the spawning season. The distribution of shortnose sturgeon within the action area will not be affected by the action.

Based on the information provided above, the non-lethal collection of two shortnose sturgeon will not appreciably reduce the likelihood of survival for shortnose sturgeon in the wild (i.e., it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect shortnose sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring and it will not result in effects to the environment which would prevent shortnose sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: 1) there will be no mortalities and therefore no loss of any age class; 2) because there will be no mortalities there will be no change in the status or trends of the Kennebec River population or the species as a whole; 3) there will be no effect on reproductive output or the levels of genetic heterogeneity in the population; 4) the temporary adverse effects to individuals captured in the fish lifts will not affect the reproductive output of any individual or the species as a whole; 5) the action will not affect the reproductive fitness of any individual spawning adult or result in any reductions in the number of eggs spawned or the successful development of any eggs or larvae; 6) the operations of the project will not affect the ability of shortnose sturgeon to successfully spawn or for eggs and larvae to successfully develop; 7)the continued operation of the dam will have only a minor and temporary effect on the distribution of no more than two shortnose sturgeon in the action area (limited to only the temporary holding of these individuals) and no effect on the distribution of the species throughout its range; and, (8) the continued operation of the dam will have no effect on the ability of shortnose sturgeon to shelter and no effect on individual foraging shortnose sturgeon.

In rare instances an action that does not appreciably reduce the likelihood of a species survival might appreciably reduce its likelihood of recovery. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that shortnose sturgeon will survive in the wild, which includes consideration of recovery potential. Here, we consider whether the action will appreciably reduce the likelihood of recovery from the perspective of

ESA section 4. As noted above, recovery is defined as the improvement in status such that listing under Section 4(a) as "in danger of extinction throughout all or a significant portion of its range" (endangered) or "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range…" (threatened) is no longer appropriate. Thus, we have considered whether the proposed action will appreciably reduce the likelihood that shortnose sturgeon can rebuild to a point where they are no longer in danger of extinction through all or a significant part of its range.

A Recovery Plan for shortnose sturgeon was published in 1998 pursuant to Section 4(f) of the ESA. The Recovery Plan outlines the steps necessary for recovery and indicates that each population may be a candidate for downlisting (i.e., to threatened) when it reaches a minimum population size that is large enough to prevent extinction and will make the loss of genetic diversity unlikely. However, the plan states that the minimum population size for each population has not yet been determined. The Recovery Outline contains three major tasks, 1) establish delisting criteria; 2) protect shortnose sturgeon populations and habitats; and, 3) rehabilitate habitats and population segments. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting, and migrations of all individuals. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether the operation of the dam will affect the Kennebec River population of shortnose sturgeon in a way that would affect the species' likelihood of recovery.

The proposed action is not expected to modify, curtail or destroy the range of the species since it will not result in any reductions in the number of shortnose sturgeon in the action area and since it will not affect the overall distribution of shortnose sturgeon other than to cause temporary changes in movements throughout the action area. The proposed action will not limit the amount of suitable habitat for foraging, resting, spawning, migration, or for the development of early life stages. As the Lockwood Dam is the historical limit of sturgeon in the Kennebec River, habitat connectivity will not be affected and individuals will continue to migrate between habitats downstream of the dam. The proposed action will not lead to any mortality of shortnose sturgeon, and therefore will allow for recruitment to all age classes so spawning can continue over time. The effects of the proposed action will not hasten the extinction timeline or otherwise increase the danger of extinction; further, the action will not prevent the species from growing in a way that leads to recovery and the action will not change the rate at which recovery can occur. Therefore, the proposed action will not appreciably reduce the likelihood that shortnose sturgeon can be brought to the point at which they are no longer listed as endangered or threatened.

Despite the threats faced by individual shortnose sturgeon inside and outside of the action area, the proposed action will not increase the vulnerability of individual shortnose sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed action. While we are not able to predict with precision how climate change will impact shortnose sturgeon in the action area or how the species will adapt to climate change-related environmental impacts, no additional effects related to climate change to shortnose sturgeon in the action area are anticipated over the life of the proposed action (i.e., through the license period of the individual projects). We have considered the effects of the proposed action in light of cumulative effects explained above, including climate change, and have concluded that even in light of the ongoing impacts of these activities and conditions, the conclusions reached above do not change.

8.2 Gulf of Maine DPS of Atlantic sturgeon

As described in the 2022 5-Year Review, the status of the Gulf of Maine DPS has likely neither improved nor declined from what it was when we listed the DPS in 2012. The Kennebec River remains the only known spawning population for the Gulf of Maine DPS despite the availability of suitable spawning and rearing habitat in other Gulf of Maine rivers. The estimated effective population size is less than 70 adults which suggests a relatively small spawning population and it is currently the only DPS with only one known spawning population. The Gulf of Maine DPS has low abundance and the current numbers of spawning adults are considered to be one to two orders of magnitude smaller than historical levels. Gulf of Maine DPS Atlantic sturgeon are still captured and killed as a result of fishery interactions, vessel strikes, and dredging but, to a lesser degree than for the other DPSs. Capture of Atlantic sturgeon in fishing gear continues to occur in other areas of the DPSs range but appears to be less prevalent in Gulf of Maine waters where sturgeon belonging to the DPS are most likely to occur. The ASMFC's 2017 Stock Assessment, concludes there is a 51 percent probability that abundance of the Gulf of Maine DPS has increased since implementation of the 1998 fishing moratorium but also a relatively high likelihood (74 percent probability) that mortality for the Gulf of Maine DPS exceeds the mortality threshold used for the Stock Assessment (ASMFC 2017a). The Stock Assessment Peer Review Report described that it was not clear if: (1) the percent probability for the trend in abundance was a reflection of the actual trend in abundance or of the underlying data quality for the DPS; and, (2) the percent probability that the Gulf of Maine DPS exceeds the mortality threshold actually reflects lower survival or was due to increased tagging model uncertainty owing to low sample sizes and potential emigration.

Atlantic sturgeon only occur in the portion of the action area downstream of the Lockwood Dam. Future operations of the Hydro-Kennebec, Shawmut, and Weston Projects will not result in any effects to Atlantic sturgeon as they are located upstream of the historic range of Atlantic sturgeon in the Kennebec River, and no Atlantic sturgeon will be exposed to effects of project operations. The Lockwood Project is located at the upstream extent of the historic range of Atlantic sturgeon and, therefore, is not considered a barrier to upstream migration. Atlantic sturgeon are known to utilize habitat downstream of the project, including for spawning. As explained in the Effects of the Action section, we do not expect that operation of Lockwood will affect the ability of Atlantic sturgeon to spawn successfully in the action area or that the operation of the project will affect the successful development of early life stages that may be present downstream of the dam. Further, we have determined that effects of construction of the new fishway will be insignificant or extremely unlikely to occur.

As explained in the “Effects of the Action” section, the operation of fishways at the Lockwood Project and the lowering of water levels during flashboard maintenance is expected to result in the stranding of no more than one adult Atlantic sturgeon. We also expect that no more than one adult Atlantic sturgeon will become trapped in the fishway over the same timeframe. As explained above, we expect all adult Atlantic sturgeon in the action area to originate from the Gulf of Maine DPS.

The licensee will adhere to the Sturgeon Handling and Protection Plan to ensure that any Atlantic sturgeon captured in the fishways, or in isolated pools, are removed promptly and returned safely downstream. It is possible that captured Atlantic sturgeon could experience minor injuries, such as abrasions, due to contact with the concrete surface of the fish lift. Atlantic sturgeon captured in the fishways will be temporarily delayed from carrying out spawning activities. However, given that regular monitoring will occur during the spawning season the amount of time that any Atlantic sturgeon would spend in the fishways, or in an isolated pool, is short and certainly less than 24 hours. As such, it is extremely unlikely that the fish would miss a spawning opportunity. Similarly, it is unlikely that the temporary capture in the fishway, or in the pools, and subsequent removal and placement back downstream would cause an individual Atlantic sturgeon to abandon their spawning attempt. Considering this analysis, the capture of two Atlantic sturgeon, is not likely to result in any serious injury or mortality or affect the fitness of any individuals, or cause any reduction in the number of eggs spawned or in the successful development of those eggs and larvae.

The proposed action is not likely to reduce reproduction of the GOM DPS of Atlantic sturgeon in the action area because: 1) there will be no reduction in the number of spawning adults; 2) there will be no reduction in fitness of spawning adults; and 3) there is not anticipated to be any reduction in the number of eggs spawned or the fitness of any eggs or larvae. The action is also not likely to reduce the numbers of Atlantic sturgeon in the action area as there will be no mortality of any individuals and no effect on spawning. The distribution of the GOM DPS of Atlantic sturgeon within the action area will not be affected by the action.

Based on the information provided above, the proposed action will not appreciably reduce the likelihood of survival for the GOM DPS of Atlantic sturgeon in the wild (i.e., it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring and it will not result in effects to the environment that would prevent Atlantic sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: 1) there will be no mortalities of any Atlantic sturgeon and therefore no impact on the strength of any age class; 2) there will be no effect on reproductive output or the levels of genetic heterogeneity in the population; 3) the temporary adverse effects to individuals captured in the fish lifts will not affect the reproductive output of any individual or the species as a whole; 4) the action will not affect the reproductive fitness of any individual spawning adult or result in any reductions in the number of eggs spawned or the successful development of any eggs or larvae; 5) the operations of the project will not affect the ability of Atlantic sturgeon to successfully spawn or for eggs and larvae to successfully develop; 6)the continued operation of the dam will have only a minor and temporary effect on the distribution of no more than two Atlantic sturgeon in the action area (limited to only the temporary holding of these individuals) and no effect on the distribution of the species throughout its range; and, 7) the continued operation of the dam will have no effect on the ability of Atlantic sturgeon to shelter and no effect on individual foraging Atlantic sturgeon.

In rare instances, an action that does not appreciably reduce the likelihood of a species' survival might appreciably reduce its likelihood of recovery. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that the Gulf of Maine DPS of Atlantic sturgeon will survive in the wild, which includes consideration of recovery potential. Here, we consider whether the action will appreciably reduce the likelihood of recovery from the perspective of ESA Section 4. As noted above, recovery is defined as the improvement in status such that listing under Section 4(a) as "in danger of extinction throughout all or a significant portion of its range" (endangered) or "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range…" (threatened) is no longer appropriate. Thus, we have considered whether the proposed action will appreciably reduce the likelihood that Gulf of Maine DPS Atlantic sturgeon can rebuild to a point where the Gulf of Maine DPS of Atlantic sturgeon is no longer likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

No Recovery Plan for the Gulf of Maine DPS has been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. In January 2018, we published a Recovery Outline for the five DPSs of Atlantic sturgeon (NMFS, 2018).[65] This outline is meant to serve as an interim guidance document to direct recovery efforts, including recovery planning, until a full recovery plan is developed and approved. The outline provides a preliminary strategy for recovery of the species. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates

[65] Available online at: https://media.fisheries.noaa.gov/dam-migration/ats_recovery_outline.pdf; last accessed Sept. 17, 2021

must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. For Gulf of Maine DPS Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. As described in the vision statement in the Recovery Outline, subpopulations of all five Atlantic sturgeon DPSs must be present across the historical range. These subpopulations must be of sufficient size and genetic diversity to support successful reproduction and recovery from mortality events. The recruitment of juveniles to the sub-adult and adult life stages must also increase and that increased recruitment must be maintained over many years. Recovery of these DPSs will require conservation of the riverine and marine habitats used for spawning, development, foraging, and growth by abating threats to ensure a high probability of survival into the future. Here, we consider whether this proposed action will affect the Gulf of Maine DPS likelihood of recovery.

This action will not change the status or trend of the Gulf of Maine DPS. The proposed action will not affect the distribution of Atlantic sturgeon across the historical range. The proposed action will not result in any mortality or reproductive output. Therefore, it will not affect abundance in a way that would impair resiliency or genetic diversity. The proposed action will have only insignificant effects on habitat and will not impact habitat in a way that makes additional growth of the population less likely, that is, it will not reduce the habitat's carrying capacity. The proposed action will not result in any loss of habitat. For these reasons, the action will not reduce the likelihood that the Gulf of Maine DPS can recover. Therefore, the proposed action will not appreciably reduce the likelihood that the Gulf of Maine DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as threatened. Based on the analysis presented herein, the proposed action is not likely to appreciably reduce the survival and recovery of this species.

8.2.1 Critical Habitat Designated for the Gulf of Maine DPS of Atlantic Sturgeon

As explained in section 6.8, we have determined that all effects of the continued operation of the Lockwood Project on PBFs 1 and 3 are insignificant; and that there will be no effect to PBF 4. PBF 2 does not occur in the action area. Based on this, all effects to the Kennebec River unit will be insignificant or extremely unlikely to occur. Therefore, the proposed actions considered here are not likely to adversely affect critical habitat in the action area or critical habitat designated for the Gulf of Maine DPS of Atlantic sturgeon. Because the proposed actions are not likely to adversely affect the critical habitat designated for the Gulf of Maine DPS, they will, by definition, not result in the destruction or adverse modification of that habitat.

8.3 Gulf of Maine DPS of Atlantic salmon

The GOM DPS of Atlantic salmon currently exhibits critically low spawner abundance, poor marine survival, and is confronted with a variety of additional threats. The abundance of GOM DPS Atlantic salmon has been low and either stable or declining over the past several decades. The proportion of fish that are of natural origin is extremely low. The conservation hatchery program assists in slowing the decline and helps stabilize populations at low levels, but has not contributed to an increase in the overall abundance of salmon and has not been able to halt the decline of the naturally reared component of the GOM DPS.

The operation of the Weston, Hydro-Kennebec, and Lockwood Projects pursuant to amended licenses that incorporate the proposed measures will lead to an improvement in passage for Atlantic salmon as compared to current operations. We expect that licensing the Shawmut Project for a 50 year period will result in continued adverse effects to Atlantic salmon associated with the continued presence of the structure in the river, when compared to a free-flowing river condition that would exist if there were no dams. However, we expect implementation of the proposed, recommended, and mandatory license terms at Shawmut will reduce effects to Atlantic salmon compared to current operational and structural conditions. While we expect an overall improvement compared to current conditions, the projects will continue to result in adverse effects to Atlantic salmon and designated critical habitat. The project will continue to affect upstream and downstream passage of Atlantic salmon, result in the injury and death of individuals, and have a negative impact on salmon habitat. In the discussion below, we consider whether the effects of the proposed actions reasonably would be expected, directly or indirectly, to appreciably reduce the likelihood of both the survival and recovery of the listed species in the wild by reducing the reproduction, numbers, or distribution of the GOM DPS of Atlantic salmon. We also determine whether the proposed action is likely to destroy or adversely modify designated critical habitat for the GOM DPS of Atlantic salmon.

As explained above the duration of the proposed license amendments at Lockwood, Hydro-Kennebec, and Weston are shorter than the proposed new license term for Shawmut; this is because the term of the license amendments extends only through the life of the projects' current licenses. Relicensing of those projects would be a federal action that requires section 7 consultation. As such, should FERC propose to issue new licenses for any of those projects, we anticipate that separate Biological Opinions will be developed to consider the effects of the Weston, Hydro-Kennebec, and/or Lockwood Projects beyond the expiration of the proposed license amendments we have considered here. Those Opinions will consider the effects of the issuance of new licenses at those projects. However, as we cannot anticipate how the projects will operate under their new licenses, in this analysis we assume that the effects of the amended licenses will persist until the expiration of the new Shawmut license, which may last for up to 50 years.

8.3.1 Summary of Upstream Passage Effects

It is possible that the proposed fishways will achieve the cumulative passage performance targets immediately upon implementation. However, if this does not occur, we have determined that it will take no longer than 10 years to meet the performance targets. As explained above, this timeline considers the time necessary to test proposed facilities, implement any additional operational or structural measures, pursuant to adaptive management, and then re-test those facilities to verify adherence to the standards. We expect that during the 10-year interim phase, 67% of prespawn adults will successfully pass all four dams, but will be harassed due to the effects of trap and truck. Approximately 33% of salmon will fail to be captured in the Lockwood fish trap, and will be harassed as they will need to locate alternative spawning and rearing habitat, or else leave the Kennebec without spawning. A small proportion of those (0.3%) may die as a result of forced straying. Of the fish that successfully pass the project, 65% will be significantly delayed (>192 hours), and therefore will be harassed (55%) or harmed (10%) due to the energetic effects of delay. After the measures have been fully implemented and evaluated (by the end of year 10), we expect that the performance standards will have been achieved such that approximately 85% of adult salmon will successfully pass upstream of all four dams in less than 192 hours. The 15% that fail to pass all four dams will be harassed, but are expected to be able to access newly available spawning and rearing habitat in the tributaries. A small proportion of those fish (0.5% total) may die as a result of straying.

8.3.2 Summary of Downstream Passage Effects

Naturally reared prespawn Atlantic salmon are trucked to spawning habitat in the Sandy River every year. Additionally, MDMR has stocked nearly eight million eggs in the Sandy over the last decade (USASAC 2021). Given the average number of eggs stocked and the average survival, we would anticipate that an average of approximately 10,000 smolts (range 4,000 to 18,000) are produced by stocking in the Sandy River annually. This is consistent with estimates (13,229 +/- 1,294) based on rotary screw trapping in the Sandy River in 2021 (USASAC, 2022). During the 3 year interim phase, we have estimated that the baseline level of mortality will be reduced due to the implementation of turbine shutdowns and spill prioritization. Therefore, for this three year period, we expect that 40% of Atlantic salmon smolts will be killed annually due to the direct and indirect effects of passage at the Weston, Shawmut, Hydro-Kennebec, and Lockwood dams. We expect that the full implementation of the proposed downstream measures will lead to an improvement in cumulative smolt survival, such that only 16% of smolts will be killed due to the direct and indirect effects of dam passage. When the impoundment effects from the Hydro-Kennebec Project, which are part of the environmental baseline, are incorporated we estimate mortality rates of 18%.

Atlantic salmon kelts migrate downstream in the fall after spawning, or in the spring after overwintering in freshwater. They are exposed to the same challenges associated with dam passage as smolts but, due to their greater length, are more likely to be struck by a turbine blade if they pass through the turbines (Alden Research Laboratory, 2012). We anticipate some proportion of kelts will be entrained in the turbines during the interim phase as the current rack spacing at these projects is not narrow enough to exclude them. However, after narrow spaced racks are installed at all four projects kelt entrainment will be eliminated, which will contribute to a cumulative increase in survival through the river. We have estimated that baseline kelt survival through the four projects is approximately 65%. The proposed action (i.e., the installation of narrow spaced racks at all four projects, improvements at non-turbine routes) will improve cumulative kelt survival to 89%.

8.3.3 Jeopardy Analysis

Jeopardy is defined as "an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Therefore, to determine if the proposed action will jeopardize the GOM DPS of Atlantic salmon, we conduct an analysis of the effects of the proposed actions on the likelihood of the species' survival and recovery.

The 2019 Recovery Plan projects four phases of recovery over a 75-year timeframe to achieve delisting of the GOM DPS of Atlantic salmon. The four phases of recovery are:

> Phase 1: The first recovery phase focuses on identifying the threats to the species and characterizing the habitat needs of the species necessary for their recovery.
>
> Phase 2: The second recovery phase focuses on ensuring the persistence (survival) of the GOM DPS through the use of the conservation hatcheries while abating imminent threats to the continued existence of the DPS. Phase 2 focuses on freshwater habitat used by Atlantic salmon for spawning, rearing, and upstream and downstream migration; it also emphasizes research on threats within the marine environment.
>
> Phase 3: The third phase of recovery will focus on increasing the abundance, distribution, and productivity of naturally reared Atlantic salmon. It will involve transitioning from dependence on the conservation hatcheries to wild smolt production.
>
> Phase 4: In Phase 4, the GOM DPS of Atlantic salmon is recovered and delisting occurs. The GOM DPS will be considered recovered once: a) 2,000 wild adults return to each SHRU, for a DPS-wide total of at least 6,000 wild adults; b) each SHRU has a population growth rate of greater than 1.0[66] in the 10-year period preceding delisting, and, at the time of delisting, the DPS demonstrates self-sustaining persistence; and c) sufficient suitable spawning and rearing habitat for the offspring of the 6,000 wild adults is accessible and distributed throughout the designated Atlantic salmon critical habitat, with at least 30,000 accessible and suitable HUs in each SHRU, located according to the known migratory patterns of returning wild adult salmon.

[66] We use the 10 year mean geometric growth rate to estimate population growth. With this metric, a value of greater than 1.0 indicates a growing population, whereas a value of less than 1.0 indicates a declining population.

The jeopardy analysis considers the effects of the proposed actions on the survival and recovery of the GOM DPS of Atlantic salmon as a whole, and not just survival and recovery of the species in the action area. Therefore, in the survival and recovery portions of this analysis, we consider how the effects to individual salmon that were identified in the *Effects of the Action* section of this Opinion will affect the Kennebec River population of Atlantic salmon, how the effects to the Kennebec River population will affect the Merrymeeting Bay SHRU, and then finally, how the effects to the Merrymeeting Bay SHRU are likely to affect the survival and recovery of the GOM DPS as a whole. As highlighted in the 2019 Recovery Plan, the survival and recovery of the Merrymeeting Bay SHRU is necessary for attainment of the downlisting and delisting criteria and recovery of the GOM DPS.

8.3.4 Survival Analysis

The first step in conducting the jeopardy analysis is to assess the effects of the proposed actions on the survival of the species. Survival is defined as the condition in which a species continues to exist into the future while retaining the potential for recovery. This condition is characterized by a species with a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, which exists in an environment providing all requirements for completion of the species' entire life cycle, including reproduction, sustenance, and shelter (USFWS and NMFS, 1998).

We are presently in Phase 2 of our recovery program, in which we work to ensure the survival of the GOM DPS through the use of the conservation hatcheries while abating imminent threats to the continued existence of the DPS. The focus of phase 2 is addressing the threats to salmon survival and recovery identified in the 2019 Recovery Plan (e.g., dams, climate change, marine survival, genetic diversity). As indicated in the 2019 Recovery Plan for Atlantic salmon, the Services do not have plans to transition from dependence on conservation hatcheries to wild fish production in the foreseeable future. Therefore, for purposes of our survival analysis, we assume hatchery supplementation will continue in the Merrymeeting Bay SHRU over the 50 year time horizon considered in this analysis. The hatchery program, sponsored by the U.S. Fish and Wildlife Service, has been in place for over 100 years and because we do not have any information to the contrary, we expect it will continue over the duration of the proposed action.

When considering how a proposed action is likely to affect the survival of a species, we consider effects to reproduction, numbers and distribution. The number of returning adult Atlantic salmon to the Merrymeeting Bay SHRU is a measure of both the reproduction and numbers of the species. We consider the ability of prespawn Atlantic salmon to access high quality spawning and rearing habitat in all the rivers of the Merrymeeting Bay SHRUs as a measure of distribution. Below, we analyze whether the proposed action (FERC issuance of license amendments and a new license for Shawmut) will reduce the reproduction, numbers, or distribution of the Atlantic salmon in the action area and the Merrymeeting Bay SHRU to a point that appreciably reduces the species likelihood of survival in the wild.

Interim Phase (Year 1 to Year 10)

The Interim Phase includes the period of time between the issuance of the amended and new licenses and the design, construction, and evaluation of the downstream and upstream measures that will allow for the achievement of the proposed passage and survival standards. This phase includes:

- Year 1 to Year 3 - During this period the structural downstream measures will be constructed, and turbine shutdowns and spill prioritization will be implemented as proposed at the four projects. Upstream fishways will also be constructed as proposed during this period.
- Year 4 to Year 10 - The downstream measures will be fully implemented throughout this period, and our analysis indicates that the proposed cumulative performance standards will likely be achieved. If they have not been, then additional measures will be implemented and evaluated. During this period, upstream passage effectiveness of the new fishways will also be evaluated. If the measures do not result in achieving the identified standards, additional adaptive management measures will be constructed and implemented. This phase is long enough to allow for the design, construction, and evaluation of a second round of measures[67]. Given the anticipated measures available for remedying poor upstream passage (including additional fishway entrances or additional fishways) that are available through the adaptive management framework, we expect this phased adaptive approach will be sufficient to achieve the cumulative upstream performance standards. As we do not expect that salmon will be passed into the Lockwood headpond until the upstream standards have been achieved, we anticipate that during this phase passage will continue via the trap and truck facility at the project.

Implementation Phase (Year 11 to Year 50)

The Implementation Phase includes the period of time from when the cumulative survival, passage, and delay performance standards are achieved to the expiration of the Shawmut license. As we do not have any information to indicate what the conditions will be at Lockwood, Hydro-Kennebec, and Weston after the expiration of the proposed amendments, we will assume for this analysis that if new licenses are issued for these projects, they will be at least as protective as the amended licenses.

Under existing natural production and stocking levels, the Kennebec River contributes significantly to the production of Atlantic salmon in the Merrymeeting Bay SHRU. Over the last decade, the number of prespawn Atlantic salmon returning to all rivers in the Merrymeeting Bay SHRU ranged between 18 and 87 annually; with an average of 45 returned individual salmon (derived from data in USASAC 2021). The Kennebec River contributes 29 individual salmon on average (USASAC, 2022), approximately two-thirds of Merrymeeting Bay SHRU returns over

[67] Each round would take approximately five years (i.e., two years for design and construction, up to three years for evaluation) to complete.

the last decade. We have estimated (based on the estimated efficiency at the Lockwood trap) that on average an additional 14 fish a year could return the Kennebec that are not captured at the trap, which would increase the proportion of returns to the SHRU attributable to the Kennebec.

To assess the overall effect of the proposed action on Atlantic salmon survival we will consider how it affects the abundance (and therefore reproduction) of adult prespawn salmon returning to the Kennebec River. For simplicity, the analysis focuses on the number of returns to the Sandy River, which is appropriate as the majority of stocking and natural reproduction in the Kennebec River watershed occurs within the Sandy River. In addition, as described in section 4, the majority of the high quality salmon rearing and spawning habitat in the Kennebec River (as well as the Merrymeeting Bay SHRU) exists within that tributary. However, as described in the Environmental Baseline, some spawning and rearing habitat occurs downstream of, and likely in between, the four dams (MDMR, 2017; MASRSC, 1986; NRC, 2004), and that salmon that return to the river but are deterred from accessing the Sandy due to passage inefficiencies will be able to access that habitat. A basic model can help predict the effect that the proposed modifications at the Weston, Shawmut, Hydro-Kennebec, and Lockwood Projects will have on the number of returning Atlantic salmon to the Kennebec River and the Sandy River. The conditions we consider are: 1) *Interim Phase* (year 1 to 10) - the effects that occur prior to the achievement of all performance standards. This phase includes the three year downstream phase (year one to three), as well as the 10 year upstream phase (year 1 to 10), for a total period not to exceed 10 years and 2) *Implementation Phase* (year 11 to 50) - effects anticipated after the measures necessary to achieve the identified downstream survival and delay and upstream passage and delay standards have been met. During this period we anticipate that at a minimum the fishways will have achieved the cumulative upstream and downstream performance standards[68].

If we assume that a free flowing (no dams) Kennebec River would allow for the maximum number of returning prespawn salmon given current freshwater and marine survival rates, we can estimate the extent to which passage modifications at the four projects would reduce the effect that the dams have on the salmon run in the Kennebec River. This model considers the proportion of smolts lost due to the direct and indirect effects of passing downstream through the four dams (as described in sections 4 and 6). For upstream passage, the interim phase considers that salmon are trapped at Lockwood under its existing average efficiency rate (67%) as we anticipate trap and truck operations will continue until the new upstream fishways have achieved their performance standards. In the implementation phase, however, we assume upstream passage will occur at all four dams due to the construction of upstream fishways that achieve the cumulative passage standard (85%=96%^4 dams). Freshwater (99.7% per km; Stevens et al.

[68] Our analysis indicates that the downstream cumulative performance standard would likely be achieved during the first three years of the interim phase, but that the upstream standard may take up to ten years to be achieved. In the implementation phase we assume that both standards have been met.

2019)[69] and marine (0.54%; USASAC 2022)[70] survival rates are also incorporated into this analysis; however, as these survival factors are constant in both phases, they do not affect the proportional results. In this analysis (Table 43), the interim phase includes both the period before (year 1-3) and after (year 4-10) the implementation of all downstream measures. We assume the effects of the proposed downstream operational measures (i.e., turbine shutdowns, spill prioritization) will begin in year 1.

Table 43. A conceptual model to demonstrate how the effects of the four dams could reduce the potential run in the Kennebec River under different conditions. The number of smolts leaving the Sandy River in the model is what is conceptually needed to have a return of 100 adults to the Sandy assuming average freshwater and marine survival rates. It is used for illustrative purposes only, as the proportional difference would be the same regardless of the number of smolts used.

	Free flowing	Baseline	Interim		Implementation Phase
			Year 1-3	Year 4-10	
Outmigrating Smolts					
Leave Sandy River	30400	30400	30400	30400	30400
Survive Passing Dams	30400	15626	17632	24776	24776
Survive Other Freshwater Threats	18516	9517	10739	15090	15090
Feed in Ocean for Two Years before Returning to the River					
Prespawn Adults					
Return to the Kennebec	100	51	58	81	81
Return to the Sandy	100	34	39	55	69
% of Free-flowing	100%	34%	39%	55%	69%

Using this simple model, we estimate that during the latter part of the interim phase, as well as the implementation phase, Atlantic salmon will return to the Kennebec downstream of Lockwood at 81% of what might be expected if the river was free flowing. This represents a substantial increase over what is anticipated under the baseline condition, where only 51% of the free-flowing run returns to the river. This increase in returns is attributable to the effects of downstream passage improvements. In order to determine the proportion that would be able to access the Sandy River, the effects of upstream passage (just Lockwood during the interim phase) need to be incorporated. As such, during year 4-10 of the interim phase we anticipate that the dam effects will lead to a run of returning salmon to the Sandy that is 55% of what might be expected if the lower Kennebec River were free flowing. However, after the upstream performance standards have been achieved (year 11 to the expiration of the new Shawmut license) we would anticipate that the run to the Sandy would increase to 69% of what might have been observed if the Kennebec was free flowing. This constitutes a doubling of the proportion

[69] Extrapolating this rate, which is consistent with free-flowing reaches in the Kennebec, over the 150-km reach from the Sandy River to the Chops equates to a total in-river survival rate of 61%, not including dam mortality.
[70] 10-year average smolt to adult return rate on the Sheepscot River (USASAC, 2022), which was chosen due to its proximity to the Kennebec and as the smolts are naturally-reared rather than hatchery-reared.

that is expected under baseline conditions. As indicated, although the run to the Sandy is limited by upstream passage inefficiencies, a higher proportion (81% of free flowing) of salmon would be expected to return to the Kennebec downstream of the Lockwood Dam. The model also indicates that 15% of the returns (i.e., 1- (0.96^4 dams)) would fail to pass upstream of all four dams. Although they would be prevented from accessing the Sandy River, most of these fish are expected to migrate to tributaries downstream of Lockwood, or between Lockwood and Weston, to seek alternative spawning habitat. Based on the results of the upstream passage expert panel (NMFS, 2012), we have estimated that less than 0.5% of these fish will die. As described in the Environmental Baseline, MDMR (2017) has mapped abundant spawning habitat downstream of the Lockwood Project. We don't expect most of this habitat to function well as it occurs in the mainstem, but a small amount was also surveyed in multiple tributaries (i.e., Bond, Togus, Seven Mile, Messalonskee, Outlet, and the Sebasticook). The MASRSC also indicated that similar spawning areas are expected to occur in the tributaries (and even in the mainstem) upstream of the Lockwood Dam, mostly in tributaries between the Shawmut and Weston Projects (MASRSC, 1986). Although not all of this tributary habitat is accessible and its suitability today is unknown, the best available information indicates that there is sufficient habitat downstream of the dams to provide spawning opportunities for the small proportion of Atlantic salmon that cannot pass the dams. Implementation of the proposed action will result in a significant increase in survival of Atlantic salmon in the Kennebec River relative to current conditions. This will result in a significant increase in the number of smolts leaving the river and the number of adults returning to spawn. This will increase the numbers and reproduction in the Kennebec River, the Merrymeeting Bay SHRU, and the DPS as a whole.

This analysis does not incorporate the effects of the proposed action on postspawn adults. In section 6 we have explained how the installation of racks with two-inch spacing at all four projects will eliminate turbine entrainment of adult salmon in the lower Kennebec River. We estimate that this would increase kelt cumulative dam-related survival from 65% to at least 89%. We expect that the increased survival of kelts leaving the Kennebec River increases the number of repeat spawners; this is because even if marine survival is the same, having more kelts leaving the river should result in more repeat spawners returning to the river. Conceptually, a higher proportion of larger spawners (which are more fecund) would lead to an increase in the number of wild smolts leaving the system. As such, a salmon population with a high proportion of repeat spawners allows for greater resiliency, as they can offset a reduction in production in years when marine survival is particularly low. The anticipated increase in repeat spawners will contribute to increased reproduction in the Merrymeeting Bay SHRU which is expected to lead to an increase in abundance.

The biological criteria for recovering Atlantic salmon described in the Recovery Plan indicate that, in addition to achieving the abundance criteria, each SHRU needs to have a positive mean population growth rate of greater than 1.0 in the 10-year (two-generation) period preceding delisting (USFWS & NMFS, 2019). A population with a growth rate of 1.0 is considered stable; whereas a population with a rate greater or less than 1.0 would be considered growing (i.e., positive growth rate) or declining (i.e., negative growth rate), respectively. The 10-year mean geometric replacement rate of naturally reared Atlantic salmon is reported annually for each of the three SHRUs (Figure 23). The growth rate of salmon in the Merrymeeting Bay SHRU has been above 1.0 over the last 10 years; whereas the rates in the Penobscot and Downeast SHRUs vary around 1.0. It should be noted that the replacement rate of naturally reared salmon is significantly influenced by stocking practices. As the returns to the Merrymeeting Bay SHRU are influenced by egg stocking in the Kennebec, it is expected that it will experience a much higher rate of naturally reared returns. This is because salmon that are stocked as eggs and fry are considered naturally reared since they are indistinguishable from fish produced by wild spawning. Despite the influence of stocking, the replacement rate of naturally reared salmon is the metric currently used for monitoring population growth of the GOM DPS of Atlantic salmon, and is reported annually by both the US Atlantic Salmon Assessment Committee (USASAC) and by the GOM DPS Atlantic Salmon Collaborative Management Strategy (CMS) management board. Therefore, we consider it the best available information regarding the productivity of Atlantic salmon within the GOM DPS. If we were able to control for the stocking effect, we would expect that the population growth rate in the Merrymeeting Bay SHRU would be similar to what is generally documented in the other SHRUs (and the GOM DPS itself); which is a population that is stable around 1.0 with little sign of growth. In 2021, the replacement rate of the GOM DPS as a whole dropped below 1.0 for the first time in a decade (0.96; 95% CL 0.57-1.16), and a similar trend was observed in the SHRU replacement rates (CMS, 2022). However, as the confidence interval still overlaps 1.0, the USASAC still considers the population to be relatively stable (USASAC, 2022).

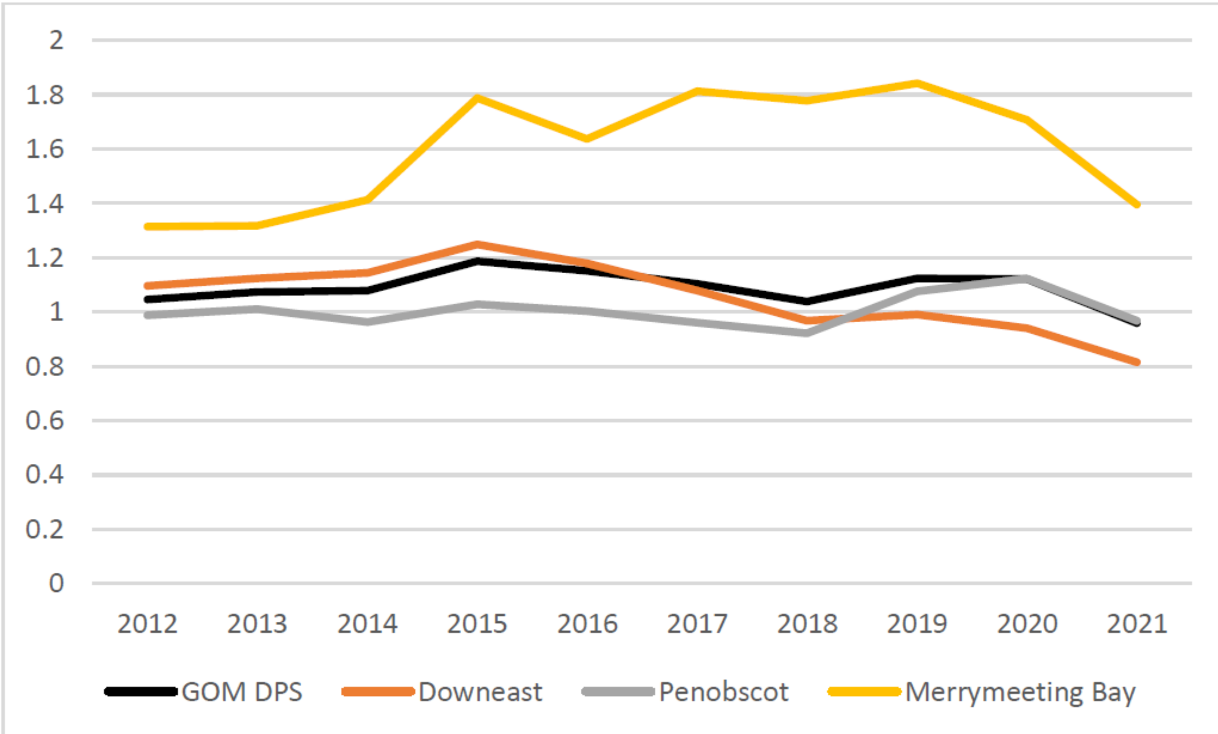

Figure 23. The 10 year geometric mean population growth rate (y-axis) of naturally-reared salmon in the GOM DPS and all three SHRUs from 2012 to 2021 (x-axis) (CMS, 2022).

Throughout this period of stability, Atlantic salmon in the Kennebec River have been exposed to the combined effects of the four dams (i.e., 47% mortality of smolts, 35% mortality of postspawn adults, and only a 67% passage efficiency of prespawn adults). As the population has maintained a stable (although not positive) growth trajectory, we expect that the improvement of the conditions in the Kennebec (i.e., reduced to 16% mortality of smolts, 11% mortality of kelts, and a cumulative prespawn adult passage rate of 85%) will lead to a population with a higher potential for positive growth. Increasing the productivity of the Kennebec River, where most of the habitat exists, should lead to a corresponding increase in the productivity of the Merrymeeting Bay SHRU as a whole.

The 2019 Recovery Plan describes accessible habitat as allowing "downstream movements of smolts during the spring migration, and upstream and downstream movement of adults that seek out habitats for spawning and resting" (USFWS and NMFS, 2019). We consider the amount of accessible habitat as the metric for determining how a proposed action affects the distribution of Atlantic salmon. Compared to current conditions, the proposed action will broaden the distribution of the species in the Kennebec River, as operating the new upstream fishways in compliance with high performance standards will provide safe and timely access of prespawn adult salmon to upstream habitats, and restore access to the migratory corridor in the lower river (between Lockwood and Weston), that has been entirely inaccessible due to a lack of fishways.

Given the anticipated efficiency of the fishways when operated in compliance with the performance standards, we expect that approximately 85% of migrating adult salmon that approach the Lockwood Project will be able to volitionally access the abundant spawning and rearing habitat in the Sandy River. As described in section 6, the remaining fish will remain below one of the four dams, where we expect that approximately 14.5% will stray to seek alternative spawning habitat, and 0.5% will die.

Although there is currently no river-specific genetic stock in the Kennebec River, the run consists of 100% naturally returned adults (stocked as eggs in the Sandy River), which can directly be counted towards the achievement of the downlisting criteria. Naturally reared fish are generally more fit, and experience substantially higher marine survival rates than hatchery reared fish[71]. Additionally, naturally reared fish are more likely to develop river-specific adaptations that would conceivably result in higher freshwater survival rates. The proposed action will significantly reduce downstream mortality of naturally reared smolts at the dams and will increase the possibility of this beneficial effect. Therefore, although the loss of Atlantic salmon due to the proposed action will continue, the substantial increase in survival will reduce the impact on the genetic heterogeneity of the Merrymeeting Bay SHRU and the species as a whole.

Presently, 12,423 units (41% of the habitat recovery criteria) are considered fully accessible in the Merrymeeting Bay SHRU (CMS, 2021). This is an overestimate of the amount of accessible and suitable habitat as it does not account for passage conditions at culverts. However, it is based on a model developed by FWS, and represents the best available information on available habitat in the SHRU (Wright et al., 2008). The proposed fish passage measures will allow upstream access to the previously inaccessible habitat between Lockwood and Weston, which includes approximately 21,000 modeled rearing habitat units (based on Wright et al., 2008). Approximately 57% of these units (~12,000 units) are in mainstem habitat that likely functions at a limited capacity for rearing or reproduction due to excessive water temperatures and water depth. However, the remaining habitat is located in tributaries that can be utilized by adult prespawn salmon that stray (either by choice or forced due to upstream passage inefficiencies) for successful spawning and rearing. More importantly, the fishways will restore access to an additional 45,000 units that occur upstream of the Weston Project, primarily in the Sandy River. Therefore, the proposed action will restore free-swim access to abundant habitat in the mainstem and Sandy River, which is expected to allow for the achievement of the habitat recovery criteria (>30,000 accessible and suitable habitat units per SHRU) in the Merrymeeting Bay SHRU. The proposed actions, therefore, will result in a significant increase in the distribution of Atlantic salmon in the action area and the Merrymeeting Bay SHRU.

In summary, the effects of the proposed action (section 6) considered in the context of the status

[71] The 10-year average smolt to adult return rate on the Penobscot is 0.14% where hatchery smolts are stocked versus 1.17% (more than a eight-fold increase) on the Narraguagus where the smolts are naturally reared (USASAC 2022). Similarly, naturally reared smolts on the Sheepscot River return at four times the rate as hatchery fish on the Penobscot (0.54% v. 0.14%).

of the species (section 3), the environmental baseline (sections 4 and 5), and cumulative effects (section 7), is anticipated to adversely affect juvenile and adult Atlantic salmon. However, the significant improvements in survival and passage efficiency, as well as reductions in migratory delay, will substantially improve conditions relative the environmental baseline and will lead to an increase in the numbers, reproduction, and distribution of Atlantic salmon in the action area and, as a result, in the Kennebec River, the Merrymeeting Bay SHRU and the DPS as a whole. As we anticipate that the USFWS conservation hatchery program will continue to operate, Atlantic salmon will continue to persist in the Kennebec River regardless of the effects of the dams. However, merely persisting is not sufficient to pass the survival test as defined above. When considering listed species, in addition to "exist[ing] into the future", there is an expectation that the species "retain[s] the potential for recovery", and that it have "sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring" (USFWS & NMFS, 1998). Similarly, the 2019 Recovery Plan indicates that "recovery actions associated with Phase 2 are geared toward creating the necessary foundation for establishment and protection of sufficiently resilient wild populations to withstand foreseeable long-term stresses, and toward providing Atlantic salmon with access to suitable habitat throughout their life cycle" (USFWS and NMFS, 2019). Although the proposed action will not eliminate the loss of salmon, the significant increase in survival and passage efficiency will allow for the "necessary foundation" that will allow for recovery. The proposed measures and performance standards will lead to a substantial increase in the number of adults anticipated to return to the Kennebec and Sandy Rivers, even when combined with the baseline effects, and will allow for increases in reproduction, abundance, and distribution. We make this conclusion in consideration of the status of the species as a whole, the status of Atlantic salmon in the action area, and in consideration of the threats experienced by Atlantic salmon in the action area as described in the Environmental Baseline and Cumulative Effects sections of this Opinion. As described in section 5, climate change will continue to affect habitat conditions inside and outside the action area; however, we have not identified any different or exacerbated effects of the action in the context of anticipated climate change.

8.3.5 Recovery Analysis

The second step in conducting the jeopardy analysis is to assess the effects of the proposed action on the likelihood of recovery of the species. As explained above, we have determined that the proposed action won't appreciably reduce the likelihood that Atlantic salmon will survive in the wild. Here, we consider the potential for the action to reduce the likelihood of recovery. Recovery is defined as the improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in section 4(a)(1) of the ESA (USFWS and NMFS 1998). Thus, we have considered whether the proposed actions will affect the likelihood that the Gulf of Maine DPS of Atlantic salmon can rebuild to a point where listing is no longer appropriate. As noted above, in 2019, NMFS and USFWS issued a recovery plan for the GOM DPS of Atlantic salmon. The plan includes a recovery strategy as well as recovery goals, objectives, and criteria. The criteria identified for downlisting and delisting focus on increasing abundance, productivity, and access to spawning and rearing habitat.

The Kennebec River's locally adapted salmon population was extirpated over a century ago with the construction of dams, and the industrialization of the watershed. However, river specific populations still persist in eight rivers in Maine, including in the Sheepscot and the Penobscot. In order to recover the Merrymeeting Bay SHRU, the Kennebec River population will need to be rebuilt using donor stocks from these other rivers. Currently, the Penobscot donor stock supports egg planting in the Sandy River and, as such, the salmon returning to the Kennebec River are actually of Penobscot genetic origin. We anticipate that over the term of the proposed amendments and potential new license (Shawmut) Atlantic salmon produced in conservation hatcheries will continue to be stocked in all three habitat units, including the Merrymeeting Bay SHRU. As long as the hatchery continues to produce Atlantic salmon, the species will not go extinct in the wild. However, recovery of the species requires a self-sustaining wild population with a positive growth rate. Here, we consider how the proposed action, in the context of the environmental baseline and cumulative effects, affects the potential for the salmon population in the Merrymeeting Bay SHRU to maintain itself and grow and therefore, how it affects the likelihood of recovery.

As described above, the condition of the GOM DPS of Atlantic salmon is dire. Adult return rates are extremely low, and it is unlikely that the species can recover unless there is a significant improvement in both marine and freshwater survival. At existing freshwater and marine survival rates, it is unlikely that the GOM DPS of Atlantic salmon will meet the criteria necessary to consider delisting (i.e., achieve recovery). A significant increase in either one of these parameters (or a lesser increase in both) will be necessary to overcome the significant obstacles to recovery. We have created a conceptual model to indicate how marine and freshwater survival rates would need to change in order to recover Atlantic salmon (NMFS, 2010). In Figure 24, the dot represents current marine and freshwater survival rates, whereas the curved line represents all possible combinations of marine and freshwater survival rates that would result in a stable population with a growth rate of zero. If survival conditions are above the curved line, the population is growing, and, thus, trending towards recovery (lambda greater than one). The horizontal red lines indicate the rates of freshwater survival that have been historically observed (Legault, 2004). This model indicates that there are many potential routes to recovery; for example, recovery could be achieved by significantly increasing the existing marine survival rate while holding freshwater survival at existing levels, or, conversely, by significantly increasing freshwater survival while holding marine survival at today's levels. Conceptually, however, the figure makes clear that an increase in both freshwater and marine survival will lead to the shortest path to achieving a self-sustaining population that is trending towards recovery.

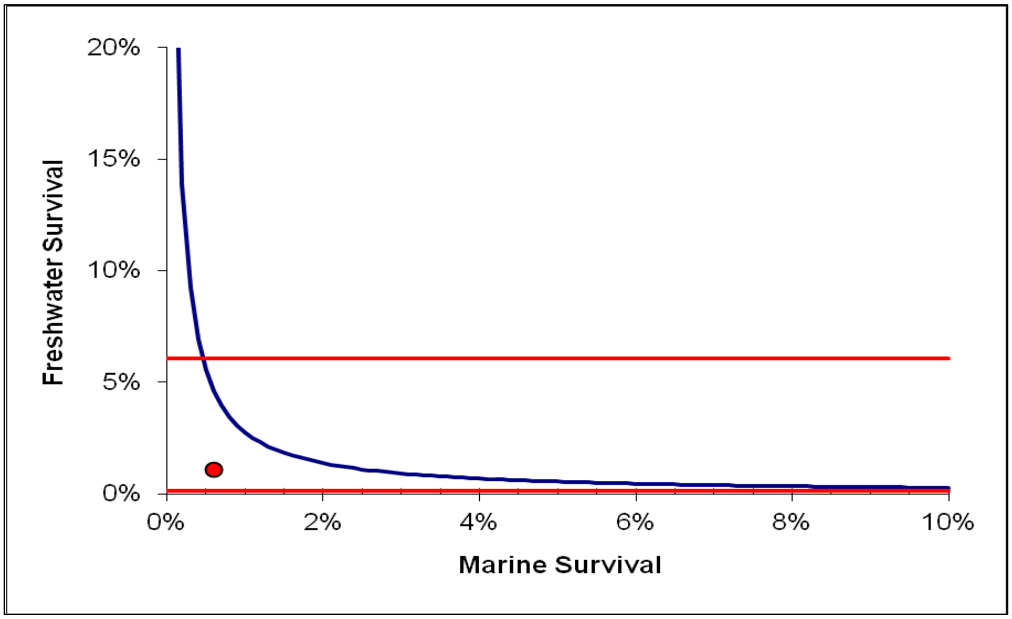

Figure 24. NMFS (2010) conceptual model depicting marine and freshwater survival relative to recovery of the GOM DPS of Atlantic salmon (Note: The dot represents current conditions, the curved line represents recovery, and the horizontal lines are the historic maximum and minimum freshwater survival).

Despite substantial improvements, the proposed action will adversely affect freshwater survival (through the direct and indirect effects of dam passage) of smolts, kelts, and prespawn adults and marine survival (through hydrosystem delayed mortality) of smolts in the Kennebec River. As illustrated above, even with the substantial improvements that will result from the proposed actions, the number of smolts and adults surviving to reproduce in the Kennebec River and in the Merrymeeting Bay SHRU is lower than it would be absent the four dams. However, overall numbers, reproduction, and distribution will be significantly improved when compared to the environmental baseline. This is important, as Atlantic salmon in the Merrymeeting Bay SHRU have maintained a relatively stable, albeit small, population (supported by stocking) despite past effects of the dams. As such, we expect that the improvement of the conditions in the Kennebec will lead to a population with a higher potential for positive growth. Increasing the productivity of the Kennebec River, where most of the habitat occurs, is expected to lead to a corresponding increase in the productivity of the Merrymeeting Bay SHRU as a whole, and an associated increase the potential for recovery.

To understand the implications of the effects of these four dams on Atlantic salmon recovery it is important to contextualize the importance of the Sandy River to Atlantic salmon utilizing the Kennebec River migratory corridor and as a recovery planning element associated with the Merrymeeting Bay habitat recovery unit. As described in section 4, the Sandy River contains abundant habitat that is suitable for Atlantic salmon rearing and spawning. The Sandy River by itself contains more than one-third of the modeled rearing habitat in the Merrymeeting Bay SHRU, and over half of the habitat in the SHRU that was modeled as highly suitable (based on

Wright et al., 2008). In light of warming water temperatures associated with climate change (as discussed in section 5), the value of this habitat to recovering Atlantic salmon is significant. In addition to abundant high quality habitat, over two-thirds of the salmon returning to the SHRU are naturally reared adults homing back to the Sandy River. Correspondingly, the majority of natural reproduction in the SHRU also occurs in the Sandy River. Given all of this, the recovery of the Merrymeeting Bay SHRU, and thus the GOM DPS, is dependent on restoring a self-sustaining Atlantic salmon run to the Sandy River. It is within this context that the effects of the proposed action at these four dams (all of which are downstream of the Sandy) are considered.

As indicated in the survival analysis, we have estimated that given the anticipated survival rates resulting from implementation of the proposed actions, the Kennebec River will support a run size of adult returns to the Sandy River that is nearly 70% of the theoretical run size absent any dams. This is approximately twice what we anticipate under baseline (current) conditions. Therefore, conceptually, we can expect that the proposed action could lead to a doubling of adult salmon abundance and reproduction in the Kennebec River, which in turn will increase the number of naturally reared and wild smolts that are outmigrating to the ocean. Increasing the number and condition of outmigrating smolts has been identified as the best strategy for overcoming poor marine survival (Thorstad et al., 2021). Therefore, given that the proposed action will significantly increase abundance, reproduction, and productivity in the Sandy River, as well as the MMB SHRU and the GOM DPS, the proposed action is not likely to appreciably reduce the species' potential for recovery. Furthermore, the increase in abundance and reproduction will improve the potential of the Merrymeeting Bay SHRU to achieve the abundance and productivity recovery criteria contained in the 2019 Recovery Plan. However, we expect that many marine and freshwater threats will still need to be addressed in order for those criteria to be achieved.

The proposal to construct fishways will improve the distribution of the species by allowing them access to the migratory corridor and the small tributaries between Lockwood and the Sandy River confluence. The proposal to create a fund to conduct habitat accessibility projects in those tributaries will further enhance spawning opportunities for adult salmon that are unable to pass all four dams due to passage inefficiencies. We anticipate that the proposed action will lead to an increase in habitat accessibility (and thus the distribution) of Atlantic salmon in the Merrymeeting Bay SHRU. As discussed in the survival analysis, the proposed fish passage measures will allow upstream access to the previously inaccessible habitat between Lockwood and Weston, which includes approximately 21,000 modeled rearing habitat units (based on Wright et al., 2008). Approximately 43% of this habitat (~9,000) is located in tributaries that could be utilized by adult salmon that stray (either by choice or forced due to upstream passage inefficiencies) for successful spawning and rearing. More consequentially, the fishways will improve access to an additional 45,000 units that occur upstream of the Weston Project, mostly in the Sandy River. Additionally, as described above, downstream accessibility for emigrating smolts and kelts migrating to the estuary and marine environment will improve significantly. Therefore, as the proposed action is expected to achieve the identified passage standards within

10 years, the habitat in the Sandy River will be considered accessible as defined by the 2019 Recovery Plan, and therefore the habitat can be counted towards the habitat recovery criterion (i.e., >30,000 habitat units per SHRU).

The proposed action will not affect Atlantic salmon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring and will result in effects to the environment that would prevent Atlantic salmon from completing their entire life cycle, including reproduction, sustenance, and shelter. The above analysis predicts that the proposed project will lead to an increase in the numbers, reproduction and distribution of Atlantic salmon.

While we are not able to predict with precision how climate change will impact Atlantic salmon in the action area, or how the species will adapt to climate change-related environmental impacts, no additional project effects related to climate change to Atlantic salmon in the action area are anticipated over the life of the proposed action (i.e., through the remainder of the existing licenses). However, climate change increases the importance of the habitat in the upper portions of the Kennebec watershed, as it is believed that those are the areas that will provide abundant cold water habitat that will be needed if salmon are to survive and recover in a warming climate. Based on the analysis presented herein, the proposed action is not likely to appreciably reduce the survival and recovery of the species.

8.3.6 Critical Habitat Designated for the Gulf of Maine DPS of Atlantic Salmon

We consider the impacts of the proposed action on critical habitat designated in the action area and the Merrymeeting Bay SHRU, and whether the proposed actions are likely to result in the destruction or adverse modification of critical habitat designated for the Gulf of Maine DPS of Atlantic salmon as a whole. On August 27, 2019, NMFS and USFWS published a revised regulatory definition of "destruction or adverse modification" (84 FR 44976). As defined, destruction or adverse modification "means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species."

According to the 2019 Atlantic salmon recovery plan (USFWS and NMFS, 2019), recovery of Atlantic salmon will require at least 30,000 units of accessible and suitable spawning and rearing habitat in each SHRU including the Merrymeeting Bay SHRU. Presently, approximately 12,423 units (41% of the recovery criteria) are currently considered fully accessible in the Merrymeeting Bay SHRU. Habitat upstream of a hydro dam will be considered "accessible" by the Services if Atlantic salmon upstream and downstream passage rates are sufficiently high to avoid jeopardizing the species (USFWS & NMFS, 2019). The Merrymeeting Bay SHRU contains 55,227 modeled habitat units suitable for salmon rearing (class 1), of which 78% (43,195 units) occur in the Kennebec River (derived from Wright et al., 2008). Of the highly suitable habitat in the Kennebec River, 73% occurs upstream of the Weston Dam (primarily in the Sandy River) and an additional 18% (7,730 units) occurs between the Lockwood and Weston Dams. Therefore, over 91% of the most suitable rearing habitat in the designated critical habitat in the

Kennebec River (or 71% in the entire SHRU) occurs upstream of one to four of the dams being considered in this Opinion. Implementation of the proposed actions considered in this Opinion will improve passage at the projects and will allow for the achievement of the habitat criteria identified in the 2019 Recovery Plan.

As explained in Section 6.4, we have determined that the action is likely to adversely affect PBFs SR 1 - 7 and M 1- 4. Here, we summarize those adverse effects and consider whether they result in a direct or indirect alteration of the critical habitat in the action area that appreciably diminishes the value of critical habitat for the conservation of the Gulf of Maine DPS of Atlantic salmon. This analysis takes into account the geographic and temporal scope of the proposed action, recognizing that "functionality" of critical habitat necessarily means that it supports the conservation of the species and progress toward recovery both now and in the future. In our analysis, we have considered the potential functional capacity of each PBF, and have then determined the conservation value based on the ability of the appropriate lifestage of Atlantic salmon to access the habitat over the term of the action. When considering the effects of the action, we analyzed how the proposed measures will affect the functioning of the PBFs themselves, as well as how they affect the conservation value in relation to access of Atlantic salmon. The analysis takes into account any changes in amount, distribution, or characteristics of the critical habitat that will be required over time to support the successful recovery of the species. Destruction or adverse modification does not depend strictly on the size or proportion of the area adversely affected, but rather on the role the action area and the affected critical habitat serves with regard to the function of the overall critical habitat designation, and how that role is affected by the action. This analysis ties directly to the recovery objective of "access to sufficient suitable habitat" that is found in both the reclassification and delisting objectives.

The conservation value of many of the adversely affected PBFs will continue to be low in the action area for the first 10 years of the action as Brookfield constructs upstream fishways and implements adaptive management to achieve the cumulative performance standards. It is possible that the standard could be achieved in less time, but for this analysis we have determined that additional operational or structural changes, informed by testing of the new fishways, may be necessary to achieve the highly effective passage standard. Throughout this interim period Atlantic salmon will be trapped at the Lockwood project and transported to the Sandy River, as they have been since the trap was constructed in 2006. When considering whether this delay will appreciably diminish the conservation value of critical habitat, we must consider the consequence of this adverse effect to the PBFs in the action area on the function of the overall critical habitat designation. As indicated, Atlantic salmon that cannot swim above Lockwood are not necessarily blocked from accessing upstream habitat. Two thirds of Atlantic salmon (67%) are successfully trapped at Lockwood and transported to high quality habitat in the Sandy River. As demonstrated by redd surveys and juvenile assessments, many of these salmon spawn successfully (USASAC 2022 (and other years)). We have estimated that up to a third of Atlantic salmon may not be captured at the Lockwood Project, and are therefore limited to the habitat downstream. As indicated above, MDMR has conducted field surveys of habitat downstream of Lockwood and have identified areas in the mainstem and its tributaries (i.e., Bond, Togus, Seven Mile, Messalonskee, Outlet, and the Sebasticook) that have the physical characteristics to support spawning. The suitability of these areas is uncertain, although it is expected that Atlantic salmon stray to habitat in at least two of the tributaries (Bond and Togus) where salmon have been documented spawning in the past (NRC, 2004; MASRSC, 1987; USASAC 2019; USASAC, 2020). Assuming consistent returns over the next ten years, we anticipate that an average of fourteen salmon a year (i.e., average capture of 29 fish divided by 67% equals 43 total fish; 43 fish - 29 fish captured at Lockwood = 14 fish) may be blocked from passing Lockwood. Although the suitability of the spawning and rearing habitat may be uncertain, given the abundance of habitat downstream of Lockwood, we anticipate that many of these fish will successfully locate, and spawn in, downstream habitat. We expect that a proportion of these fish may fail to locate suitable habitat and therefore may end up spawning in nonfunctioning habitat. As the interim phase is only ten years long, and as we anticipate that during this period most salmon will still end up in high quality habitat in the Sandy, and that only a fraction will fail to locate functioning PBFs, the delay in access will not appreciably diminish the value of critical habitat for the conservation of the Gulf of Maine DPS of Atlantic salmon.

Here, we summarize the adverse effects that occur with full implementation (year 10 to year 50) of the proposed actions and consider whether they result in a direct or indirect alteration of the critical habitat in the action area that appreciably diminishes the value of critical habitat for the conservation of the Gulf of Maine DPS of Atlantic salmon.

PBFs for Adult Spawning and Migration (SR 1 - 3, M 1 - 2)

PBF M 1: Freshwater and estuary migratory sites free from physical and biological barriers that delay or prevent access of adult salmon seeking spawning grounds needed to support recovered populations.

In section 4, we determined that PBF M 1 is not functioning in the action area as three of the four projects do not have swim-through fishways for prespawn Atlantic salmon, and the fourth (Hydro-Kennebec) has yet to be evaluated. In section 6, we determined that the construction of fishways and achievement of cumulative passage and delay standards will allow PBF M 1 to function at a limited capacity by year 11 of the proposed action, but that it will continue to be non-functional during the interim phase (year 1 to year 10). Further, we determined that while the action will lead to an improvement in the conservation value of the PBF, the proposed action will still adversely affect the PBF in the action area as passage will not be restored until year 10 (effect of delay of access during the interim phase is considered above), and because a small proportion of prespawn salmon will still be excluded from passing the projects, even with the achievement of the performance standards.

The proposed action includes evaluations of the effectiveness of the new fishways and, informed by those studies, requirements to “develop and implement additional operational or infrastructure measures, as reasonable and practicable, that are likely to meet or exceed the upstream performance standard" (Brookfield's 9/21/2022 filing with FERC). Brookfield's adaptive management proposal does not include any limitations on the type and scope of adaptive improvements that could be necessary to achieve its proposed passage standards. From experience at other projects, if a single new fishway is not sufficient to meet the standards, we anticipate that there may be relatively few alternatives for remedying poor upstream passage conditions at some projects. Typically, upstream passage ineffectiveness is related to inadequate attraction to the fishway itself. Fish that are attracted to a section of the dam that is distant from the new fishway entrance (such as the spillway on the other side of the river), for instance, are unlikely to be attracted to the fishway entrance within a reasonable amount of time if competing flows cannot be adequately managed. In an instance such as this, we would anticipate that significant structural modifications, such as additional fishway entrances or additional new fishways, may be necessary to achieve the upstream performance standard. This type of step is not precluded by the adaptive management protocol incorporated into the proposed action; as such, we consider that if necessary, such measures would be required and implemented within 10 years. Given the proposal to construct new fishways and adaptively manage to achieve the cumulative performance standard, we anticipate that not only will access to the habitat with the PBFs be greatly improved but the PBFs affected by upstream passage efficiency will function at a higher level due to the proposed action.

As indicated, we expect that the four projects will continue to adversely affect PBF M 1 in the action area by limiting access to the migratory corridor to a small proportion of Atlantic salmon that are migrating to spawning habitat in the Sandy River. Brookfield's proposal to manage passage at the projects to achieve an average of 96% per dam (~85%, cumulative) means that a significant majority of salmon that are motivated to pass the projects will be able to do so. This restoration of function to the PBF will allow this habitat to be considered accessible for the first time in over a century, and will greatly increase the conservation value of PBF M 1 in the action area. However, even dams with very high passage efficiency will lead to a substantial cumulative effect when there are many of them. The proposed action will lead to ~15% of motivated adults being blocked from accessing PBF M 1 upstream of all four dams during the implementation phase. However, the PBFs for spawning and rearing also occur in the tributaries in the action area between Weston and Lockwood, as well as downstream of Lockwood. As the proposed actions will still allow for the fish that have failed to pass one of the dams to access the habitat lower in the river, PBF M 1 is still functioning at a limited level for these fish. As such, given the presence of spawning and rearing habitat in the lower river, and that fish that fail to pass one of the four dams will still be able to migrate to this habitat, we expect that the adverse effects to PBF M1 in the action area will be relatively minor and will not appreciably diminish the value of critical habitat for the conservation of the Gulf of Maine DPS of Atlantic salmon.

SR 1: Deep, oxygenated pools and cover (e.g., boulders, woody debris, vegetation, etc.), near freshwater spawning sites, necessary to support adult migrants during the summer while they await spawning in the fall.

SR 2: Freshwater spawning sites that contain clean, permeable gravel and cobble substrate with oxygenated water and cool water temperatures to support spawning activity, egg incubation, and larval development.

SR 3: Freshwater spawning and rearing sites that contain clean, permeable gravel and cobble substrate with oxygenated water and cool water temperatures to support emergence, territorial development and feeding activities of Atlantic salmon fry.

M 2: Freshwater and estuary migration sites with pool, lake, and in-stream habitat that provide cool, oxygenated water and cover items (e.g., boulders, woody debris, and vegetation) to serve as temporary holding and resting areas during upstream migration of adult salmon.

In section 4, we determined that the PBFs related to spawning and adult migration are present and have the potential to function at limited capacity in the action area, but due to the lack of swim through passage beyond the Lockwood Project, the PBFs have low conservation value. In section 6, we determined that the proposal to construct upstream fishways and manage them to achieve a cumulative passage standard of 85% (~96% per dam) will restore access to the PBFs in the action area for the first time in over a century. This will significantly increase the conservation value of the features in the action area, and will allow them to function at the expected functional capacity. We also determined that while the action will lead to an improvement in the conservation value of the PBFs, the proposed action will still adversely affect them as passage will not be restored until year 10 (effect of delay of access during the interim phase is considered above), and because a small proportion of prespawn salmon will still be excluded from accessing them even with the achievement of the performance standard.

As indicated above, the adult salmon that are not able to access habitat that contains the spawning PBFs upstream of the projects due to passage inefficiencies will still be able to access habitat with these PBFs downstream of the projects. As has been made clear in this analysis, most of the high quality spawning habitat in the Kennebec basin occurs in the Sandy River upstream of all four dams, and it is essential that the majority of salmon in the river can access it. However, we have determined that the spawning PBFs are present in several other tributaries upstream and downstream of the dams. The suitability of this habitat is unknown, and it is probable that some of it, particularly in the mainstem, is not functioning fully for spawning. However, given the quantity of habitat identified by MDMR (2017) and MASRSC (1986), and that it is distributed throughout multiple tributaries upstream and downstream of Lockwood, we expect that the small number of adults that will be deterred from passing the dams will still be able to access habitat with the PBFs relevant to spawning. As such, given the presence of habitat with the spawning PBFs in the lower river, and that fish that fail to pass one of the four dams will still be able to migrate to this habitat, we expect that the adverse effects to the spawning PBFs will be relatively minor and will not appreciably diminish the value of critical habitat for the conservation of the Gulf of Maine DPS of Atlantic salmon.

PBFs for Juvenile Rearing and Migration (SR 4 - 7, M 4)

Freshwater rearing sites with the space (SR4), habitat diversity (SR5), cool water (SR6), and diverse food resources (SR7) necessary to support growth and survival of Atlantic salmon parr.

In section 4, we determined that the PBFs related to juvenile rearing are present and have the potential to function at a limited capacity in the action area, but due to the lack of swim through passage beyond the Lockwood Project, the PBFs have low conservation value. This is because without adult passage and spawning we would not expect juvenile salmon to be able to access the action area upstream of the Lockwood Project. In section 6, we determined that the proposal to construct upstream fishways and manage them to achieve a cumulative passage standard of 85% (~96% per dam) will restore access to the PBFs in the action area for the first time in over a century. This will significantly increase the conservation value of the features in the action area, and will allow them to function at their expected capacity. We also determined that while the action will lead to an improvement in the conservation value of the PBFs, the proposed action will still adversely affect them as passage will not be restored until year 10 (effect of delay of access during the interim phase is considered above), and because a small proportion of prespawn salmon will still be excluded from accessing them, which will limit the amount of spawning and rearing that can occur within the action area even with the achievement of the performance standard.

As indicated above, the adult salmon that are not able to access habitat with the rearing PBFs upstream of the projects due to passage inefficiencies will still be able to access habitat with the PBFs downstream of the projects. As has been made clear in this analysis, most of the high quality rearing habitat in the Kennebec basin occurs in the Sandy River upstream of all four dams, and it is essential that the majority of salmon in the river can access it. However, we have determined that the rearing PBFs are present in the mainstem as well as several other tributaries upstream and downstream of the dams. The suitability of this habitat is unknown, and it is probable that some of it, particularly in the mainstem, is not functioning fully for rearing. However, given the quantity of habitat identified by MDMR (2017), MASRSC (1986), and predicted by the rearing habitat model (Wright et al., 2008), and that it is distributed throughout multiple tributaries upstream and downstream of Lockwood, we expect that rearing PBFs will be accessible to the relatively low proportion of adults that cannot access habitat upstream of the Weston Project. As such, given the presence of the rearing PBFs in the lower river, and that fish that fail to pass one of the four dams will still be able to migrate to this habitat, we expect that the adverse effects to the rearing PBFs will be relatively minor and will not appreciably diminish the value of critical habitat for the conservation of the Gulf of Maine DPS of Atlantic salmon.

PBF M 4: Freshwater and estuary migration sites free from physical and biological barriers that delay or prevent emigration of smolts to the marine environment.

In section 4, we determined that PBF M 4 has limited functioning in the action area as the projects lead to the delay, injury, and mortality of abundant outmigrating Atlantic salmon smolts as a result of downstream passage at the dams. In section 6, we determined that the proposed structural and operational measures, as well as the achievement of the cumulative survival and delay standards, will significantly improve the functionality of PBF M 4 in the action area by year 4 of the proposed action. The proposal will increase the conservation value of the habitat with the PBF in the action area, smolt mortality and delay will still result from passage and therefore we expect that it will continue to function at a limited level. Similarly, we determined that the proposed action will still adversely affect the PBF as passage will not be restored until year 4 (effect of delay of access during the interim phase is considered above), and because a proportion of smolts will still be delayed and killed due to effects of the projects, even with the achievement of the performance standards.

As indicated, we expect that the four projects will continue to adversely affect PBF M 4 in the action area by delaying and preventing emigration of a proportion of Atlantic salmon smolts that are migrating from rearing habitat in the Sandy River to the ocean. Brookfield's proposal to implement operational and structural changes at the projects to achieve an average of 97% per dam (~89%, cumulative) means that a significantly higher proportion of salmon smolts should survive to the ocean. This restoration of function to the habitat with the PBF in the action area will allow this habitat to be considered accessible for the first time in over a century, and will greatly increase the conservation value of PBF M 4 in the action area. However, even dams with very high passage efficiency will lead to a substantial cumulative effect when there are many of them. Even following full implementation of all proposed measures, ~11% of emigrating smolts will be killed due to the direct and indirect effects of passage during the implementation phase. Although this loss will continue to limit the size of the run of salmon to the Kennebec River, the significant improvement in downstream passage conditions for smolts is expected to result in a 59% increase in the number of adults returning to the Kennebec River (Table 43; (81 - 51)/51 = 59%) by year 4 of the action. Given that the Kennebec comprises 63% of the Merrymeeting Bay SHRU returns (over the last 10 years) under baseline conditions, we expect that this improvement will lead to a significant improvement in salmon abundance in the SHRU as a whole. As such, this represents a significant increase in the conservation value of the habitat in the action area.

In our analysis, we have indicated that habitat with the PBFs for spawning and rearing also occur in the tributaries in the action area between Weston and Lockwood, as well as downstream of Lockwood. Production of smolts in the previously inaccessible tributaries (that flow into the mainstem action area upstream of Lockwood) will partially offset the effect caused by the loss of smolts at the dams. The proposed action will further improve access to this juvenile production habitat by providing funds for connectivity projects, such as upgrading road-stream crossings. Although the action will lead to a significant increase in the conservation value of the PBF, it will still lead to direct and indirect smolt mortality; and therefore PBF M 4 will still function at a limited level during the implementation phase. However, as we expect additional juvenile production habitat will be made available by restoring access of adults to the action area, and due to the implementation of additional connectivity projects, we expect that the adverse effects to PBF M 4 will be relatively minor and will not appreciably diminish the value of critical habitat for the conservation of the Gulf of Maine DPS of Atlantic salmon.

PBF for Coevolved Species (M 3)

PBF M 3: Freshwater and estuary migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation.

In section 4, we determined that the PBF requiring abundant and diverse fish communities to buffer predation of salmon is not functioning in the action area above Lockwood as the other diadromous species (e.g., alewives, blueback herring, American shad) are not passed beyond that project. River herring are trapped and transported to habitat upstream in the Kennebec, as well as in other systems. Most shad are trucked and released upstream of Lockwood; whereas others are released below the project at MDMR's direction (KHDG 2021). In section 6, we determined that the proposal to construct upstream fishways will restore access for alosines to the entirety of the action area for the first time in over a century. This will allow the PBF to function in the action area, but as we expect the fishways will still block access to some proportion of upstream migrants and kill some proportion of outmigrating adults and juveniles, the proposed action will only allow for limited functioning of the PBF in the action area. We also determined that while the action will lead to an improvement in the conservation value of the PBF in the action area, the proposed action will still adversely affect it as passage of salmon will not be restored until year 10 (effect of delay of access during the interim phase is considered above), and because the project will directly limit the abundance and distribution of alosines in the action area by limiting the number that pass upstream and downstream of each project.

As addressed in section 4, much of the benefit of prey buffering for Atlantic salmon smolts occurs in the estuary and lower river. The Biological Valuation that supports the critical habitat designation (NMFS, 2009), describes the benefit this way:

> Adult and smolt migration through the estuary often coincides with the presence of alewives (*Alosa* spp.), American shad (*Alosa sapidissima*), blueback herring (*Alosa aestivalis*), and striped bass (Morone *saxatilis*). The abundance of diadromous species present during adult migration may serve as an alternative prey source for seals, porpoises and otters (Saunders et al., 2006)...
>
> As Atlantic salmon smolts pass through the estuary during migration from their freshwater rearing sites to the marine environment, they experience high levels of predation. Predation rates through the estuary often result in up to 50 percent mortality during this transition period between freshwater to the marine environment (Larsson, 1985). There is, however, large annual variation in estuarine mortality, which is believed

to be dependent upon the abundance and availability of other prey items including alewives, blueback herring, and American shad, as well as the spatial and temporal distribution and abundance of predators (Anthony, 1994).

The effect is mostly limited to the estuary because smolts start outmigrating in mid-April, but adult alewives are not generally trapped at Lockwood in significant numbers until the first or second week of May. When comparing the timing of the middle 90% of both runs (excluding the tails of the run to isolate the peak when fish would be expected to occur in greater abundance) the overlap between the smolt run and the alewife run in the action area was approximately 11 and 6 days in 2021 and 2022, respectively[72]. However, we would expect the overlap to be more significant in the lower river and the estuary as the peak of the outmigrating smolt run coincides in space and time with the peak of the upstream alewife migration.

The benefit in freshwater could be more pronounced for adult Atlantic salmon as the upstream migration timing coincides with the migration of American shad and river herring. However, predators (such as seals, porpoises, and otters) that would be a threat to a large fish like an adult Atlantic salmon are more limited in the action area, which is well above the head of tide and largely lies upstream of the dams, which are not accessible to those species. As such, here we have primarily focused on how PBF M 3 functions for Atlantic salmon smolts.

As indicated in section 4, the Sebasticook River contains the majority of river herring habitat in the Kennebec basin, with approximately two-thirds of the total habitat occurring in that watershed (derived from Table 1 in Wippelhauser, 2021). Only one-quarter of the alewife habitat in the watershed occurs upstream of Lockwood; another 8% occurs in the Seven Mile Stream watershed downstream of Lockwood. Although only 54% of the habitat in the Sebasticook is accessible to alewives (Wippelhauser, 2021), large runs (2 - 5.5 million individuals) are passed upstream annually at the first dam (Benton Falls Project)[73]. Although these runs are likely significantly less than what would have been expected historically, this indicates that there are abundant adult and juvenile herring in the estuary that allow for at least limited functioning of PBF M 3 in the Kennebec River watershed. Although the Sebasticook provides the majority of historical alewife habitat and production in the system, the habitat above the Lockwood project needs to be accessible to alosines in order for it to contribute to the functioning of the PBF in the lower river and estuary, as well as to provide some amount of prey buffering within the action area.

In this analysis, we consider how the proposed action affects the potential for prey buffering within the action area itself, as well as in the lower river and estuary where much of the prey

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[72] Alewife timing was derived from the weekly fishway reports sent to the agencies by Brookfield in 2021 and 2022. Rotary screw trap information was provided by NOAA's Northeast Fisheries Science Center (Hawkes, J., NEFSC, Personal Communication, January, 24, 2023).

[73] Maine DMR. Trap Count Statistics. Historical annual data for 2011-2021. https://www.maine.gov/dmr/fisheries/sea-run-fisheries/programs-and-projects/trap-count-statistics

buffering benefit is realized. As indicated above, we anticipate that with the implementation of the proposed action PBF M 3 will function at a limited capacity within the action area as some proportion of shad and herring will be blocked from passing upstream of all four dams. Due to expected passage efficiencies, we expect that the distribution of alosines throughout the action area will not be even. For example, if we assume that each dam has a passage efficiency of 75%, for every 100 fish that approach the projects 75 (100 fish x 75%) will access the habitat between Lockwood and Hydro-Kennebec; 56 (75 fish x 75%) will access the habitat between Hydro-Kennebec and Shawmut; 42 (56 x 75%) will access habitat between Shawmut and Weston; and 32 (42 fish x 75%) will access habitat upstream of Weston. Given this, we expect that functioning of the PBF will be more limited in the upper reaches of the action area. As the proposed action will have a direct adverse effect on the functioning of the PBF in the action area (i.e., by limiting upstream passage and by killing outmigrating adult and juvenile alosines), we anticipate that PBF M3 will continue to be adversely affected in the action area. As indicated above, this PBF may contribute minimally to prey buffering of Atlantic salmon smolts within the action area as the overlap between the adult alewife run and the Atlantic salmon smolt run is minimal. Additionally, although predation of adult salmon likely would occur in the action area (likely due to large avian predators such as eagles and ospreys), many of the more prevalent aquatic predators, such as seals, cannot access habitat upstream of Lockwood. As such, given the minimal overlap between salmon, alosines, and likely predators, we expect that the adverse effects to PBF M 3 in the action area will be relatively minor and will not appreciably diminish the value of critical habitat for the conservation of the Gulf of Maine DPS of Atlantic salmon.

The effect of the proposed action on the functioning of PBF M 3 in the lower river and estuary has the potential to be more pronounced. Due to upstream and downstream passage inefficiencies the proposed actions limit the number of adult and juvenile alewives that occur in those areas where a prey buffer would be the most beneficial. As indicated in section 4, the habitat upstream of Lockwood only contains 25% of the river herring habitat in the Kennebec River basin. Most of the habitat occurs in the Sebasticook River watershed, which contains two-thirds of the alewife production habitat, with another 8% occurring in a tributary (Seven Mile Stream) to the Kennebec River downstream of the action area (Wippelhauser, 2021). The Sebasticook currently has runs of alewives between 2 and 5 million annually; a number that is expected to increase with the recent restoration of access to China Lake, a 4,000 acre lake in the lower Sebasticook River. Although large by today's standards, these runs are substantially lower than what would have been expected historically. Regardless, this context suggests that PBF M 3 is likely functioning at some level in the lower Kennebec River and estuary regardless of the proposed action, and that the added production expected due to passage being restored at the dams should only increase the functioning of the PBF in those areas even more. As such, we expect that the adverse effects to PBF M 3 will be relatively minor and will not appreciably diminish the value of critical habitat for the conservation of the Gulf of Maine DPS of Atlantic salmon.

We have concluded that the proposed actions will continue to limit the functioning of the PBFs in the designated habitat. However, we expect that the proposed operational and structural measures will substantially increase the conservation value of the designated critical habitat as a result of significant improvements of access and function. The restoration of accessible passage (i.e., passage of a sufficiently high proportion of juveniles and adults to allow for survival and recovery) for the term of the proposed actions will not "preclude or significantly delay development" of functioning PBFs, and therefore will not preclude or delay the ability of the Kennebec River and the Merrymeeting Bay SHRU to support a sufficient spawning and rearing population to achieve the recovery criteria. Therefore, as we anticipate that the effects of the proposed action will not appreciably diminish the conservation value of critical habitat for the conservation of the Merrymeeting Bay SHRU, it is not likely to result in the destruction or adverse modification of critical habitat designated for the Gulf of Maine DPS of Atlantic salmon.

9 Conclusion

After reviewing and analyzing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is our Opinion that the proposed actions may adversely affect but are not likely to jeopardize the continued existence of the GOM DPS of Atlantic salmon, shortnose sturgeon, or the GOM DPS of Atlantic sturgeon. Furthermore, the proposed actions are not likely to destroy or adversely modify critical habitat designated the GOM DPS of Atlantic salmon and are not likely to adversely affect critical habitat designated for the GOM DPS of Atlantic sturgeon.

10 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. In the case of threatened species, section 4(d) of the ESA leaves it to the Secretary's discretion whether and to what extent to extend the statutory 9(a) ''take'' prohibitions, and directs the agency to issue regulations it considers necessary and advisable for the conservation of the species.

"Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. NMFS has not yet defined "harass" under the ESA in regulation, but has issued interim guidance on the term "harass," (Interim Guidance on the Endangered Species Term "Harass"[74]) defining it as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering" (NMFS PD 02-110-19). We considered NMFS' interim definition of harassment in evaluating whether the proposed activities are likely to result in

[74] http://www.nmfs.noaa.gov/op/pds/documents/02/110/02-110-19.pdf

harassment of ESA-listed species. Incidental take statements serve a number of functions, including providing reinitiation triggers for all anticipated take, providing exemptions from the Section 9 prohibitions against take, and identifying reasonable and prudent measures that will minimize the impact of anticipated incidental take and monitor incidental take that occurs. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. "Otherwise lawful activities" are those actions that meet all State and Federal legal requirements except for the prohibition against taking in ESA Section 9 (51 FR 19936, June 3, 1986), which would include any state endangered species laws or regulations. Section 9(g) makes it unlawful for any person "to attempt to commit, solicit another to commit, or cause to be committed, any offense defined [in the ESA]" (16 U.S.C. § 1538(g)). See also 16 U.S.C. § 1532(13) (definition of "person").

The measures described below must be undertaken by the relevant action agency and/or applicant so that they become binding conditions for the exemption in section 7(o)(2) to apply. FERC (and USACE, as appropriate) has a continuing duty to regulate the activity covered by this ITS. If FERC (1) fails to assume and implement the terms and conditions or (2) fails to require the licensees or their contractors to adhere to the terms and conditions of the ITS through enforceable terms that are added to licenses and permits as appropriate, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, FERC or Brookfield must report the progress of the action and its impact on the species to us as specified in the ITS [50 CFR §402.14(i)(3)] (See U.S. Fish and Wildlife Service and National Marine Fisheries Service's Joint Endangered Species Act Section 7 Consultation Handbook (1998) at 4-49).

10.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent of such incidental taking on the species (50 C.F.R. §402.14(i)(1)(i)).

The following sections describe the amount or extent of take that we expect will result from proposed actions; the identified amount or extent of take is exempted throughout the ITS. If the proposed actions result in take of a greater amount or extent than that described, FERC or ACOE would need to reinitiate consultation immediately. The exempted take only includes take incidental to the proposed actions described in this Opinion.

10.1.1 Atlantic salmon

Smolts

We anticipate that direct and indirect mortality of smolts associated with passage at the Weston, Shawmut, Hydro-Kennebec, and Lockwood Projects will not exceed the levels described in Table 44.

Table 44. A summary of the take of juvenile Atlantic salmon anticipated due to the proposed actions.

Project	Source	Type	Phase	
			Interim (Y1-3)	Implementation (Y4-50)
Lockwood	Direct	Mortality	2.9%	2.9%
	Indirect (HDM)	Mortality	0.4%	0.4%
	Sublethal Injury	Injury	0.7%	0.7%
	Delay (%>24 hr)	Harassment	0.0%	0.0%
	Stranding (fish stocked downstream)	Harrassment	13 per 100,000 stocked	
		Mortality	10 per 100,000 stocked	
Hydro-Kennebec	Direct	Mortality	4.7%	3.1%
	Indirect (HDM)	Mortality	0.5%	0.2%
	Sublethal Injury	Injury	0.6%	0.2%
	Delay (%>24 hr)	Harassment	0.0%	0.0%
Shawmut	Direct	Mortality	12.9%	2.6%
	Indirect (HDM)	Mortality	7.6%	0.9%
	Sublethal Injury	Injury	6.9%	0.5%
	Delay (%>24 hr)	Harassment	8.5%	1.8%
Weston	Direct	Mortality	9.70%	2.50%
	Indirect (HDM)	Mortality	9.30%	4.80%
	Sublethal Injury	Injury	5.00%	1.70%
	Delay (%>24 hr)	Harrassment	19.20%	12.30%

In addition to these project specific take estimates, the implementation of project changes to achieve a cumulative performance standard of 89%, means that 11% of smolts will continue to be killed annually during the implementation phase due to the effects of passage at the four dams. We have also determined that the cumulative effects of migratory delay of smolts will lead to the harm of 6.5% and 3.2% of the run annually that survive passage through all four projects (as well as the Shawmut impoundment) in the interim and implementation phase, respectively. This delay could significantly impair essential behavioral patterns (i.e., migration) to the extent that fish could potentially be killed, and therefore we consider it harm. This amount of take is exempted by this ITS.

Hydrosystem delayed mortality is difficult to monitor using traditional telemetry methods. In circumstances where we cannot effectively monitor take, we use a surrogate to estimate its extent. As described in 8- FR 26832 (June 10, 2015) a surrogate may be used to express the amount or extent of anticipated take when the incidental take statement: (1) Describes the causal link between the surrogate and take of the listed species; (2) describes why it is not practical to express the amount of anticipated take or to monitor take-related impacts in terms of individuals of the listed species; and (3) sets a clear standard for determining when the amount or extent of the taking has been exceeded. For this proposed action, the estimated migratory delay (>24 hour residence time per dam) and sublethal injury rates at the projects provide a surrogate for estimating the amount of incidental take associated with hydrosystem delayed mortality. We will consider take associated with indirect mortality (i.e., hydrosystem delayed mortality) (Table 44) to have been exceeded if smolts monitored during downstream passage studies exceed the average of the project specific migratory delay or sublethal injury rates. As such, take for HDM will be considered exceeded if the average delay (measured as the proportion of smolts that take more than 24 hours to pass each dam) exceeds 6.9% (i.e., (0%+0%+8.5%+19.2%)/4 projects) during the interim phase and 3.5% (i.e., (0%+0%+1.8%+12.3%)/4 projects) during the implementation phase. Similarly, take for HDM will be considered exceeded if the average sublethal injury exceeds 3.3% during the interim phase and 0.8% during the implementation phase. We consider the take threshold as an average of the four projects as hydrosystem delayed mortality is a cumulative effect of passage at multiple dams. As such, an excess of delay or injury at any single project may or may not affect the amount of HDM depending on what the delay and injury rates are at the other projects in that year. Take will be monitored at the projects through passage studies conducted after the implementation of the proposed measures, as well as through injury assessments that are part of the proposed actions.

We have determined that in years when smolt stocking occurs downstream of the Lockwood Project that 0.023% (i.e., 23 for every 100,000 smolts stocked) could be stranded in pools downstream of the dam when the flashboards are being replaced. We anticipate that 0.013% (i.e., 13 for every 100,000 smolts stocked) will be harassed due to the effects of stranding and handling, and that 0.010% (i.e., 10 for every 100,000 smolts stocked) will be killed.

Kelts

The best available information indicates that a cumulative 65% of postspawn adult salmon survive passage at the Weston (85%), Shawmut (89%), Hydro-Kennebec (93%), and Lockwood (90%) Projects under existing conditions (i.e., 35% mortality), which will persist during the first three years of the action. We anticipate that the implementation of the proposed measures will reduce mortality to no more than 3% per project, which equates to no more than 11%[75] cumulatively. Therefore, this ITS exempts the death or injury of up to 35% of kelts migrating in the action area annually for the first three years, which will be reduced to 11% for the remainder of the term of the action.

Prespawn Adults

We anticipate that direct and indirect effects to prespawn adult Atlantic salmon associated with passage at the Weston, Shawmut, Hydro-Kennebec, and Lockwood Projects will not exceed the levels described below.

[75] Calculated cumulatively: 97% x 97% x 97% x 97% = 89%.

We expect that during the 10-year interim phase, an average of 67% of prespawn adults will successfully pass all four dams (via trap and truck), but will be harassed due to the effects of handling and transport. No more than 33% of salmon on average will fail to be captured at the Lockwood fish trap, and will be harassed as they will need to locate alternative spawning and rearing habitat, or else stray to other watersheds, such as the Sebasticook or Androscoggin. A small proportion of those (0.3% of the run) may die as a result of forced straying that occurs at the Lockwood Project during the interim phase. Given the expected runs to the Kennebec River during the interim period we do not anticipate this equating to more than one adult. After the measures have been fully implemented and evaluated (by the end of year 10), we expect that the performance standards will have been achieved such that approximately 85% (average of 96% per dam) of adult salmon will successfully pass upstream of all four dams in less than 192 hours. The 15% that fail to pass all four dams will be harassed, but are expected to be able to access newly available spawning and rearing habitat in the tributaries. A small proportion of those fish (0.5% total) may die as a result of straying at one of the four projects, most likely downstream of the Shawmut or Hydro-Kennebec Projects as there are few tributaries in those reaches to provide cold water refuge. The amount of take outlined in this paragraph is exempted by this ITS.

In this analysis, we have considered migratory delay as a cumulative effect, such that fish that take more than a 192 hours (average of 48 hours per dam) to pass all four dams[76] will be considered harmed or harassed. Of the fish that successfully pass the Lockwood project during the interim phase, 65% will be significantly delayed (>192 hours), and therefore will be harassed (55%) or harmed (10%) due to the energetic effects of delay. During the implementation phase, we do not anticipate that any of the fish that successfully migrate above all four projects will do so in more than 192 hours; therefore, we do not expect that any of them will be harmed or harassed due to excessive delay at the dams.

We anticipate that on average one adult salmon per year could become stranded in the ledges downstream of the Lockwood, Hydro-Kennebec, Shawmut, and Weston Projects during the implementation phase, and that an average of one per year will be stranded at the Lockwood Project during the interim phase. Any stranded fish would be harassed due to the effects of stranding, handling, and transport. Additionally, we expect that one adult Atlantic salmon could become entrapped in the cofferdam that will be constructed in the Lockwood bypass reach to isolate the area where the new fishway will be constructed. As with the stranded fish, we anticipate that this fish will be harassed due to the effects of stranding, handling, and transport. This amount of take is exempted by this ITS.

[76] Measured as the additive delay (i.e., Lockwood delay + Hydro-Kennebec delay + Shawmut delay + Weston delay) experienced by upstream migrating adults at each of the four dams once they approach within 200 meters of each dam.

Fish Passage Monitoring

All Atlantic salmon smolts used in the downstream passage studies will be handled and injured due to tag insertion. The proposed smolt studies are expected to involve handling and surgical implantation of radio tags in up to 200 smolts per project per year, for a total of 4,800 smolts. Of these, up to 2% (96 smolts) are expected to die due to handling and tagging. The remaining smolts are expected to be harmed and injured due to tag implantation and handling (Table 46).

Brookfield has proposed to conduct "qualitative" and "quantitative" upstream passage evaluations using adult Atlantic salmon. The qualitative studies will make use of a relatively small number of salmon returning to the Sandy, as a result of egg stocking and wild production, to evaluate the efficacy of the new bypass fishway at Lockwood. For these studies, up to 40 adults will be implanted with radio tags annually for up to three years of studies. These studies, therefore, will affect up to 120 adult salmon (40 salmon a year for 3 years). Although no mortality is expected, all study fish will be harassed and experience minor, recoverable injury due to handling and tagging during the study.

The "quantitative" studies will use a larger number of study fish, resulting from smolts stocked in the Sandy River specifically for this purpose. These fish will be used to evaluate the effectiveness of all four fishways and will be used to determine the attainment of the passage and delay performance standards. For these studies, up to 200 adults will be surgically implanted with radio tags for up to six years of studies. These studies, therefore, will affect up to 1,200 adult salmon (200 salmon a year for six years). Although no mortality is expected, all study fish will be harassed and experience minor, recoverable injury due to handling and tagging during the study.

Table 45. The maximum number of study fish expected to be used in upstream (qualitative and quantitative) and downstream passage effectiveness and survival studies. This is also the amount of take exempted by this ITS. Although the upstream studies will be designed to assess the cumulative passage effects of all four projects, we have distributed the 1,200 study fish evenly across the four projects for the purposes of this take statement.

Project	Lifestage	# Years	Max Study Fish	Type of Take	% Take
Weston	Smolts	6	1200	Harm	98%
				Mortality	2%
	Adults	6	300	Harrass	100%
Shawmut	Smolts	6	1200	Harm	98%
				Mortality	2%
	Adults	6	300	Harrass	100%
Hydro-Ken nebec	Smolts	6	1200	Harm	98%
				Mortality	2%
	Adults	6	300	Harrass	100%
Lockwood	Smolts	6	1800	Harm	98%
				Mortality	2%
	Adults	6	420	Harrass	100%

This level of incidental take is a reasonable estimate of incidental take that will occur given the seasonal distribution and abundance of Atlantic salmon in the action area. In the accompanying biological opinion, we determined that this level of anticipated take is not likely to result in jeopardy to the species.

10.1.2 Shortnose and Atlantic sturgeon

We anticipate that no more than one shortnose sturgeon or Gulf of Maine DPS Atlantic sturgeon will be captured in the fishway at the Lockwood Project and that no more than one shortnose sturgeon or Gulf of Maine DPS Atlantic sturgeon will become stranded below Lockwood as a result of flashboard replacement. Capture, handling, and biological sampling could lead to the minor injury of these sturgeon. This amount of take is exempted by this ITS.

10.2 Reasonable and Prudent Measures

Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the proposed action is likely to incidentally take individuals of ESA-listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. To minimize such impacts, reasonable and prudent measures, and terms and conditions to implement the measures, must be provided. Only incidental take resulting from the agency actions and any specified reasonable and prudent measures and terms and conditions identified in the ITS are exempt from the taking prohibition of section 9(a), provided that, pursuant to section 7(o) of the ESA, such taking is in compliance with the terms of the ITS. This ITS is effective upon issuance, and the action agency and applicant may receive the benefit of the take exemption as long as they are complying with the relevant terms and conditions.

Reasonable and prudent measures (RPMs) are measures determined to be necessary or appropriate to minimize the impact (i.e., amount or extent) of incidental take (50 C.F.R. §402.02). The RPMs and terms and conditions are specified as required by 50 CFR 402.14 (i)(1) to minimize the impact of incidental take of ESA-listed species by the proposed action, to document and report that incidental take and to specify the procedures to be used to handle or dispose of any individuals of a species actually taken. The RPMs must be undertaken by the appropriate Federal agency and/or the applicant so that they become binding conditions for the exemption in section 7(o)(2) to apply.

The RPMs identified here are necessary and appropriate to minimize impacts of incidental take that might otherwise result from the proposed action, to document and report incidental take that does occur, and to specify the procedures to be used to handle or dispose of any individual listed species taken. These reasonable and prudent measures and terms and conditions are in addition to the measures described as part of the proposed action (see Section 2 above). However, in some cases, the RPMs and Terms and Conditions provide additional detail or clarity to measures that are part of the proposed action. We consider that a failure to implement the measures identified as part of the proposed action in Section 2 of this Opinion would be a change in the action that may necessitate reinitiation of consultation and may render the take exemption inapplicable to the activities that are carried out.

All of the RPMs and Terms and Conditions are reasonable and prudent and necessary and appropriate to minimize or document and report the level of incidental take associated with the proposed action. None of the RPMs and the terms and conditions that implement them alter the basic design, location, scope, duration, or timing of the action and all of them involve only minor changes (50 CFR§ 402.14(i)(2)).

10.2.1 Reasonable and Prudent Measures

The following reasonable and prudent measures are necessary and appropriate to minimize and monitor incidental take of Atlantic salmon, shortnose sturgeon, and Atlantic sturgeon. These reasonable and prudent measures and terms and conditions are in addition to the measures contained in the September 2022 supplemental SPP, as well as the DEA for the Shawmut relicensing that the Licensees have committed to implement and FERC is proposing to incorporate into the project licenses. As those measures will become requirements of the amended licenses, we do not repeat them here as they are considered to be part of the proposed action.

1. Effects to ESA listed salmon and sturgeon must be minimized and monitored during project operations.

2. Project modifications and operations and effects to ESA listed species must be documented and reported throughout the life of the licenses.
3. Effects to ESA listed salmon and sturgeon must be minimized during construction activities.

10.2.2 Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, FERC and/or ACOE must comply (and ensure that the Licensees comply) with the following terms and conditions, which implement the reasonable and prudent measures above. These include take minimization, monitoring, and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)). If FERC and/or ACOE fail to ensure compliance with these terms and conditions and the reasonable and prudent measures they implement, the protective coverage of section 7(o)(2) may lapse.

To implement the requirements of reasonable and prudent measure #1, FERC must ensure that the following measures are implemented:

1. Prepare, in consultation with NMFS, a plan to measure the survival, migratory delay, and injury of downstream migrating Atlantic salmon smolts at the Lockwood, Hydro-Kennebec, Shawmut, and Weston projects using a scientifically acceptable methodology.
   a. The study must include the following components:
      i. Measure the survival of downstream migrating smolts approaching within 200 meters of the dam downstream to the point where delayed effects of passage can be quantified. At the upper three dams, this location should be at least as far downstream as 200-meters upstream of the next downstream dam. At Lockwood, Brookfield should consult with NMFS to identify a location that is sufficiently far downstream to document the effect of passage.
      ii. Document the survival and rate of movement of smolts migrating through all four project impoundments.
      iii. Use a Cormack-Jolly-Seber (CJS) model, or other acceptable approach, to determine if the survival estimate and associated error bounds are within the scope of published telemetry work for salmon in the region. Use a sufficient number of study fish to provide statistically valid results.
      iv. Procedures for the licensees to consult with NMFS concerning the application of appropriate statistical methodology and requirements for providing an electronic copy of model(s) and data to NMFS.
   b. Require Brookfield to conduct an injury assessment at the Shawmut Project, concurrent with the assessments that have been proposed at the Lockwood, Hydro-Kennebec, and Weston Projects.
   c. All tags released in the system must have codes that are not duplicative of tags used by other researchers in the river, including university, state, federal and international tagging programs.

d. FERC must only consider the downstream performance standard achieved if, based upon an average of three years, 89% (cumulative survival through the Lockwood, Hydro-Kennebec, Shawmut, and Weston projects) of smolts survive downstream passage. If, after the first or second year of the three-year evaluation, it is determined that it is statistically impossible or improbable that the standard can be met, the study will cease and additional measures will be installed as soon as possible.

2. Prepare, in consultation with NMFS, a plan to evaluate adult Atlantic salmon upstream and downstream passage at the Lockwood, Hydro-Kennebec, Shawmut, and Weston projects. The plan must include the following components:
   a. Conduct an upstream passage study at Lockwood dam within two years following construction of the bypass fishway. The study must include:
      i. Brookfield must document the amount of migratory delay that occurs.
      ii. Brookfield must monitor the survival of downstream migrating kelts approaching within 200 meters of the dam downstream to the point where delayed effects of passage can be quantified.
      iii. A Cormack-Jolly-Seber (CJS) model, or other acceptable approach, must be used to determine if the survival estimate and associated error bounds are within the scope of published telemetry work for salmon in the region. Consult with NMFS and MDMR to determine a sufficient number of study fish necessary.
      iv. Procedures for the licensees to consult with NMFS concerning the application of appropriate statistical methodology and requirements for providing a copy of model(s) and data to NMFS.
      v. All tags released in the system must have codes that are not duplicative of tags used by other researchers in the river, including university, state, federal and international tagging programs.
   b. Conduct a cumulative upstream passage study at the four projects after fishways have been constructed. These studies should be timed to occur in years that a sufficient number of motivated adults are anticipated due to the proposed stocking of smolts. The study must include:
      i. Brookfield must document the amount of migratory delay that occurs at each project.
      ii. A Cormack-Jolly-Seber (CJS) model, or other acceptable approach, must be used to determine if the passage efficiency estimate and associated error bounds are within the scope of published telemetry work for salmon in the region.
      iii. Procedures for the licensees to consult with NMFS concerning the application of appropriate statistical methodology and requirements for providing an electronic copy of model(s) and data to NMFS.

iv. All tags released in the system must have codes that are not duplicative of tags used by other researchers in the river, including university, state, federal and international tagging programs.
v. FERC must only consider the upstream performance standard achieved if, based upon an average of three years, 85% (cumulative passage through all four dams) of adult Atlantic salmon approaching the Lockwood project successfully pass upstream the Weston project. If, after the first or second year of the three-year evaluation, it is determined that it is statistically impossible or improbable that the standard can be met, the study will cease and additional measures consistent with the adaptive management plan will be installed as soon as possible.

c. At all four projects, Brookfield must install, operate, and maintain a PIT tag array near the entrance and exit of the fishways to monitor movements of salmon (all four projects) and sturgeon (Lockwood only) in the project area annually. The PIT tag array design must be submitted to NMFS for review and approval at least 60 days before initial deployment. All PIT tag data collected must be submitted in the annual report by March 31 of the following year.
d. PIT tagging all ESA-listed Atlantic salmon that are trapped and handled at the Lockwood fishway.
e. Within 6 months prior to the completion of the Lockwood bypass fishway, develop a plan in consultation with NMFS to enumerate salmon and other co-evolved sea-run fish species at the projects upon operation of the Lockwood bypass fishway.

3. Require that Brookfield operate the upstream and downstream fishways at the Lockwood, Hydro-Kennebec, Shawmut, and Weston Projects to ensure that passage of Atlantic salmon is safe, timely, and effective.
    a. Implement 12 hour nighttime shutdowns (based on the schedule and trigger defined in 3(b)) of the Unit 1 - 6 Powerhouse at the Shawmut Project, until spillway repairs and fishway construction have been completed. Once construction is complete, shutdowns of Units 1 - 6 may cease and shutdowns of Units 7 - 8 must be implemented, consistent with the proposed action.
    b. Consult annually with NMFS regarding the appropriate timing for the initiation of the implementation of downstream spill measures.
        i. When rotary screw traps are being operated and monitored in the Sandy River, turbine shutdowns must be initiated based on the timing of the first smolt captured in the trap in the spring. Twelve-hour nighttime shutdowns at Lockwood, Shawmut, and Hydro-Kennebec must occur for a minimum of four weeks, to be extended up to six weeks. The determination for extending the shutdown will be made on a weekly basis and will be based on a threshold approved by NMFS.
        ii. When rotary screw traps are not being operated and monitored in the Sandy River, twelve-hour nighttime shutdowns at Lockwood, Shawmut, and Hydro-

Kennebec will occur for an appropriate length of time (up to 54 days) to overlap with 97% of the smolt run. The timing of the shutdown will be informed by the results of the smolt run timing model.

iii. Until the new upstream fishway at Lockwood is operational, Brookfield must consult with NMFS annually regarding appropriate timing of turbine shutdowns to limit false attraction into the bypass that would delay upstream migrating adult salmon.

c. Remove any debris that could affect the ability of fish to pass either the downstream or upstream fish passages immediately upon inspection.
d. Annual maintenance requiring the shutting down of upstream fishways should be conducted during the first two weeks of August. The fishway should not be inoperable for any longer than it takes to make the necessary repairs.
e. Consult with NMFS regarding the timing of the replacement of flashboards.

4. Require that the Licensees convene a work group to coordinate the development and implementation of an adaptive management and monitoring strategy to address any potential upstream passage deficiencies in the lower Kennebec River. The Licensees will include appropriate federal, state, and tribal representatives, and the group will focus on providing comments and guidance to the licensees on study planning and adaptive management of upstream fish passage at the Lockwood, Hydro-Kennebec, Shawmut, and Weston Projects. As part of this process, Brookfield must develop an Adaptive Management and Monitoring Plan that includes:
   a. A problem statement that details the specific metrics/questions that will be addressed and managed (e.g., passage effectiveness, migratory delay, survival, injury, habitat usage between dams);
   b. Details regarding the proposed studies, including descriptions of field and statistical methodology, the source of study fish (inclusive of agreements on funding to support costs of raising and marking these fish), and anticipated timelines. The plan should be developed in coordination with USFWS and NMFS to ensure that, to the extent practicable, the use of hatchery products necessary for the evaluation of project effects does not interfere with efforts to increase escapement of naturally reared returns in the GOM DPS of Atlantic salmon;
   c. A framework for how results will be used to inform potential modifications;
   d. A list of potential operational and structural modifications to be implemented at each project to improve passage effectiveness under probable scenarios;
   e. This plan must be submitted for final approval to NMFS no later than December 31, 2024.

5. Require that Brookfield actively monitor for the stranding of listed fish downstream of the projects, as appropriate.
   a. Develop, in consultation with NMFS, an appropriate schedule for regularly surveying the ledges and pools downstream of the dams for stranded salmon (all four projects)

and shortnose and Atlantic sturgeon (Lockwood only). This plan should be completed no later than December 31, 2024.

6. Require that Brookfield update the sturgeon handling plan to incorporate the following conditions:
    a. Brookfield must record the weight, length, and condition of all sturgeon that are handled and submit this information to NMFS on the appropriate form (see: https://media.fisheries.noaa.gov/2021-07/Take%20Report%20Form%2007162021.pdf?null). Sturgeon must also be scanned for PIT tags. Fin clips will be taken and submitted to the Atlantic Coast Sturgeon Tissue Repository for genetic analysis, following NMFS recommended procedures as outlined here: https://media.fisheries.noaa.gov/dam-migration/sturgeon_genetics_sampling_revised_june_2019.pdf (or in any update to those procedures). Captured sturgeon, regardless of the presence or scale of injury, must be safely returned to the Kennebec River downstream of the Lockwood project.
    b. In the unlikely event that a dead sturgeon is observed, it should be placed on ice or be refrigerated. NMFS must be contacted immediately for further instructions on transport and/or disposal.

7. Prepare, in consultation with NMFS and consistent with NMFS' Mitigation Policy (https://www.noaa.gov/organization/administration/noaa-administrative-orders-chapter-216-program-management/nao-216-123-noaa-mitigation-policy-for-trust-resources), a plan to fund habitat restoration focusing on restoring access to, and suitability of, high value, climate resilient, spawning and rearing habitat for Atlantic salmon within the Kennebec River watershed and Merrymeeting Bay SHRU. The plan should be filed with FERC within 1 year following the issuance date of this Opinion. At a minimum, the plan should incorporate the following elements:
    a. A contribution of $300,000 ($75,000 per Project) in the aggregate annually for the first 10 years following filing of the mitigation plan for the purpose of funding habitat enhancement and connectivity projects.
    b. Mechanisms for the review of project proposals, awarding of funds, fund disbursement, and progress reporting.
    c. A review in year 10 to determine attainment of the upstream and downstream performance standard.
    d. Contingencies for the cessation or reduction of funding should the lower Kennebec River Projects attain the proposed performance standards for upstream and downstream passage within the 10-year timeframe, from the year of attainment to the expiration of the SPP.

To implement reasonable and prudent measure #2, FERC must require Brookfield to:

8. Inspect the upstream and downstream fish passage facilities at the Lockwood, Hydro-Kennebec, Shawmut, and Weston Projects daily when they are open. The licensees must submit summary reports to NMFS weekly during the fish passage season.
9. Notify NMFS of any changes in operation including maintenance activities and debris management at the project during the term of the amended license.
10. Submit as-built drawings to NMFS for the current configuration of the upstream and downstream fishways.
11. Allow NMFS staff to inspect the upstream and downstream fishways at reasonable times, including but not limited to annual engineering inspection.
12. Review and update Fishway Operations and Maintenance Plans a minimum of every three years in cooperation with NMFS. The plans must be updated as soon as possible to ensure they are consistent with the terms and conditions of this Opinion, as well as with the latest version of the State of Maine's *Atlantic salmon Trap Operating and Fish-Handling Protocols* (except where it may conflict with the terms and conditions included with this Incidental Take Statement).
13. In the event of a serious injury or mortality of any ESA listed species, allow NMFS access to investigate the source of the mortality and work in cooperation with NMFS to correct the source of serious injury/mortality.
14. Submit annual reports summarizing the results of proposed action and any takes of listed sturgeon or Atlantic salmon to NMFS by March 31.
15. Contact NMFS within 24 hours of any interactions with Atlantic salmon, shortnose sturgeon, or Atlantic sturgeon, including non-lethal and lethal takes (Matt Buhyoff: by email (Matt.Buhyoff@noaa.gov) or phone (207) 370-2797 and to: incidental.take@noaa.gov.
16. In the event of any lethal takes, any dead specimens or body parts must be photographed, measured, and preserved (refrigerate or freeze) until disposal procedures are discussed with NMFS.

To implement reasonable and prudent measure #3, ACOE must require Brookfield to:

17. Should blasting be required for the construction of the Lockwood and Weston fishways, Brookfield must develop and implement a blasting plan outlining pre-blast surveys and monitoring, blasting procedures and sequencing, and blast vibration and sound pressures. Thresholds for vibration and sound must be consistent with NMFS' most recent guidelines for acoustic thresholds for fish (https://www.fisheries.noaa.gov/s3/2023-02/ESA%20all%20species%20threshold%20summary_508_OPR1.pdf).

The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize and monitor the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, the level of incidental take is exceeded, reinitiation of consultation and review of the reasonable and prudent measures are required.

FERC must immediately provide an explanation of the causes of the taking and review with us the need for possible modification of the reasonable and prudent measures.

The discussion below explains why the RPM and Terms and Conditions are necessary and appropriate to minimize or monitor the level of incidental take associated with the proposed action and how they represent only a minor change to the action as proposed by FERC.

RPM #1 and its associated Terms and Conditions for FERC are necessary and appropriate as they describe how FERC and Brookfield will be required to implement the measures and monitor their success. Terms and Conditions #1 and #2 require that Brookfield measure their adherence to proposed action in a way that is statistically sound and appropriate; as well as adequately monitor the effects of the action. Term and condition #2 requires that Brookfield PIT tag every adult salmon that is handled at the Lockwood fishway, and install a PIT tag receiver at all of the fishway entrances and exits. This is necessary to monitor the effects of the proposed action and will provide information regarding the use of the fishway by sturgeon and salmon that have been tagged in other rivers, as well as the fate of salmon that fall back over the dam after being handled and released into the headpond.

RPM 1, Term and Condition #3 makes minor modifications to the action that will allow for more effective protection for listed Atlantic salmon.

- 3(a) requires that the turbines in the Unit 1 -6 Powerhouse be shut down at night at the Shawmut Project during the interim phase. Brookfield has proposed to defer shutting down the propeller turbines in the Unit 7 - 8 Powerhouse until the spillway and bypass modifications have been implemented, as survival through the units is the highest at the project. The Francis turbines in the Unit 1- 6 Powerhouse, however, entrain 3-21% of the smolts annually and have the lowest survival rates at the project. Therefore, shutting them down at night during the interim period prior to the completion of construction will allow for a higher overall smolt survival at the project.
- 3(b) establishes specific timing triggers and duration requirements for turbine shutdowns that are based on documented run timing and model results specific to the Sandy River. Brookfield's proposed trigger for initiation of shutdowns is when the number of expected smolts in the river drops below 50. According to MDMR, this is not a calculation that can be made in real time, as the extrapolation from trap counts to abundance in the river takes a significant amount of analysis. Therefore, we require that an alternative trigger be established in consultation with the agencies. Frechette et al. (Frechette et al., 2022) indicated that they considered the run complete when there were at least three consecutive days of zero captured fish at the rotary screw traps. A similar threshold should be established here.
- Additionally, 3(b) requires that Brookfield extend the duration of the protection window at the Lockwood, Hydro-Kennebec, and Shawmut projects. As indicated in our analysis, both the trap data and the model results indicate that 28 days is insufficient to protect salmon smolts on the Sandy, where the run persisted for 48 and 53 days (in 2021 and

2022, respectively). Frechette et al. (2022) concluded that a minimum 54-day protection window would be necessary "to account for variable timing and shape of the run" and to "preserve the adaptive variation required for populations to respond to climate-driven changes in temperature and hydrology" (Frechette et al., 2022). As such, and to be consistent with Sandy-specific empirical data, we are requiring that Brookfield extend the duration of protection under both conditions (i.e., start date triggered either by trap captures or by a smolt timing model).

- Trap captures: If trapping is occurring in the Sandy River, we are requiring that Brookfield extend the nighttime shutdowns to as much as six weeks (reevaluated weekly after week four based on an established trigger). This only obligates Brookfield to continue shutdowns for one week beyond the proposed five week period if the threshold has been exceeded.
- Smolt timing model: When trapping is not occurring, it is not possible to precisely predict when the smolt run begins and ends. Although the model is helpful, it is unlikely to predict the exact date that the run begins. For example, the model results were off by nine to thirteen days when compared to what was determined by the rotary screw traps in 2021 and 2022. This is likely due to annual variation in factors other than air temperature that influence when smolts begin to move in the spring. Given the potential discrepancy between predicted and actual run timing, the protection window must be of sufficient length that we can still conclude with confidence that a significant proportion of the run is being protected. Frechette et al. (2022) indicated that although the trap confirmed initiation date in 2021 was nine days earlier than the model predicted date, "approximately 99% of the Sandy smolt wave would have passed all four of the dams during the suggested 54-d protective window" (Frechette et al., 2022). As such, and given that the trap confirmed run timing in the Sandy varies between 48 and 53 days, we are requiring that Brookfield extend the duration of the shutdowns up to 54 days when no real time monitoring is occurring in the Sandy River or at the projects.

These modifications represent only a minor change to the proposed action as implementing them only extends an operational measure that Brookfield has already proposed, and should not significantly increase the cost of the projects.

RPM 1, Term and Condition 4 requires a planning process that will inform decisions pertaining to the adaptive management of upstream passage in the lower Kennebec. This is appropriate as the adaptive management of passage for the purpose of achieving proposed performance and migratory delay standards at these four projects is likely to be complex and require regular coordination between the Licensees and the agencies.

RPM #2 and its associated Term and Conditions for FERC and Brookfield are necessary and appropriate to ensure the proper documentation of any interactions with listed species as well as requiring that these interactions are reported to us in a timely manner with all of the necessary information. This is essential for monitoring the level of incidental take associated with the proposed action. This RPM and the Terms and Conditions represent only a minor change as compliance will not result in any increased cost, delay of the project or decrease in the efficiency of the project.

RPM considered but not adopted

Removal of the lower Kennebec River dams would eliminate effects that would otherwise occur as a result of their continued existence. However, dam removal is well outside the scope of a Reasonable and Prudent Measure. As explained above, RPMs are those measures that are necessary and appropriate to minimize impacts of incidental take that might otherwise result from the proposed action, to document and report incidental take that does occur, and to specify the procedures to be used to handle or dispose of any individual listed species taken. RPMs "cannot alter the basic design, location, scope, duration, or timing of the action and may involve only minor changes" [50 CFR §402.14(i)(2)]. Dam removal would neither be consistent with the proposed action nor be considered only a minor change. Therefore, it cannot be required as an RPM. Our RPMs focus on additional measures that will minimize the impacts of incidental take as much as possible, *without altering the basic design, location, scope, duration, or timing of the action, and that involve only minor changes*. [50 CFR §402.14(i)(2)]. We have not identified any RPMs that will allow for 100% passage effectiveness or passage survival, while maintaining compliance with the definition of an RPM.

11 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. We have determined that the proposed action is not likely to jeopardize the continued existence of endangered Atlantic salmon in the action area. To further reduce the adverse effects of the proposed project on Atlantic salmon, we recommend that FERC implement the following conservation measures.

- Consistent with our recommendation under section 10(a) of the Federal Power Act (dated August 28, 2020), evaluate decommissioning and removal of the Shawmut Project as an alternative to relicensing.
- Accelerate the timing of the proposed action components so that they are implemented as soon as all of the necessary state and federal authorizations are in place.
- FERC should require that Brookfield support any efforts to increase hatchery capacity or to develop a Kennebec broodstock program.

- FERC should require that Brookfield implement measures to further protect the coevolved suite of sea-run species in the Kennebec River, particularly river herring and American shad.
- FERC should require that Brookfield develop a comprehensive strategy to compensate for all unavoidable effects of their actions in the GOM DPS of Atlantic salmon by requiring the licensee to carry out activities that improve the environmental baseline. This could involve the removal of other barriers to fish migration, or the construction of fishways. FERC and the licensee should work closely with the state and federal fisheries agencies to identify suitable projects that contribute to the recovery of Atlantic salmon and address the effects of degradation of designated critical habitat, over the duration of the new license and license amendments.

12 Reinitiation Notice

This concludes formal consultation concerning 1) FERC's proposal to amend the existing licenses of the Weston, Shawmut, Hydro-Kennebec, and Lockwood Projects, 2) FERC's proposal to issue a new license for the Shawmut Project, and 3) ACOE's proposal to authorize the construction of new fishways at the Lockwood and Weston Projects. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of taking specified in the incidental take statement is exceeded; (2) new information reveals effects of the action that may not have been previously considered; (3) the action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this Opinion;; or (4) a new species is listed or critical habitat designated that may be affected by the identified action. In instances where the amount or extent of incidental take is exceeded, section 7 consultation must be reinitiated immediately. Reinitiation of section 7 consultation is also required should FERC, ACOE, or Brookfield not carry out the RPMs or associated Terms and Conditions contained within this Opinion.

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13.2 Atlantic Salmon

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