Appendix 6 2013 Interim Species Protection Plan (ISPP) and Biological Opinion Documents

a) 2013 ISPP for Lockwood, Shawmut and Weston Projects (February 21, 2013)
b) Biological Opinion and ITS issued by NMFS for Terms of 2013 ISPP (July 22, 2013)
c) FERC Order Amending Licenses to Incorporate 2013 ISPP (May 19, 2016)

NEXTera ENERGY RESOURCES

February 21, 2013

Ms. Kimberly Bose, Secretary
Federal Energy Regulatory Commission
Mail Code PJ 12-5
888 First Street, NE,
Washington, DC 20426

Subject: Submittal of Draft Biological Assessment and Interim Species Protection Plan for Atlantic salmon; Androscoggin River Brunswick Project (FERC Project No.2284), Lewiston Falls (FERC Project No. 2302) and Kennebec River Lockwood (FERC Project No.2574) Shawmut (FERC Project No. 2322) Weston (FERC Project No. 2325)

Dear Ms. Bose:

In a January 31, 2012 letter to the Federal Energy Regulatory Commission (Commission or FERC) on behalf of Merimil Limited Partnership, owners of the Lockwood hydroelectric project, and FPL Energy Maine Hydro LLC ("Maine Hydro"), owner of the Brunswick, Lewiston Falls, Shawmut and Weston hydroelectric projects (collectively, the "Projects"), Maine Hydro requested that the Commission designate it as the non-federal representative for the purpose of undertaking informal consultation with the National Marine Fisheries Service ("NMFS") pursuant to § 7 of the Endangered Species Act ("ESA") regarding potential Project effects to Atlantic salmon. The Commission designated Maine Hydro as the non-federal representative for such purposes by letter dated February 7, 2013.

Licensee has developed this draft Biological Assessment ("BA") that, among other things, evaluates the effects to Atlantic salmon of potential measures to be adopted to protect the species in its interactions with the Project. These measures are identified in the draft BA. Attachment A of the draft BA is the Licensee's proposed Interim Species Protection Plan ("ISPP"), containing protective measures to be implemented to protect Atlantic salmon and identifying proposed studies to gather additional Project-specific data on effects to Atlantic salmon.

Licensee collaboratively developed the provisions of this ISPP with NMFS acting as the lead agency. Therefore, it is anticipated that measures included in any Biological Opinion prepared by NMFS during formal ESA consultation with the Commission will be consistent with the protection and enhancement measures proposed in the ISPP.

Licensee respectfully requests that the Commission expeditiously initiate the formal ESA consultation process with NMFS. If you have any questions regarding this letter, please contact Bob Richter at Robert.Richter@NextEraEnergy.com or 207-242-5001.

Sincerely,

Chad P. Clark
Vice President
FPL Energy Maine Hydro LLC

e-copy: Peter Yarrington, FERC
Jeff Murphy, NMFS
Steve Shepard, USFWS
Oliver Cox, MDMR
Kathy Howett, MDEP

Draft Biological Assessment for
Atlantic Salmon at the
Lockwood, Shawmut, Weston, Brunswick and Lewiston Falls
Hydropower Projects
on the
Kennebec and Androscoggin Rivers, Maine

FPL Energy Maine Hydro LLC

and

Merimil Limited Partnership

February 21, 2013

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1.0 BACKGROUND

FPL Energy Maine Hydro LLC (Maine Hydro) owns or indirectly partially owns through its interest in the Merimil Limited Partnership five hydropower projects located on the Androscoggin and Kennebec Rivers in Maine including the Brunswick and Lewiston Falls projects on the Androscoggin River, and the Lockwood (owned by the Merimil Limited Partnership), Shawmut and Weston projects on the Kennebec River.

All five of the hydropower projects are licensed to the project owners with the Federal Energy Regulatory Commission (FERC). The expiration years for the current FERC licenses for the five projects are Brunswick (2029), Lewiston Falls (2026), Shawmut (2021), Weston (2036) and Lockwood (2036).

Portions of each of the five hydroelectric projects covered under this draft Biological Assessment (BA) occur within the range of the endangered Gulf of Maine Distinct Population Segment (GOM DPS) of Atlantic salmon, and four of the five are entirely within designated critical habitat for salmon; Lewiston Falls is partially within the designated critical habitat. Through informal consultation, the National Marine Fisheries Service (NMFS) has preliminarily determined that the continued operation of these projects is likely to have adverse effects on both the species and its designated critical habitat. To address these effects, Maine Hydro has prepared and the Licensees are proposing to implement an Interim Species Protection Plan (ISPP) for Atlantic salmon at the five projects. The ISPP outlines the specific measures for protection of the species during the interim period, and it was developed in cooperation with NMFS, U.S. Fish and Wildlife Service (USFWS), and Maine Department of Marine Resources (MDMR). The Licensees request that FERC amend each of the project licenses to incorporate the applicable terms of the accompanying proposed ISPP; this will (1) protect the listed species in the project areas; and (2) will allow the development by NMFS of Incidental Take Statements (ITSs) to account for any unavoidable “take” of Atlantic salmon.

Shortly after filing this ISPP with FERC, Maine Hydro will file an amendment detailing plans for protecting listed shortnose sturgeon and Atlantic sturgeon at the Lockwood and Brunswick projects. Maine Hydro will request FERC initiate a single, comprehensive consultation for all three species (Atlantic salmon, Atlantic sturgeon, and shortnose sturgeon) with NMFS. Accordingly, it is anticipated that NMFS will issue a single Biological Opinion (BO) for all species and projects of Maine Hydro considered in this ISPP. In addition, the final Species Protection Plan (SPP) that will be filed by Maine Hydro with FERC in 2019 will also contain protection measures for sturgeon at the projects, as applicable.

1.1 Endangered Species Act (ESA) Listing

The GOM DPS Atlantic salmon was originally listed as endangered by NMFS and USFWS (collectively, the Services) on November 17, 2000 (65 FR 69459). Subsequently, the Services expanded the endangered listing range for the GOM DPS of Atlantic salmon on June 19, 2009 (74 FR 29344). As part of the 2009 expanded listing, the Services identified impassable falls that historically restricted the upstream riverine range of listed Atlantic salmon on the Kennebec and Androscoggin Rivers. On the Kennebec, Atlantic salmon historically ranged to

Grand Falls on the Dead River in Township 3 Range 4 BKP WKR, and to an unnamed falls impounded by Indian Pond Dam that is located directly upstream from the Kennebec River Gorge in the township of Indian Stream (USFWS and NMFS 2009). On the Androscoggin, Atlantic salmon historically ranged to Rumford Falls in Rumford, Maine. As a result, the geographic boundaries of the freshwater range of GOM salmon on the Kennebec and Androscoggin rivers included all freshwater bodies up to the aforementioned historically impassable falls, thus encompassing the Lockwood, Shawmut, Weston, Brunswick and Lewiston Falls project areas. Coincident with the June 19, 2009 endangered listing, NMFS designated critical habitat for the GOM DPS of Atlantic salmon (74 FR 29300; June 19, 2009).

1.2 Merrymeeting Bay Salmon Habitat Recovery Unit (SHRU)

To accommodate the life history characteristics of Atlantic salmon, the Services have established a geographic framework for the GOM DPS represented by three Salmon Habitat Recovery Units (SHRUs) which they concluded would be reasonably protective of the species and to ensure that Atlantic salmon are widely distributed across the DPS to provide protection from demographic and environmental variation. The three SHRUs established by the Services include the Downeast Coastal SHRU, the Penobscot Bay SHRU, and the Merrymeeting Bay SHRU.

The Merrymeeting Bay SHRU includes two large river basins: the Androscoggin and Kennebec River watersheds, as well as the smaller Sheepscot, Medomak, and St George river watersheds (NMFS, 2009b). All five of the projects are located within the Merrymeeting Bay SHRU.

1.3 Critical Habitat Designation for Atlantic Salmon

1.3.1 Critical Habitat in the Project Areas

Critical habitat in the mainstem of the Kennebec River begins in the Kennebec River estuary and extends upstream on the mainstem to the base of the Abenaki Dam in Madison and into the Sandy River. The Lockwood, Shawmut and Weston projects are all located within Atlantic salmon critical habitat.

Critical habitat in the mainstem of the Androscoggin River begins at the confluence with the Kennebec, and extends upstream to Lewiston Falls in Lewiston/Auburn and into the lower Little Androscoggin River in Auburn. The Brunswick project is located wholly within the designated critical habitat, while the Lewiston Falls project is partially located within the critical habitat.

1.3.2 Primary Constituent Elements

As a result of the June 19, 2009 Atlantic salmon listing, the Services were required to evaluate historical occupancy of the watershed scale for the process of designating critical habitat for the GOM DPS. Section 3 of the ESA defines critical habitat as:

1. Specific areas within the geographical area occupied by the species at the time of listing, in 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; and

2. Specific areas outside the geographical area occupied by the species at the time of listing that are essential for the conservation of a listed species.

As part of the critical habitat designation, the Services described the known primary constituent elements (PCEs) that are deemed essential to the conservation of the GOM DPS Atlantic salmon, including (1) sites for spawning and rearing, and (2) sites for migration (excluding marine migration). The physical and biological features of the two PCEs for Atlantic salmon critical habitat are as follows.

1.3.3 Physical and Biological Features of the Spawning and Rearing PCE

A1. 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.

A2. 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.

A3. 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.

A4. Freshwater rearing sites with space to accommodate growth and survival of Atlantic salmon parr.

A5. 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.

A6. Freshwater rearing sites with cool, oxygenated water to support growth and survival of Atlantic salmon parr.

A7. Freshwater rearing sites with diverse food resources to support growth and survival of Atlantic salmon parr.

1.3.4 Physical and Biological Features of the Migration PCE

B1. 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.

B2. 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.

B3. Freshwater and estuary migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation.

B4. Freshwater and estuary migration sites free from physical and biological barriers that delay or prevent emigration of smolts to the marine environment.

B5. Freshwater and estuary migration sites with sufficiently cool water temperatures and water flows that coincide with diurnal cues to stimulate smolt migration.

B6. Freshwater migration sites with water chemistry needed to support sea water adaptation of smolts.

On June 19, 2009, NMFS designated as critical habitat 45 specific areas occupied by the GOM DPS of Atlantic salmon at the time of listing. Critical habitat includes the stream channels within the designated stream reaches and includes a lateral extent as defined by the ordinary high-water line (33 CFR 329.11). Critical habitat in estuaries 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 is designated to include all perennial rivers, streams, and estuaries and lakes connected to the marine environment within the range of the GOM DPS, except for those particular areas within the range which are specifically excluded (NMFS 2009a).

2.0 PURPOSE AND DESCRIPTION OF DRAFT BIOLOGICAL ASSESSMENT

The Services have indicated that activities related to the recent listing of the GOM DPS of Atlantic salmon in Maine will be jointly managed and administered; however, NMFS will have the lead on issues pertaining to dams and their effects on Atlantic salmon and their critical habitat. NMFS believes the hydroelectric projects operating on the Kennebec and Androscoggin rivers, including the Lockwood, Shawmut, Weston, Brunswick, and Lewiston Falls projects, may have an effect on the listed Atlantic salmon or its critical habitat. The ESA prohibits the take of endangered species, including the GOM Atlantic salmon DPS, unless the take is authorized under specific provisions of the ESA. "Take" is defined by the ESA as "to harass, harm, pursue, ban, shoot, wound, kill, trap, capture, or collect," or to attempt to engage in any such conduct.

Authorization can be provided by the Services through the issuance of a permit under Section 10 or Section 7 of the ESA. Under ESA Section 10(a)(l)(B), permits may be issued for taking that is incidental to the purposes of an otherwise lawful activity (incidental take permits). Under ESA Section 7(a)(2), ITSs may be issued to exempt from the prohibitions any potential mortality as an incidental result of an activity conducted, permitted, or funded by a federal agency, provided this take would not be likely to result in jeopardy to the species or destruction of its critical habitat. Section 7 of the ESA mandates that when a federal action is pending, all federal agencies consult with the Secretaries of Commerce (through NMFS) and Interior (through the USFWS) to determine whether a proposed action is likely to be categorized, with respect to listed species and designated critical habitat, as follows:

1. *No Effect:* No effects to the species and its critical habitat from the proposed action, either positive or negative, are expected.

2. *May Affect, Not Likely to Adversely Affect:* All effects of the proposed action to the species and its critical habitat are beneficial, insignificant, or discountable. Beneficial effects have positive effects to the species or its critical habitat. Insignificant effects relate to the size of the impact and should not reach the scale where incidental or unintentional take (harming or killing) occurs. Discountable effects are those that are extremely unlikely to occur. Determinations of "not likely to adversely affect" due to beneficial, insignificant, or discountable effects require written concurrence from the USFWS or NMFS.
3. *May Affect, Likely to Adversely Affect:* The action would have an adverse effect on the species or its critical habitat. Any action that would result in take of an endangered species is considered an adverse effect. A combination of beneficial and adverse effects is still considered "likely to adversely affect," even if the net effect is neutral or positive. An effect that can be detected in any way is not insignificant and is considered an adverse effect. Adverse effects are not considered discountable because they are expected to occur. This determination requires formal consultation with the USFWS or NMFS.

The information in this draft BA will be used by FERC to prepare a BA to submit to NMFS to determine whether formal consultation is necessary [50CFR §402.02; 50 CFR §402.12). The regulations under Section 7 mandate a formal consultation when an agency determines that a proposed action is likely to adversely affect a listed species or designated critical habitat.

On behalf of the project Licensees, Maine Hydro has been consulting with NMFS, USFWS and other agencies to develop a thorough evaluation of project effects and an ISPP for the operation of its five hydroelectric projects (Attachment A). The ISPP has been prepared to enhance the restoration of Atlantic salmon while also avoiding and minimizing potential impacts associated with the five projects operated by the Licensees that are covered under this BA. On behalf of the Licensees, Maine Hydro will submit the draft BA and ISPP to FERC. FERC will review and finalize the documents and, as appropriate, initiate ESA consultation with NMFS. NMFS will review the BA submitted by FERC and, if appropriate, develop a BO that makes the determination if the effects from the projects avoid jeopardy to the GOM DPS Atlantic salmon. If NMFS determines that continued operation of the projects is not likely to jeopardize the continued existence of Atlantic salmon or adversely modify or destroy designated critical habitat, the BO will include an ITS which will list "reasonable and prudent" measures to minimize take and, with these measures, exempt the Licensees from "takings" liability with respect to Atlantic salmon, during the term covered by the ISPP. FERC will then amend the existing FERC licenses for the five projects included in this draft BA to incorporate the applicable terms of the ISPP.

Shortly after filing this ISPP with FERC, Maine Hydro will file an amendment detailing plans for protecting listed shortnose sturgeon and Atlantic sturgeon at the projects. Maine Hydro will request FERC initiate a single, comprehensive consultation for all three species (Atlantic salmon, Atlantic sturgeon, and shortnose sturgeon) with NMFS. Accordingly, it is anticipated that NMFS will issue a single BO for all species and projects of Maine Hydro considered in this ISPP. In addition, the final SPP that will be filed by Maine Hydro with FERC in 2019 will also contain protection measures for sturgeon at the projects, as applicable.

2.1 Agency Consultation and Review of Ongoing Operations for their Interactions with Listed Fish

Following the listing of GOM DPS Atlantic salmon, on July 30, 2009 Maine Hydro sent a letter to NMFS stating its intention to take measures to protect Atlantic salmon. That letter was followed by another letter in August, 2009, in which Maine Hydro stated its intention to work with NMFS on the Atlantic salmon issue. Over the next several months, Maine Hydro met several times with representatives of NMFS, USFWS and the State of Maine to discuss the Atlantic salmon listing and to review the ITP process. In a letter dated May 21, 2010 Maine Hydro informed NMFS of its intent to initiate formal ITP procedures under ESA Section 10. On September 23, 2010, Maine Hydro met with NMFS regional staff to discuss the Section 10 HCP process and to review the content requirements of an HCP. In October, 2010, Maine Hydro initiated the Section 10 process and formed a Technical Advisory Committee and Steering Committee. The Committees met numerous times in 2011-2012, and Maine Hydro prepared a draft HCP that was provided to the agencies in February, 2012.

In November, 2012, Maine Hydro met again with NMFS to discuss the steps necessary to obtain take authorization at the five projects under Section 7. On January 30, 2013, Maine Hydro met again with NMFS, and NMFS agreed that both initiation of informal consultation under Section 7 and subsequent preparation of an ISPP and draft BA, would be the appropriate steps to allow NMFS to authorize take of Atlantic salmon at the five projects. On January 31, 2013, Maine Hydro requested that FERC designate them the Commission's non-federal representative for informal ESA consultation with NMFS regarding Atlantic salmon; FERC granted this request on February 7, 2013.

2.2 Assess the Potential Measures Proposed in the Species Protection Plan to Impact Listed Fish

To obtain an incidental take statement or permit through Section 7 or 10 of the ESA, there must be sufficient data available to determine whether a take is occurring, and if so, to quantify that take. Consistent with a previous fish passage agreement between the Licensees and state and federal agencies (the Kennebec Hydro Developers Group Agreement or "KHDG Agreement"), over the past several years, Maine Hydro has undertaken certain fish passage monitoring studies at the Lockwood Project. Despite these efforts, quantitative assessment of fish passage for Atlantic salmon at the five projects on the Kennebec and Androscoggin rivers is limited, and not sufficient to precisely determine the potential impact on the listed species.

Maine Hydro has developed an ISPP (Attachment A), which includes protection measures and proposed studies for Atlantic salmon, in order to identify enhancements to avoid and minimize impacts to salmon related to the operation of the five hydropower projects. The ISPP will be used to specify actions to be taken by the project Licensees to protect the species and form the basis for a Section 7 consultation with FERC, and its term will be for the period of time necessary to conduct studies at the projects and implement enhancements. The ISPP is included as Attachment A to this draft BA.

3.0 PROJECT DESCRIPTION

3.1 Lockwood Project

The Lockwood Project, owned by the Merimil Limited Partnership, is a 6.8 MW hydroelectric project located at river mile 63 and is the first dam on the mainstem Kennebec River (Figure 1). The Lockwood Project includes an 81.5-acre reservoir, an 875 ft long and 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 at or near the U.S. Route 201 Bridge along a site known as Ticonic Falls. The east spillway section begins at the east abutment of the dam and extends about 225 ft in a westerly direction to a small island. The west spillway extends about 650 ft from the small island in a southwesterly direction to the forebay canal headworks, which extend to the west bank of the river. Each spillway is equipped with 15 inch high flashboards.

From the headworks, the forebay canal directs water to two powerhouses located on the west bank of the Kennebec River. The original powerhouse contains six generating units, each with a hydraulic capacity of 660 cfs, and the second powerhouse contains one generating unit with a hydraulic capacity of 1,700 cfs (Table 3.1-1). At maximum flow efficiencies for these turbines range from 82 to 86 percent, and at minimum flow efficiencies range from 10 to 51 percent.

Table 3.1-1. Lockwood Project Generating Unit Summary

Units	Turbine Design/Type	Hydraulic Capacity	Rotation Speed (rpm)	Number of Blades/ Buckets	Max Flow		Peak Efficiency Flow		Min Flow	
					CFS	Effic. (%)	CFS	Effic. (%)	CFS	Effic. (%)
Unit 1	Francis/vertical	660 cfs	133.0	11	721	86	600	90	266	25
Unit 2	Francis/vertical	660 cfs	133.0	11	679	85	607	90	297	10
Unit 3	Francis/vertical	660 cfs	133.0	11	710	84	597	90	266	26
Unit 4	Francis/vertical	660 cfs	133.0	11	666	82	607	90	239	32
Unit 5	Francis/vertical	660 cfs	133.0	11	676	86	578	90	289	51
Unit 6	Francis/vertical	660 cfs	133.0	11	670	82	599	90	314	51
Unit 7	Kaplan/ horizontal	1,700 cfs	144.0	5	1,689	86	775	90	111	35

The Lockwood Project impoundment is 1.2 miles long encompassing a surface area of 81.5 acres and a gross storage volume of only 250 acre-feet. The Lockwood impoundment is riverine in nature and has no significant embayments or shoal areas. The impoundment width is nearly uniform throughout. The substrate of the impoundment consists of a mixture of bedrock, cobble, and rubble with gradual accumulations of silt deposits moving from upstream to downstream. A few shallow littoral areas with gravel or finer substrate and scattered submerged aquatic vegetation beds exist, but much of the shoreline is steep, with depths of 5 feet only a few feet from the shoreline (FERC, 2005).

Project Operation

The Lockwood Project operates as run-of-river. Impoundment drawdowns are generally limited to no more than six inches below the top of the spillway flashboards when the flashboards are in place, and no more than one foot below the spillway crest when the flashboards are being replaced.

The Lockwood Project is operated to provide a minimum flow of 2,114 cfs, or inflow, whichever is less. In addition, three orifices, each three feet long by eight inches high, are annually placed along the spillway. The purpose of the orifices is to pass a 50 cfs minimum flow into the bypass reach. The orifices also provide downstream passage routes along the spillway even when the project is not spilling over the top of the flashboards. During periods of no spillage (approximately 30 percent of the time on an annual basis), the bypassed reach receives leakage plus orifice flows, which range from approximately 50 cfs at full headpond level to approximately 30 cfs at a drawdown of 6inches below the top of the flashboards. During flashboard installation, the reach receives only leakage flows.

Upstream Fish Passage

In accordance with the FERC license and the 1998 KHDG Agreement, the Licensee for the Lockwood Project (Merimil Limited Partnership or Merimil), completed construction of a fish lift, trap, sort and transport system in 2006. The system was completed and became operational in May, 2006. In consultation with resource agencies, the Licensees developed operational and effectiveness study plans for the new fish lift. These plans were filed with FERC on January 30, 2006, and approved on April 26, 2006.

The Lockwood fish lift facility is located on the west side of the powerhouse adjacent to Unit 7.The lift operates with an attraction flow of up to150 cubic feet per second (cfs), and entrance water velocities are 4 to 6 ft per second (fps). The lift has an approximate 10 minute cycle time.

The attraction flow attracts the fish through the fish lift entrance gate into the lower flume of the fish lift. The fish then swim through a vee-gate crowder and remain in the lower flume of the lift. During the cycling process, the vee-gate crowder closes to hold the fish in the hopper area. The 1,800 gallon water-filled hopper lifts the fish to the holding tank elevation and the fish are sluiced into the 2,500 gallon round discharge tank. Liquid oxygen is introduced into all tanks via carbon micro porous stones to reduce stress and mortality. Two auxiliary water pumps provide a constant flow of ambient river water to all the tanks, and they provide ambient river water to the stocking trucks. The fish lift operates to accommodate all target species, and attraction flows are passed continuously during lift operation. The fish lift is designed to pass up to 164,640 alewives, 228,470 American shad and 4,750 Atlantic salmon per year.

The sorting and trucking portion of the facility includes: one 2,500 gallon, 12 ft diameter, round discharge tank, which collects fish discharged from the 1,800 gallon fish lift hopper; two 1,250 gallon, 10 ft diameter, round holding tanks that sluice fish into MDMR stocking trucks; and one 250 gallon, rectangular holding tank for Atlantic salmon. The 2,500 gallon discharge tank is also equipped with piping that can discharge fish back into the tailrace.

The Lockwood upstream fish passage facility is operated seasonally as necessary to ensure effective operation of the facility. Under a cooperative agreement, the project owner is responsible for capturing shad, river herring and Atlantic salmon, and the MDMR is responsible for collecting biological data and trucking fish to upstream spawning locations. MDMR's roll in handling fish at the Lockwood Project is expected to continue through the term of this ISPP, and authorization for take will be covered under a Section 10 research permit issued by USFWS to MDMR.

During the fish lift operation season, the Licensee coordinates daily with the MDMR regarding sorting, counting and trucking operations. During the river herring, American shad and Atlantic salmon migration season (approximately May through mid-July), the fish lift is generally manned seven days per week, as necessary, to meet resource agency trap and truck requirements. During the run, the fish lift is generally operated from early morning to late afternoon.

During other times of the year, the fish lift is generally operated three to five times per day, seven days per week for Atlantic salmon capture. The Licensee determines the precise timing of the fish lift operation, in consultation with the MDMR, based on factors such as the number of migrating fish, water temperature, time of year, and river flow. As outlined in the ISPP, the Licensee proposes to increase the fish lift cycle to five to eight times per day.

During periods of fish lift operation, personnel routinely monitor four underwater cameras that are connected to a monitor and DVD recorder. The monitor and DVD recorder are located in the control room of the fish lift and typically record from dawn until dusk. The cameras are also used in real time to help determine the presence of fish in the lift and maximize fishing effectiveness.

Camera 1 is located just downstream of the vee-gates and provides a good view of fish moving through the vee-gates into the hopper area. Camera 2 is located just upstream of the entrance gate and provides a good view of fish swimming towards and into the fish lift. Camera 3 is located in the river just downstream of the fish lift entrance gate. This location provides a view of the tailrace area below the entrance gate. Camera 4 is positioned between the entrance gate and sorting tank sluice pipe on the edge of the river. This camera offers another good view of the fish lift entrance gate vicinity. Since all four cameras show good detail, fishway personnel are able to identify species, obtain an approximate number of fish, and initiate the lift cycle manually, when appropriate.

Downstream Fish Passage

In accordance with the KHDG Agreement, the project Licensee is also providing interim measures for downstream Atlantic salmon passage at Lockwood. In 2006, the MDMR began transporting adult Atlantic salmon from the Lockwood fish lift to above the Weston Project. In addition, the MDMR has been stocking Atlantic salmon eggs in the Sandy River above the Weston Project since 2003.

In 2009, the project owner installed a permanent downstream fish passage facility in the Lockwood power canal. This facility consisted of a 10 ft deep floating boom leading to a new 7 ft wide by 9 ft deep fish sluice and associated mechanical over-flow gate. Maximum flow through the gate is 6% of station capacity or 340 cfs. The sluice is located on the river side of the power canal just upstream of the Unit 1 trash rack and discharges directly into the river. To enhance use of the sluice gate, a guidance boom is seasonally installed in the power canal. The boom is approximately 300 ft long, is secured on the land side of the canal, and angles downstream to the new sluice gate. The boom has flotation, and is suspended in the water column.

The 2009 shakedown period and associated evaluation of the new floating guidance boom and surface sluice gate indicated that the boom was not buoyant and strong enough to handle existing unit flows, and thus would not fully meet the Licensee's needs. In the winter of 2009/2010, the Licensee reviewed the available floating boom products on the market and subsequently selected a product manufactured by "Tuffboom".

By early April 2010, the Licensee developed a new guidance boom design and consulted with resource agency personnel. The new design consists of two ten-foot-long plastic cylindrical "Tuffboom" brand floats per section (i.e., 30 sections which equate to 300-feet-long) with a four-foot-deep section of 5/16-inch metal punch plate located in between the floats. Attached to the punch plate is 6 feet of the 5/16-inch dynema netting used in the 2009 system. All gaps between the panels are covered by rubber flanges. The new boom was installed in May of 2010 and then evaluated using Atlantic salmon smolts and PIT tags. The results of the PIT tag tests were suspect due to issues associated with PIT tag antenna interference, limited PIT tag antenna range, and non-detection of fish.

The Licensee subsequently conducted another evaluation using radio telemetry techniques in the spring of 2011. Based upon the 2011 study results, a number of recommendations for enhancing the downstream bypass for Atlantic salmon smolts at Lockwood were developed. These modifications, which were implemented in the spring of 2012, included the replacement of 32 feet of the downstream section of the boom with 10 foot deep metal punch plate panels (to replace the vulnerable portion of the existing netting). The modification also included a new flexible attachment point and new larger floats. And finally, the existing trash rack exclusion bars at the entrance of the bypass, which were causing noise and vibration, were removed.
The Licensee completed a second Atlantic salmon smolt radio telemetry downstream passage study at Lockwood in the spring of 2012. The purpose of the study was to evaluate the effectiveness of the guidance boom modification completed earlier that spring.

During the spring 2012 study, five groups of radio-tagged smolts were released upstream of the Weston Project and their passage routes and bypass usage were recorded at Weston, Shawmut and Lockwood. Two groups of radio-tagged smolts were released upstream of Lockwood, and their passage routes and bypass usage were recorded at the Lockwood Project. Additional data on smolt passage routes and bypass usage at Lockwood were collected from four groups of smolts radio-tagged and released upstream of the Hydro-Kennebec Project, located about one mile upstream from Lockwood. Kennebec River flow conditions during the 2012 study did not allow for all turbine units to run at a 100% gate setting; however, river conditions did allow for the evaluation of passage routes under limited to no spill conditions at Weston, Shawmut and Lockwood, as well as the assessment of downstream passage effectiveness at the Weston and Lockwood Projects. Kennebec River flows during smolt releases were low (exceeded 94% of the time based on the May flow duration curve for the Lockwood Project). Smolt releases were conducted during the latter part of the 2012 smolt run, as evidenced by the lack of smolts observed in rotary screw trap catches on the Sandy River for all dates following the day prior to the first test release. Results of the 2012 study at Lockwood were as follows:

- Discharge through the bypass was held constant throughout the study period at 6% of actual powerhouse flows. When smolts from all releases are combined, the bypass effectiveness rate of radio-tagged individuals entering the Lockwood forebay canal (n = 128) was 66.4%. This was a significant improvement over the 2011 bypass effectiveness (20.9% at 6% of powerhouse flow), which indicates that the modifications completed during spring 2012 improved downstream passage conditions for smolts.
- Bypass effectiveness was lower for individuals released directly upstream of Lockwood (33.3%) than those released upstream of Hydro-Kennebec (81.0%). This seems to confirm the theory that additional acclimation time in the river allows smolts to approach the Lockwood Project in a more natural manner.
- Passage route data were collected at Lockwood for a total of 153 smolts. Individual smolts detected passing Lockwood were originally released upstream of the Weston (n = 42), Hydro-Kennebec (n = 72) and Lockwood (n = 39) Projects. Of the 153 smolts which passed the Lockwood Project, 55.6% (85 of 153) passed through the downstream bypass, 13.7% (21 of 153) passed through the Kaplan turbine, 14.4% (22 of 153) passed through the Francis turbines and 15.7% (24 of 153) passed on spill.
- When all smolts successfully using the downstream bypass along with those which were detected in close proximity to the entrance at the Lockwood Project are considered, 85.9% of smolts were guided to the downstream bypass entrance when set at 6%.
- Of the 153 smolts passing the Lockwood Project, 20 (13.1%) were determined during manual tracking efforts to be stationary downstream of the Project and one individual was still in the forebay canal at the conclusion of the study. Of the resulting 132 smolts that continued downstream movement, 93% (123 of 132) passed the downstream Lockwood Monitoring Station 6.
- The impact of the 66.4% bypass effectiveness rate (observed at 6% of station flow during spring 2012) on estimated whole station smolt survival (Normandeau, 2012c) was examined for median (50% occurrence) and low flow (10% occurrence) river conditions; estimated whole station survival at Lockwood increased from 92% to 94% under median river conditions and from 90% to 94% under low flow river conditions.

In addition to the new surface sluice gate and associated guidance boom, downstream passage is also provided through the three orifices, 3 ft long by 8 inches high, cut into the flashboards along the spillway. The orifices pass approximately 50 cfs, and provide downstream passage routes along the spillway even when the project is not spilling over the top of the flashboards. In addition, river flows exceed the turbine capacity for much of the time period that downstream fish migrations occur, thus providing substantial passage capability via spill over the dam.

3.2 Shawmut Project

The Shawmut Project, owned by Maine Hydro, is located at river mile 66 and is the third dam on the mainstem of the Kennebec River (Figure 2). The Shawmut Project includes a 1,310-acre reservoir, a 1,135 ft long dam with an average height of about 24 feet, headworks and intake structure, enclosed forebay, and two powerhouses. The crest of the dam has a 380 ft section of 4 ft high hinged flashboards serviced by a steel bridge with a gantry crane; a 730 ft long section of dam topped with an inflatable bladder composed of three sections, each 4.46 ft high when inflated; a 25 ft wide by 8 ft deep log sluice equipped with a timber and steel gate; and a surface sluice (4 ft wide by 22 inches deep), next to Unit # 7, which discharges into a 3 ft deep man-made plunge pool.

The headworks and intake structure are integral to the dam and the powerhouse. The forebay intake section contains eleven headgates and two filler gates. A non-overflow concrete gravity section of dam connects the west end of the 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 1912 powerhouse located to the east, and the 1982 powerhouse located to the south. Located at the south end of the forebay between the two powerhouses is a 10 ft wide by 7 ft deep Taintor gate and a 6 ft wide by 6 ft deep gate. The 1912 powerhouse contains six generating units, and the 1982 powerhouse contains two generating units (Table 3.2-1).

Table 3.2-1. Shawmut Project Generating Unit Summary

Units	Turbine Design/Type	Hydraulic Capacity	Rotation Speed (rpm)	Number of Blades/ Buckets	Max Flow		Peak Efficiency Flow		Min Flow	
					CFS	Effic. (%)	CFS	Effic. (%)	CFS	Effic. (%)
Unit 1	Francis/ horizontal	650 cfs	200.0	10 X 4	648	78	581	83	400	52
Unit 2	Francis/ horizontal	650 cfs	200.0	10 X 4	645	80	583	84	438	41
Unit 3	Francis/ horizontal	650 cfs	200.0	10 X 4	641	82	581	84	453	40
Unit 4	Francis/ horizontal	650 cfs	200.0	13 X 4	672	71	539	81	367	67
Unit 5	Francis/ horizontal	650 cfs	200.0	10 X 4	742	71	520	84	326	55
Unit 6	Francis/ horizontal	650 cfs	200.0	13 X 4	667	78	575	83	264	37
Unit 7	Propeller/ horizontal	1,200 cfs	160.0	3	N/A	N/A	1,312	82	N/A	N/A
Unit 8	Propeller/ horizontal	1,200 cfs	160.0	3	N/A	N/A	1,347	85	N/A	N/A

Project Operation

The Shawmut Project typically operates as run-of river, with a target reservoir elevation near the full pond elevation of 112.0 ft during normal conditions. The maximum hydraulic capacity of the turbines is 6,755 cfs. After maximum flow to the turbines has been achieved, excess water is spilled through the existing log sluice. When flows exceed the capacity of the log sluice, sections of the rubber dam are deflated to pass additional water.

Upstream Fish Passage

The Shawmut Project has historically used the Lockwood fish lift and transport system as its means of interim upstream fish passage since 2006. The MDMR capture Atlantic salmon (and other anadromous species) at the Lockwood lift and transport the fish in trucks to areas of suitable habitat, primarily the Sandy River, which is upstream of the Shawmut Project.

Downstream Fish Passage

Interim downstream passage for Atlantic salmon at Shawmut is provided through a sluice located on the right-hand side of the intake structure next to Unit 6. The sluice, which is manually adjusted and contains three stoplogs, is 4 ft wide by 22 in. deep. With all stoplogs removed, this sluice passes flows between 30 and 35 cfs. Flows from this sluice discharge over the face of the dam and drain into a man-made 3 ft deep plunge pool connected to the river.

In addition, there is a Taintor gate located next to this sluice that measures 7 feet high by 10 feet wide and can pass 600 cfs. This gate is used to pass debris and excess flows, which also discharge over the face of the dam into a shallow plunge pool connected to the river.

In 2009, Maine Hydro engineers, operations personnel, and biologists investigated options to resolve both ongoing debris issues and downstream anadromous and catadromous fish passage needs at Shawmut. It was agreed that options for debris resolution could be designed to also address downstream fish passage needs. In 2010, Maine Hydro subsequently hired a team of consultants, including Wright Pierce Engineers, Alden Research Labs and Blue Hill Hydraulics, to design a new facility at the Shawmut Project that would address both the debris and fish passage needs.

In 2011, the Licensee, in consultation with resource agencies, developed designs for a new combined intake structure and downstream fish bypass facility at the Project. At that time, the proposed facility included the use of new full depth one inch angled trashracks and a new surface sluice and flume leading to the river. The proposed location and design of this facility, which resulted from significant efforts in hydraulic modeling and evaluation of alternatives by both the Licensee and resource agencies, was just upstream of the existing intake structure. However, the need for this proposed facility is being re-evaluated in light of favorable results from a 2012 downstream smolt study conducted at Shawmut. This study indicated that the majority of study smolts (over 80%) used the existing forebay Taintor gate for successful downstream passage. The Licensee will continue evaluations of downstream smolt passage at Shawmut and discussions with the resource agencies regarding how to provide safe and efficient passage to downstream migrants at the Shawmut Project.

The Licensee completed an Atlantic salmon smolt radio telemetry downstream passage study involving the Shawmut Project in the spring of 2012. The primary focus of the study was on the Lockwood and Weston projects, but the study was utilized to also gain information on bypass effectiveness at Shawmut. During the spring 2012 study, five groups of radio-tagged smolts were released upstream of the Weston Project and their passage routes and bypass usage were recorded at Weston, Shawmut and Lockwood. Results of the 2012 study at Shawmut were as follows:

- The Shawmut Taintor gate, which was fully opened to simulate a surface sluice, passed approximately 600 cfs for the duration of the study. Relative to the total flows observed during 2012, 600 cfs represented from 9-17% of actual powerhouse flow. When all smolts entering the Shawmut forebay canal are considered (n = 64), 82.8% of smolts passing Shawmut used the downstream bypass. When examined by setting, 100% (15 of 15) of smolts passed Shawmut with the bypass releasing 9-11% of powerhouse flow, 80.0% (24 of 30) of smolts passed Shawmut with the bypass releasing 12-13% of powerhouse flow, and 73.7% (14 of 19) of smolts passed Shawmut with the bypass releasing 15-17% of powerhouse flow.
- Of the 65 smolts which passed the Shawmut Project, 81.5% (53 of 65) passed through the Taintor gate, 16.9% (11 of 65) passed through the propeller turbines, and 1.5% (1 of 65) passed on spill.
- When all smolts successfully using the downstream bypass along with those which were detected in close proximity to the entrance at the Shawmut Project are considered, 100.0% of smolts were guided to the downstream bypass entrance when set at 9-11%, 86.7% of smolts were guided to the downstream bypass entrance when set at 12-13%, and 94.7% of smolts were guided to the downstream bypass entrance when set at 15-17%.
- Of the 65 smolts passing the Shawmut Project, five (7.7%) were determined during manual tracking efforts to be stationary downstream of the Project. Of the resulting 60 smolts that continued downstream movement, 97% (58 of 60) passed the downstream Shawmut Monitoring Station 5.
- The impact of the 82.8% bypass effectiveness rate (observed over all flow conditions during spring 2012) on estimated whole station smolt survival (Normandeau, 2012b) was examined for median (50% occurrence) and low flow (10% occurrence) river conditions; estimated whole station survival at Shawmut increased from 90% to 95% under median river conditions and from 89% to 95% under low flow river conditions.

3.3 Weston Project

The Weston Project, owned by Maine Hydro, is located at river mile 82 in the Town of Skowhegan and is the fourth dam on the mainstem of the Kennebec River (Figure 3). The Weston Project includes a 930-acre reservoir, 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. U.S. Route 2 crosses the island, spanning the South Channel impoundment above South Channel dam and the North Channel bypass section located below the North Channel dam.

The North Channel dam is a concrete gravity and buttress dam 38 ft high, with a crest elevation of 156.0 feet. The dam extends about 529.5 ft 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 North Channel dam consists of four sections: a 22.5 ft long concrete non-overflow section; a 244 ft long stanchion section with five bays; a 160.5 ft long pneumatic gate section with 7.5 ft high steel panels; and a 93 ft long gated section (located next to the island) containing two steel Taintor gates. The normal full pond elevation of the impoundment is 156.0 ft.

The South Channel dam is a concrete gravity and buttress dam 51 ft high, with a crest elevation of 156.0 ft. The dam extends about 391.5 ft between abutment walls from the island to the south riverbank and consists of five sections: a 125 ft long powerhouse/intake section; a 33 ft long concrete spillway section; a 24 ft long sluice section; a 188 ft long stanchion section with five bays; and a 21.5 ft long concrete non-overflow section. The powerhouse/intake section of the dam, located adjacent to the north abutment and integral to the project dam, includes the headworks and four intake bays, one for each of the four turbine generator units. Each bay houses three reinforced concrete gates that can isolate flow to the individual turbines; the hydraulic capacity for each turbine is 1,450 cfs (Table 3.3-1). The trashracks, which are situated in front of the gate slots, are cleaned using a motor-operated trash rake. The concrete spillway section has a permanent crest elevation of 154.0 ft and is topped by 2 ft high stoplogs. A 14 ft high Taintor gate controls flows through the sluice section, which extends 69.5 ft downstream.

Table 3.3-1. Weston Project Generating Unit Summary

Units	Turbine Design/Type	Hydraulic Capacity	Rota-tion Speed (rpm)	Number of Blades/ Buckets	Max Flow		Peak Efficiency Flow		Min Flow	
					CFS	Effic. (%)	CFS	Effic. (%)	CFS	Effic. (%)
Unit 1	Francis/vertical	1750 cfs	100.0	13	1,750	82	1,614	90	434	49
Unit 2	Francis/vertical	1500 cfs	100.0	16	1,498	83	1,207	88	426	73
Unit 3	Francis/vertical	1750 cfs	100.0	13	1,750	84	1,614	90	434	49
Unit 4	Francis/vertical	1700 cfs	100.0	16	1,710	81	1,428	87	634	63
Unit 4 planned	Francis/vertical	1900 cfs	100.0	13	1,900	87	1,688	90	TBD	

Project Operation

The Weston Project operates as run-of-river by maintaining the impoundment water surface elevation within one foot of the full pond elevation of 156.0 ft msl, during normal operations. The existing FERC license requires the project to provide an instantaneous minimum flow of 1,947 cfs or inflow, whichever is less.

The hydraulic capacity of the Weston Project is currently 6,075 cfs. When river flow exceeds the hydraulic capacity of the turbines, excess water is passed downstream through the South Channel sluice, and/or Taintor gates. The south channel sluice gate is capable of passing up to 2,500 cfs, and each of the Taintor gates are capable of passing up to 5,000 cfs. If after opening the south channel sluice and Taintor gates the elevation of the impoundment is 156.0’ and still rising, then additional water is released via hinged flashboards, top boards, and north and south channel stanchions.

Upstream Fish Passage

The Weston Project has used the Lockwood fish lift and transport system as its means of interim upstream fish passage since 2006. Atlantic salmon (and other anadromous species) are captured at the Lockwood lift and transported in trucks by the MDMR to areas of suitable habitat, primarily the Sandy River, which is upstream of the Weston Project.

Downstream Fish Passage Measures

Interim downstream passage at the Weston Project was provided though a sluice gate and associated concrete flume located on the South Channel dam. The gate and flume were formerly used as a log sluice during river log drives and both are located near the Unit 4 intake. The sluice is 18 ft wide by 14 ft high and discharges into a deep plunge pool. Maximum flow through the gate at full pond is 2,250 cfs

In 2011, the Licensee enhanced the existing downstream passage facility by installing a guidance boom consisting of a 300 ft long floating boom with suspended 10 ft deep sections of 5/16 inch metal punch plate screens. The boom leads to the existing log sluice gate, which in turn discharges via an existing concrete flume to a deep pool in the river. The Licensee had previously (in 2010) made some major structural repairs to the existing sluice gate structure, which included resurfacing of the concrete flume.
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During the downstream migration period, the gate is opened to pass 6% of station unit flow. The sluice is opened for smolt and kelt passage generally from April 1 through June 15 and between November 1 and December 31, if river and ice conditions allow. As detailed in the ISPP, studies to evaluate the effectiveness of the bypass with the new guidance boom will be undertaken after resource agency consultation and approval of a study plan.

On the North Channel side of the Weston Project, there are two Taintor gates, an inflatable rubber dam section, and stanchion gate sections. Interim passage is provided on the North Channel side via spillage.

The Licensee completed an Atlantic salmon smolt radio telemetry downstream passage study at the Weston Project in the spring of 2012. During the spring 2012 study, five groups of radio-tagged smolts were released upstream of the Weston Project and their passage routes and bypass usage were recorded at Weston, Shawmut and Lockwood. Results of the 2012 study at Weston were as follows:

- Downstream bypass usage data were collected for smolts at the Weston Project at 6%, 4% and 2% of actual powerhouse flows during 2012. When examined by setting, 68.4% (26 of 38) of smolts used the downstream bypass with the bypass set at 6%, 45.5% (15 of 33) of smolts used it with the bypass set at 4%, and 43.8% (7 of 16) of the smolts passed through the Weston downstream bypass with the bypass set at 2%.
- Passage route and bypass usage data at Weston were collected for a total of 89 smolts. Of the 89 smolts which passed the Weston Project with known routes, 54.0% (48 of 89)

passed through the downstream bypass, 43.8% (39 of 89) passed through the turbines, and 2.2% (2 of 89) passed on spill.

- When all smolts successfully using the downstream bypass along with those which were detected in close proximity to the entrance at the Weston Project are considered; 84.2% of smolts were guided to the downstream bypass entrance when set at 6%, 78.8% of smolts were guided to the downstream bypass entrance when set at 4%, and 50.0% of smolts were guided to the downstream bypass entrance when set at 2%.
- Of the 111 smolts passing the Weston Project, five (4.5%) were determined during manual tracking efforts to be stationary downstream of the Project. Of the resulting 106 smolts that continued downstream movement, 76% (81 of 106) passed the downstream Weston Monitoring Station 5.
- The impact of the 68.4% bypass effectiveness rate (observed at 6% of station flow at Weston during spring 2012) on estimated whole station smolt survival (Normandeau, 2012a) was examined for median (50% occurrence) and low flow (10% occurrence) river conditions; estimated whole station survival at Weston increased from 90% to 94% under median river conditions and from 88% to 94% under low flow river conditions.

3.4 Brunswick Project

The Brunswick Project, owned by Maine Hydro, is located at river mile 6 at the head of tide, and is the first dam on the mainstem of the Androscoggin River (Figure 4). The dam and powerhouse span the Androscoggin River immediately above the U.S. Route 201 bridge connecting Topsham and Brunswick, at a site originally known as Brunswick Falls. The Brunswick Project includes a 300-acre reservoir; a 605 ft long and 40 ft high concrete gravity dam; a gate section containing two Taintor gates and an emergency spillway; and a powerhouse and intake. The Project also has vertical slot fishway, a 21 ft high fish barrier wall between the dam and Shad Island, and a 3 ft high 20 ft long concrete fish barrier weir across Granney Hole Stream in Topsham.

The concrete gravity dam consists of two ogee overflow spillway sections separated by a pier and barrier wall. The right spillway section, about 128 ft long, is topped with wooden flashboards that are 2.6 ft high. The left section does not have flashboards. The intake structure and powerhouse are integral with the dam and located adjacent to the Brunswick shoreline. The powerhouse contains three vertical propeller turbine generators. Unit 1 has a hydraulic capacity of 4,400 cfs, and units 2 and 3 have a hydraulic capacity of 1,200 cfs (Table 3.4-1).

Table 3.4-1. Brunswick Project Generating Unit Summary

Units	Turbine Design/Type	Hydraulic Capacity	Rotation Speed (rpm)	Number of Blades/ Buckets	Max Flow		Peak Efficiency Flow		Min Flow	
					CFS	Effic. (%)	CFS	Effic. (%)	CFS	Effic. (%)
Unit 1	Propeller/ vertical	4,400 cfs	90.0	5	5,075	83	4,519	93	2,741	57
Unit 2	Propeller/ horizontal	1,200 cfs	211.8	4	N/A	N/A	1,336	88	N/A	N/A
Unit 3	Propeller/ horizontal	1,200 cfs	211.8	4	N/A	N/A	1,336	88	N/A	N/A

Project Operations

The Brunswick Project normally operates as run-of-river. Due to the on/off nature of the units and the small pond available, the pond fluctuates to allow the units to operate efficiently; however the pond is too small to store water for any significant amount of peaking. Thus, the station is considered run of river. Impoundment drawdowns are generally limited to less than two feet below the top of the spillway.

Upstream Fish Passage Measures

Upstream passage at Brunswick is provided via a vertical slot fishway and associated trap, sort, and truck facility that were installed in 1983. The fishway is 570 ft long and consists of 42 individual pools, with a one-foot drop between each. The trapping facility, located at the upstream end of the fishway, provides biologists the opportunity to collect data on migratory and resident fish species that use the fishway. As fish swim to the top of the fishway, fixed grating guides them past a viewing window and into a 500-gallon capacity fish hoist (trap). The hoist elevates the fish to overhead sorting tanks where staff sort and pass fish upstream. Atlantic salmon pass upstream above the 40-foot dam after biological data are collected. The fishway is operated between May 1 and October 31. During the period of fishway operation, an attraction flow of 100 cfs is provided.

The Brunswick fishway facility is maintained by the Licensee; however, since its construction, MDMR personnel have operated the fishway each season under prior agreement.[1]

The Brunswick Project also has a fish barrier wall located between the dam and Shad Island and a concrete cap over the ledges at the southern end of the spillway section. These structures were installed in the 1980s in an effort to prevent fish from accessing the spillway section and to prevent spill from entering the tailrace and interfering with fish attraction to the fishway.

Downstream Fish Passage Measures

Downstream passage is provided at the Brunswick Project via a surface sluice and associated 18-inch pipe that discharges fish into the project tailrace. The existing sluice gate and pipe were installed in 1983. The sluice is located along the face of the powerhouse between units 1 and 2.

3.5 Lewiston Falls Project

The Lewiston Falls Project, owned by Maine Hydro, includes a dam consisting of several distinct dam sections (Figure 5.). There are four stone-masonry dam sections (Dams 1-4), each of which support 4 ft high flashboards. A fifth dam section (Dam 5) is 4 ft high and supports 1.34 foot high flashboards. The island spillway is a concrete section located on a small island between Dams 3 and 4 and it is fitted with flashboards. The Licensee is in the process of replacing approximately 681 feet of flashboards over four sections of the spillway (Dams #1, #2, #3, & #4) with inflatable rubber dams. The work includes resurfacing the cap and upstream face of the dam

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[1] MDMR operates the Brunswick fishway with take authorization from NMFS under a Section 10 research permit.

to provide a base for the new bladder system; and resurfacing and modifying the end piers on either end of the spillways to support the inflatable bladders that will be required to span the flashboard sections. There are two sections of approximately 154 feet of operational rubber dam (Dam #4) currently installed. There will be three more sections (Dams #1, #2, and #3), approximately 578 feet installed in 2013. It is anticipated that the project will be completed by the end of 2013.

The Project also includes a canal system that originally served to deliver water to small generating facilities located in several mills. The Project was redeveloped in 1990 when a new powerhouse (Monty Station) was added to the project. The Canal generating units are currently out of service and are awaiting final disposition.

As detailed in Table 3.5-1, the Monty Station units (Units1 and 2) are vertical Kaplan units each with a generating capacity of 12,500 kW when passing 3,300 cfs under a 54 ft gross head. After satisfying a 150 cfs minimum flow requirement for the Lewiston Canal system, all additional river flow goes to Monty Station up to the capacity of the turbines (6,600 cfs). Units 1 and 2 are remotely controlled.

Table 3.5-1. Lewiston Falls Project Generating Unit Summary

Number of Units: 18	Turbine Design/Type	Generator Rating	Hydraulic Capacity	Rotation Speed (rpm)
Monty Station				
Unit 1	Kaplan/vertical	12.5 MW	3,300 cfs	150.0
Unit 2	Kaplan/vertical	12.5 MW	3,300 cfs	150.0
Lewiston Canal Units				
Bates Weave Shed				
Unit 1	Francis/horizontal	1.2 MW	650 cfs	257.0
Unit 2	Francis/horizontal	1.5 MW	650 cfs	257.0
Unit 3	Francis/horizontal	1.2 MW	650 cfs	257.0
Hill Mill				
Unit 1	Francis/vertical	0.360 MW	205 cfs	180.0
Unit 2	Francis/vertical	0.360 MW	205 cfs	180.0
Unit 3	Francis/vertical	0.360 MW	205 cfs	180.0
Unit 4	Francis/vertical	0.360 MW	205 cfs	180.0
Unit 5	Francis/vertical	0.360 MW	205 cfs	180.0
Unit 6	Francis/vertical	0.360 MW	205 cfs	180.0
Lower Androscoggin				
Unit 1	Leffel/vertical	0.270 MW	340 cfs	164.0
Continental Mills				
Unit 1	Hercules/vertical	0.400 MW	325 cfs	120.0
Unit 2	Hercules/vertical	0.400 MW	325 cfs	120.0
Unit 3	Hercules/vertical	0.400 MW	325 cfs	120.0
Unit 5	Hercules/vertical	0.192 MW	150 cfs	164.0
Unit 6	Hercules/vertical	0.192 MW	150 cfs	164.0

Project Operations

The Lewiston Falls Project is licensed to operate with up to four feet of impoundment fluctuation to allow for peaking under normal conditions. The station has a minimum flow requirement of 1,430 cfs at Lewiston Falls, with a minimum flow of 1,280 cfs required at Monty Station and 150 cfs through the canal.

The Lewiston Canal is typically operated at a minimum flow of 150 cfs, which is contractually required to supply Androscoggin Upper, a small generating facility owned and operated by the City of Lewiston under separate license. The City may be considering retirement of this facility in the future. Since the Androscoggin Lower generating facility cannot operate at this low flow, flows are spilled there and released back to the river.

Upstream Fish Passage

There are no upstream fish passage facilities at the Lewiston Falls Project.

Downstream Fish Passage

There are no downstream fish passage facilities at the Lewiston Falls Project.

3.6 Project Operation and Maintenance Activities to be Covered

Activities anticipated to be covered under the incidental take authorized for the five projects include the operations specified above, as well as the operational and maintenance activities outlined below. Maintenance activities covered include both routine project maintenance and any maintenance or repairs undertaken in emergencies, or as deemed necessary for the safety of project personnel or the public.

Authorized project operations include:

- Operate any spillway gates associated with the project.
- Operate any canal gates and sluice gates associated with the project.
- Operate any canals, penstocks, turbines and powerhouse facilities.
- Operate any portion of the project dams.
- Operate flashboards, inflatable dams and any other flow control devices utilized as part of the dams or spillways
- Operate the project turbines as specified under the conditions of the current FERC license for the Project.
- Provide an instream flow from the project as specified under the current FERC license for the Project.
- Regulate the impoundment water level in accordance with the conditions of the current FERC license.
-

Authorized maintenance activities include:

- Maintain any spillway gates associated with the project.
- Maintain any canal gates and sluice gates associated with the project.
- Maintain any canals, penstocks, turbines and powerhouse facilities.

- Maintain any portion of the project dam.
- Maintain flashboards, inflatable dams and any other flow control devices utilized as part of the dams or spillways.
- Maintain the project turbines and generators as specified under the terms of this HCP and the project FERC.

At any time, the Licensees are authorized to operate the projects as necessary for the safety of project personnel and the public. In addition, any proposed fish passage measures or studies detailed in the ISPP and outline in Section 8, will also be covered by the incidental take authorization.

4.0 ENVIRONMENTAL CONDITIONS IN THE PROJECT AREAS

Kennebec River Basin

The Kennebec River basin is the largest of the watersheds that comprise the Merrymeeting Bay SHRU. The Kennebec River watershed covers an area of 5,910 square miles, approximately 1/5 of the state of Maine, and flows 138 miles from Moosehead Lake to Merrymeeting Bay where it joins the Androscoggin River. The Kennebec watershed is bordered on the west by the Androscoggin River Basin, on the north and east by the Penobscot River Basin, and by coastal streams and the Gulf of Maine on the south.

The Kennebec River's mainstem originates at the outlet of Moosehead Lake and flows generally southward through the towns and cities of Bingham, Solon, Anson, Madison, Norridgewock, Skowhegan, Waterville, and Augusta. The river transitions from a high gradient cold water river from upstream of Indian Pond to Madison, to a warmwater river from Skowhegan to Augusta. A 24 mile long, mostly freshwater tidal segment of the river exists downstream from Augusta, and slightly brackish conditions exist periodically in Merrymeeting Bay (CABB, 2006).

The Kennebec River basin has been extensively developed for over a century for industrial use, including driving of logs and pulp, mills, and hydroelectric power production. The Lockwood Project, located at river mile 63, is the lowermost dam and hydroelectric plant on the mainstem river. The drainage area above the Lockwood Project is 4,228 square miles. Other mainstem projects upstream of Lockwood include Hydro-Kennebec (FERC Project No. 2611), Shawmut (FERC Project No. 2322), Weston (FERC Project No. 2325), Abenaki (FERC Project No. 2364), Anson (FERC Project No. 2365), Williams (FERC Project No. 2335), Wyman (FERC Project No. 2329), and Harris (FERC Project No. 2142). The Fort Halifax Project (FERC No. 2552), which was removed in 2008, was formerly located near the mouth of the tributary Sebasticook River, only about 0.5 miles downstream of Lockwood. Edwards dam (FERC Project No. 2389), which was removed in 1999, was located about 18 miles downstream of Lockwood on the main stem.

Historically, the Kennebec River provided access to a large and diverse aquatic habitat for diadromous and resident fish species. American shad and river herring migrated into the Sandy

River and Atlantic salmon migrated to Grand Falls on the Dead River and to the unnamed falls (presently impounded by Indian Pond Dam) on the Kennebec River.

Androscoggin River Basin

The Androscoggin River is Maine's third largest river with a watershed area covering 3,500 square miles; the river flows 161 miles from Umbagog Lake to Merrymeeting Bay. The Androscoggin River basin is bordered on the west by the Presumpscot River basin and on the east by the Kennebec River basin.

The Androscoggin River basin has also been extensively developed for industrial use for well over a century, including hydroelectric power production. The first dam on the river is the Brunswick Project, located near the Merrymeeting Bay head of tide. Other mainstem hydroelectric projects upstream of Brunswick include the Pejepscot, Worumbo, Lewiston Falls, Deer Rips, Gulf Island, Livermore Falls, Otis, Jay, Riley Lower Rumford Falls, and Upper Rumford Falls projects in Maine, and a number of other hydropower projects in New Hampshire. There are also a number of hydroelectric projects on the Little Androscoggin River, which is a tributary that joins the mainstem just below Lewiston Falls in Auburn Maine, including Barkers Mills Lower, Barkers Mills Upper, Hackett Mills, Marcal, and Biscoe Falls.

Historically, the Androscoggin provided access to a large and diverse aquatic habitat for diadromous and resident fish species. For several species, the natural upstream migration barrier on the main stem of the Androscoggin River was Lewiston Falls, 23 river miles above tidewater. Although this site was an impassable barrier for most species, sea-run Atlantic salmon and American eel were able to ascend the falls and migrate upstream to Rumford, approximately 80 miles above Merrymeeting Bay. Rumford Falls was an impassable barrier to migrating salmon and excluded them from New Hampshire waters of the Androscoggin River (MDMR, 2010, NMFS, 2009b).

4.1 Climate

The portion of the Merrymeeting Bay SHRU that is south and east of a line extending from near Fryburg to Livermore Falls, and extending westward to Skowhegan lies within the Laurentian Mixed Forest eco-region, which is a transitional zone between the broadleaf deciduous and boreal forests. This region has moderately long winters with a frost free season of between 100-140 days. Precipitation is moderate, ranging between 61 and 115 cm a year. Average annual precipitation in the Kennebec watershed is about 106 cm (NMFS, 2009b).

North and west of line, the Merrymeeting Bay SHRU lies within the New England Mixed Forest eco-region, which is composed mainly of transitional forest between boreal spruce-fir to deciduous forest with vertical vegetation zonation. During the summer, well-defined maximum temperatures, indicative of the dominating tropical air masses, characterize the climate within this region. In the winter, cold air from continental-polar air masses dominate the weather conditions. This region has an average frost-free season of approximately 100 days (NMFS, 2009b).

4.2 Hydrology

Kennebec River

The Kennebec River begins at the outlets of Moosehead Lake and flows generally southward for approximately 230 miles to the Gulf of Maine. Along the way, the Kennebec passes through a number of towns and cities including Bingham, Solon, Anson, Madison, Norridgewock, Skowhegan, Waterville, and Augusta. Major tributaries to the upper Kennebec include the Dead River, Carrabasset River, and Sandy River. These three tributaries are high elevation streams characterized by rapids, riffles and occasional falls, with a substrate composed of boulders, cobble, and gravel. Major tributaries to the lower Kennebec include Messalonskee Stream, which flows out of the Belgrade Lakes, and the Sebasticook River which flows from Sebasticook Lake. From Moosehead Lake to Augusta, Maine, the Kennebec mainstem falls about 312 meters over a distance of 193 km, with an average gradient of 4.1 meters per km (NMFS, 2009b).

On the Kennebec, upstream headwater storage projects including the Moosehead Project (FERC Project No. 2671), Brassua Project (FERC No. 2615), and the Flagstaff Project (FERC No. 2612) on the Dead River, help regulate approximately 30 percent of the basin drainage area. The oldest of the three is Moosehead, which has been dammed since at least 1835. Flows from these headwater projects are managed by Kennebec Water Power Company (KWP) to provide a more uniform flow, moderate downstream flooding, and maximize power generation during the summer high peak usage period. The headwater storage lakes are typically filled to near full pond during the snowmelt and spring runoff periods and regulated during the summer and early fall to supplement flow during low natural-runoff periods. During the fall, the reservoirs typically partially refill because of runoff from rainfall, but they are drawn down in the winter to provide more stable river flows and to make room for spring runoff. In addition to these major lakes, numerous other smaller lakes and ponds exist within the watershed.

Peak flows typically occur in the spring as a result of snowmelt and rainfall, with April having the highest monthly average flows of 16,427 cfs. August, at 4,105 cfs, has the lowest monthly average flow (FERC, 2005). The maximum flow recorded at the Lockwood project was 210,000 cfs on April 2, 1987.

Androscoggin River

The Androscoggin River originates at Umbagog Lake near Errol, NH and flows approximately 260 km to Merrymeeting Bay. Along the way, the Androscoggin passes through a number of sizeable towns including Rumford, Dixfield, Jay, Livermore Falls, and the cities of Lewiston/Auburn. Major tributaries to the Upper Androscoggin include the Swift River and the Webb River. Major tributaries to the lower Androscoggin include the Nezinscot River, the Little Androscoggin River, the Sabattus River, the Dead River and the Little River. The Androscoggin River drops over 305 meters from its headwaters to its confluence with Merrymeeting Bay, with an average gradient of 3.9 meters per km (NMFS, 2009b).

On the Androscoggin River, upstream headwater storage projects including Mooselookmeguntic Lake (Upper Dam), Richardson Lake (Middle Dam) (FERC No. 11834), and Aziscohos Lake (FERC No. 4026), regulate river flow in the Androscoggin River in order to provide a more consistent flow in the summer months (FERC, 1996). These dams have been in place dating back into the 1800's. Flows from these headwater projects are managed in cooperation with downstream power generators to provide a more uniform flow and maximize generation during the summer high peak usage period. The headwater storage lakes are typically filled to near full pond during the snowmelt and spring runoff periods and then regulated during the summer and early fall to provide flow during low natural-runoff periods. During the fall, the reservoirs typically partially refill because of runoff from rainfall. During the winter, the reservoirs are commonly drawn down to provide more uniform river flows and make room for spring runoff. In addition to these major lakes, there are numerous other smaller lakes and ponds within the watershed.

Peak flows typically occur in the spring because of snowmelt and rainfall, with April having the highest monthly average flows and August having the lowest monthly average flow.

4.3 Water Quality

Kennebec River

The Maine Department of Environmental Protection (MDEP) has classified the Kennebec River from the Route 201A bridge in Anson-Madison to the Skowhegan/Fairfield town line, including all impoundments, as Class B waters. Class B waters are defined as suitable for drinking water supply after treatment, for fishing, agriculture, recreation in and on the water, industrial process and cooling water supply, hydroelectric generation, navigation, and as habitat for fish and other aquatic life. From the Fairfield/Skowhegan town line to Shawmut Dam is classified as Class C, and from Shawmut Dam to the confluence with Messalonskee Stream is classified as Class B, except the impoundments (which are Class C). The Kennebec River from the confluence with Messalonskee Stream to the Calumet Bridge at Old Fort Western in Augusta, including all impoundments, is classified as Class B waters. From the Calumet Bridge at Old Fort Western in Augusta to Merrymeeting Bay is classified as Class B waters. The designated water uses for Class C waters are the same as for Class B, but the standards have different numeric and narrative criteria.

Data collected since 1990 in and around the Weston and Lockwood Projects suggest that existing water quality standards are being met. No recent water quality data for the Shawmut Project exist.

Even at the lowest classification of C, water quality is sufficient to seasonally support Atlantic salmon. Class C waters in Maine must have dissolved oxygen levels of at least five parts per million or 60% of saturation, whichever is higher, except that in identified salmonid spawning areas where water quality is sufficient to ensure spawning, egg incubation and survival of early life stages, that water quality sufficient for these purposes must be maintained (Fay et al., 2006).

The Kennebec River has restricted fish consumption due to the presence of dioxin from industrial point sources. Combined sewer overflows from Skowhegan to the Gardiner-Randolph region on the river produce elevated bacteria levels, thus inhibiting recreation uses of the river (primary contact). The MDEP lists approximately 208 miles of the Kennebec River and tributaries as impaired (Fay et al., 2006).

On the Kennebec, recent water quality data are limited. In their 2006 report on Maine river fish assemblages, the Center for Applied Bioassessment and Biocriteria, Midwest Biodiversity Institute (CABB) conducted water quality sampling at stations along the Kennebec River. Water temperatures were measured in summer and fall of 2002 and summer of 2003. These data showed a longitudinal temperature profile along the mainstem with an overall increase from less than 20^{o}C immediately downstream of Wyman Dam, to >25^{o} C at several locations between Shawmut Dam and Gardiner, ME. This same study found dissolved oxygen (DO) concentrations were in the 8-9 mg/l range throughout most of the Kennebec mainstem in July and August. Values were slightly higher in September, 2002, reflecting cooler water temperatures. Water quality sampling by CABB revealed no obvious zones of oxygen decline and no areas of oxygen depletion.

The results of water quality monitoring conducted by the Licensee in support of the Lockwood Project FERC license application demonstrate that Lockwood Project waters comply with state water quality standards. As part of the relicensing study effort, dissolved oxygen sampling was conducted in August, 2000 in three areas: the lower impoundment area near Two Cents Bridge, just upstream of the powerhouse, and in the upper tailwater area of the bypassed reach. DO levels ranged from 7.4 to 10.0 milligrams per liter (mg/l) (83.5 to 118.2 percent saturation), and averaged about 8.8 mg/l (about 100 percent saturation). Readings were relatively consistent, but did vary somewhat between the three stations. (FERC, 2005)

Secchi depth measurements recorded at the same locations in the Lockwood impoundment showed a Secchi depth of at least 3 meters, which in the case of two of the sampling locations, was the bottom of the impoundment. The Secchi depth readings, along with the relatively low chlorophyll-*a* levels, also recorded during summer 2000, indicate that algal blooms and other signs of high nutrient levels and resulting eutrophication are not found within the Lockwood Project area.

Additional DO sampling at the Lockwood Project was conducted in July and August 2001 in the Ticonic Falls ledge pools, in the upper bypassed reach. These samples were collected during non-spillage times to determine habitat suitability in the bypassed reach. DO levels averaged 9.2 mg/l during July and 8.7 mg/l during August. Because of the short residence time, oxygenated inflow water, and a relatively shallow depth, stratification is not a significant factor within the impoundment (FERC, 2005).

Water temperature was also recorded in the three areas of the Lockwood Project that were sampled for DO during summer 2000, and in the ledge pools during July and August 2001. In August 2000, the average daily temperature was about 22^{o}C in the three locations. Temperatures recorded in the ledge pools averaged slightly under 22^{o}C, and about 25^{o}C during July and August 2001, respectively. The water temperatures in August were suboptimal for salmon and trout, but at or slightly above the preferred range for smallmouth bass (FERC, 2005).

In August 1998, MDEP collected limited water quality data from in the lower Kennebec River in support of a river water quality modeling effort. As part of this sampling effort, MDEP conducted three days of DO, temperature and nutrient sampling in the Shawmut impoundment. These data showed that the impoundment was meeting DO and temperature standards for Class

C waters (MDEP, 2000). The data also showed that nutrient concentrations were similar to those measured elsewhere in the Kennebec mainstem between Fairfield and Augusta, and slightly higher than those measured upstream between Madison and Skowhegan. A similar pattern was shown in the chlorophyll-a concentrations. However, none of the water quality parameters measured at Shawmut were notably higher than measured elsewhere in the river mainstem. There is no more recent data on the water quality of the Shawmut Project.

In August 1998, MDEP collected limited water quality data from the Weston Project area in support of a river water quality modeling effort. At the Weston Project, MDEP did three days of DO, temperature and nutrient sampling in the Weston impoundment near the Norridgewock boat launch, as well as in Skowhegan. These data showed that the impoundment was meeting DO and temperature standards (MDEP, 2000). The data also showed that nutrient concentrations were similar to those measured at the other MDEP stations between Madison and Skowhegan. A similar pattern was shown in the chlorophyll-a concentrations. However, none of the water quality parameters measured at Weston was notably higher than measured elsewhere in the river mainstem.

Androscoggin River

Maine has classified the Androscoggin River mainstem from above Lewiston Falls to Merrymeeting Bay as Class C waters. The Androscoggin River has restricted fish consumption due to the presence of dioxin. In addition, combined sewer overflows in the Androscoggin have increased the presence of bacteria in the lower river. Municipal and industrial point sources on the lower Androscoggin River have added nutrients and reduced the dissolved oxygen content and transparency of the water (Fay et al., 2006).

In their 2006 report on Maine river fish assemblages, CABB conducted water quality sampling at stations along the Androscoggin River. During their 2002-2003 water quality sampling effort, CABB found that on the Androscoggin River, with the exception of two sites, water temperatures in the late summer and early fall were <25^{o}C from Errol, NH to Lewiston Falls. Water temperatures from Lewiston to Brunswick were generally >25^{o}C. DO concentrations were generally >8.0 mg/l from Errol, NH to below Rumford. DO values declined some to 7.1 mg/l from downstream of Riley Dam to Turner Falls. DO levels in Gulf Island Pond were notably higher on several sampling dates reflecting the effect of algal productivity in this impoundment. DO concentrations were observed to decline to the 7 mg/l range immediately downstream from Gulf Island Pond, but increased to near 10 mg/l downstream to the Worumbo impoundment, another reflection of algal productivity due to nutrient enrichment. From Pejepscot Dam to Brunswick, DO concentrations were on the order of 7 mg/l (CABB, 2006).

More recently, MDEP developed a water quality model for the lower Androscoggin to examine the potential for the lower river to meet Class B water quality standards. This study was conducted in 2010 and the resulting report was published by MDEP in March, 2011. In support of the modeling effort, water quality data was collected in the lower Androscoggin River from below Gulf Island Pond Dam to the Bath-Brunswick town line in Merrymeeting Bay (MDEP, 2011). Water quality samples were taken at nine stations for three days each during July (July 13-15) and August (August 2-5), 2010. DO, temperature, and pH readings were taken at 13 stations twice daily (early morning and afternoon) during the same three day periods in July and August, 2010. In addition to the water quality sampling and modeling conducted as part of the 2010 study, MDEP also conducted macroinvertebrate sampling at three stations in the lower Androscoggin River in 2010.

Table 4.3-1. Summary of Results of Lower Androscoggin River Basin Water Quality Study (MDEP, 2011)

- During the three-day July sample survey, the average morning dissolved oxygen (DO) readings (6.99, 6.86, and 6.84) in the Brunswick-Topsham Dam impoundment were below Class B criterion of 7.0 mg/L. On the second sample day, two tidal sample stations below the dam had readings at 7.0 mg/L. During the August sample survey no readings were below 7.0 mg/L. The river was not at critical low flow nor were the discharges at maximum licensed loads for this period.
- During Critical Water Quality Conditions of low river flow, high water temperature, and maximum licensed discharge from the Publicly Owned Treatment Works, the water quality model predicts dissolved oxygen concentrations will be below the Class B criterion of 7.0 mg/L in eight of the twelve fresh water river segments from the confluence with the Little Androscoggin River in Auburn to the Brunswick-Topsham Dam. Predicted dissolved oxygen concentrations were below the Class B criterion of 7.0 mg/L for the entire fresh water river segments proposed for reclassifications from the Worumbo Dam to the Brunswick-Topsham Dam. Non-attainment is primarily driven by periphyton respiration during non-daylight hours.
- The tidal segments from the Brunswick-Topsham Dam to the Bath-Brunswick town line in Merrymeeting Bay were not included in the water quality model, but were evaluated separately for the impact of the licensed load from the Brunswick Sewer District. Although measured DO readings during the sample surveys were at or slightly below 7.0 mg/L, a mass balance analysis showed little influence from the Brunswick Sewer District. Low DO readings are attributed to Biological Oxygen Demand from upstream sources and incoming tides from Merrymeeting Bay. Sediment Oxygen Demand in the lower portion of Merrymeeting Bay is also a likely contributor to these low DO readings.
- The river sampling showed a nutrient loading from sources upstream of the study area. A separate model run was performed to assess the effect of these upstream sources relative to the point source discharges within the study area. After completely removing the discharges from the Lewiston-Auburn Water Pollution Control Authority and the Lisbon Wastewater Treatment Facility, the water quality model predicted that DO concentrations would still be below the Class B criterion of 7.0 mg/L in two of the twelve fresh water river segments.
- An Aquatic Life Classification Attainment Study was performed at three sites on the river; within the impoundments of the Worumbo Dam and Pejepscot Dam and downstream of the Pejepscot Dam. Both impoundment sites had aquatic communities that indicate organic pollution and siltation, but met the Class C aquatic life criteria. The site downstream of Pejepscot consisted of a good number of sensitive organisms and attained the Class B aquatic life criteria.
- The free flowing river segments encourage re-aeration of the water from the atmosphere

raising the DO concentration. The increased depth, volume, and decreased velocity in the impoundments diminish the re-aeration rate and depress the overall DO concentration. These impoundments also create slow moving segments that accumulate organic sediment, which also decreases the DO concentration.

The water quality data collected in 2010 were used to construct, calibrate and verify a water quality model for the lower Androscoggin River. The results of the water quality sampling and modeling efforts, allowed MDEP to draw several conclusions about the current quality of water in the lower Androscoggin River (MDEP, 2011).

It is important to note that a purpose of the study was to determine if sections of the river currently meet Class B standards, even though they are classified as Class C. The results indicate that while the river sections described meet Class C standards, those sections are not yet ready to be reclassified to Class B.

4.4 Aquatic Habitat

Aquatic habitat studies of the Kennebec and Androscoggin River mainstems in the vicinity of the five hydropower projects covered by this BA are generally limited to studies done in support of FERC relicensing efforts. In that regard, there is relatively recent information on habitat conditions at the Lockwood Project, more limited and older information on habitat conditions at the Weston Project, and almost no detailed information on aquatic habitat conditions at the Shawmut, Brunswick, or Lewiston Falls projects.

Lockwood Project Aquatic Habitat

The Lockwood Project's three main types of aquatic habitat include bypassed reach habitat, tailwater habitat, and impoundment habitat.

The Lockwood bypassed reach is approximately 1,275 feet long and consists of two distinct areas (Figures 6 and 7). The upper bypassed reach, known as Ticonic Falls, is approximately 600 feet long and is composed of a series of descending exposed bedrock terraces. During times of spillage, water cascades throughout this reach. During low flow conditions, this area contains scour pocket pools that are interconnected by chutes of water spilling or leaking from the dam, which further supplement flow provided through the engineered orifices in the flashboards. These connecting flows enable fish and other aquatic organisms to move in and out of the pools.

Several species of fish, including adult Atlantic salmon, American eel, anadromous clupeids, and smallmouth bass, utilize many key wetted pools located in the Ticonic Falls. Of note, in May 2003 an adult shortnose sturgeon was collected from one of these pools (FERC, 2005). Previous studies have shown that adult salmonids, including landlocked and anadromous Atlantic salmon, were found in pools below both the west and east spillways during July and again in September. Adult alewife have been observed in the upper bypassed reach during the migration period May through June. Juvenile clupeids were found in the pools below the spillway in September. In addition, numerous American eels and smallmouth bass have been found throughout the period of July to October (FERC, 2005).

The lower portion of the Lockwood Project bypassed reach consists of a large backwatered pool with depths ranging up to 17 feet (FERC, 2005). This pool maintains relatively stable hydraulic and water quality characteristics across a wide range of discharges with little difference in wetted area or depth, from leakage flow up to high spillage flows. The habitat quality of the upper portion of the bypassed reach (Ticonic Falls), however, is poor with a predominant substrate of bedrock and ledged terraces which, during Lockwood relicensing studies, received a suitability index rating of less than 0.5 (on a scale of 0 to 1.0) for all species and lifestages considered (Merimil, 2001). The bedrock and ledged terraces do not provide adequate substrate or cover and would not provide suitable habitat for most fish and invertebrates under any flow conditions.

Within the Lockwood ledge pools, fish are present at depths ranging from 3 to 4 feet to over 10 feet. Velocities within these pools vary depending upon the basin geometry. During periods of low flow, with only leakage flows coming from the dam, some of the ledge pools still maintain mean column velocities greater than zero. Fish can enter these pools in the following ways: 1) downstream passage over the dam during spillage events, 2) via leakage passage, or 3) by upstream movement when spillage or leakage flows are adequate enough to provide zones-of-passage into and out of the pools. Relicensing studies found that a flow of approximately 50 cfs was sufficient to maintain acceptable water quality parameters, provide zones-of-passage between the individual pools and the deep backwatered pool of the lower bypassed reach (for species of interest), and add approximately 0.8 to 1 foot of additional depth to each pool, over no-flow conditions. At 50 cfs the majority of the pools maintain depths that exceed the minimum depths required for suitable habitat for the species of concern (Merimil, 2001, FERC, 2005).

The Lockwood Project tailrace is contiguous with the Kennebec River and extends from the powerhouse downstream approximately 375 ft. This area is predominantly low gradient run/pool with cobble/rubble/boulder substrates, and it remains wetted from bank to bank at all discharges. Wetted area and depth in this stretch of river vary little with changing river flows due to the low gradient, the wide channel, and natural hydraulic controls. The bypassed reach and tailrace fish communities consist of both warmwater and coldwater species typical to the region, with smallmouth bass being the most abundant species. These waters support good smallmouth bass and brown trout fisheries (Merimil, 2002). Other resident species include largemouth bass, white sucker, yellow perch, white perch, black crappie, blacknose dace, common shiner, and a variety of other forage species. The tailwater area also supports a popular striped bass fishery. In recent years, three exotic species, gizzard shad, white catfish and Northern Pike, have also been found in the project area waters below the dam. During the Licensees' year 2000 field investigations associated with relicensing, gizzard shad were recorded for the first time in the Kennebec River, and in 2001 adult white catfish were collected in a cooperative sampling effort with MDMR. This was the first documented occurrence of this species in the inland (non-tidal) portion of the Kennebec River (Merimil, 2002).

The Lockwood fish lift has been in operation since 2006, and the following fish species have been captured at the fish lift since that time: Atlantic salmon, alewife, blueback herring, American shad, landlocked salmon, brown trout, brook trout, rainbow trout, splake, smallmouth and largemouth bass, striped bass, white sucker, yellow perch, white perch, redbreast sunfish, pumpkin seed, black crappie, fallfish, chain pickerel, northern pike, American eel, sea lamprey, white catfish and gizzard shad.

Shawmut Project Aquatic Habitat

There are two main types of aquatic habitat at the Shawmut Project; impoundment habitat, and tailwater habitat. This project does not have a bypass reach . The assumed current condition of the Shawmut impoundment habitat is discussed below.

Though no formal studies of the Shawmut impoundment aquatic habitat have been made, given the proximity of the impoundment to Weston, and given that, like Weston, the impoundment is riverine in nature, the aquatic habitat conditions are likely similar.

The Shawmut Project impoundment is riverine in nature and consists primarily of deeper, low-velocity water bordered by steep sand/silt-sand vegetated river banks. With the exception of a few deep pools and some fallen trees, cover in this section of the impoundment is minimal as the steep river banks rise almost immediately from the water surface.

The Shawmut impoundment is generally managed by Maine Department of Inland Fisheries and Wildlife (MDIFW) for a coldwater and warmwater fishery, but creel information for this section of the river is very limited. The coldwater fish population of the impoundment consists of dropdowns from upstream river segments and tributaries. Smallmouth bass primarily comprise the warmwater fishery.

The Shawmut tailwater area is divided into three distinct areas. The Shawmut Project has two powerhouses and an angled spillway section. The older power house (units 1-6) is oriented such that it discharges at an angle to the flow of the river. The newer powerhouse (units 7-8) is adjacent to the original powerhouse, and oriented such that it discharges directly downstream. The tailrace areas for both powerhouses are excavated channels, separated by a low retaining structure. To the east of the powerhouse is the dam that extends to the eastern shore of the Kennebec River. The dam includes an angled spillway section with initial spilling occurring at the eastern portion of the spillway, which is equipped with an inflatable rubber dam. The area immediately below the spillway section is composed of bedrock ledges, and during times of spillage, water cascades throughout this short reach (Figures 8 and 9). Downstream of the ledges, the river is predominantly low gradient run/pool with cobble/rubble/boulder substrates and remains wetted from bank to bank at all discharges. Wetted areas and depths in this stretch of river vary little with changing river flows due to the low gradient, the wide channel, and natural hydraulic controls. The bypassed reach and tailrace fish communities consist of both warmwater and coldwater species typical to the region, with smallmouth bass being the most abundant species.

Weston Project Aquatic Habitat

There are three main types of aquatic habitat at the Weston Project; impoundment habitat, tailwater habitat, and the North Channel bypass reach habitat. The current condition of each is discussed below.

The Weston impoundment is approximately 12.4 miles long, 930 acres in area, and has an average depth of 20 ft (Richter, personal communication). The impoundment is riverine in nature and, with the exception of the area immediately upstream of the Project dam, the impoundment is bordered by rural areas consisting of moderately steep, vegetated banks rising from the water surface to the flood terrace above. The Licensee operates the Weston Project as run-of-river and minimizes impoundment water level fluctuations generally to less than one foot.

The lower two-thirds of the Weston Project impoundment consists primarily of deeper, low-velocity water bordered by steep sand/silt-sand vegetated river banks. With the exception of water depth and some fallen trees, cover in this section of the impoundment is minimal, as the steep river banks rise almost immediately from the water surface. Aquatic vegetation located at the mouths of several intermittent brooks, which are the only tributaries to this section of the impoundment, would provide limited nursery habitat for resident fish species (CMP, 1991).

The upper one-third of the impoundment consists of shallower, higher velocity water that is more likely preferred habitat for resident cold water species. The river channel in this portion of the impoundment is composed of a wide variety of substrates ranging from sand to some gravel shoals, with larger cobble and boulder substrate in scattered locations. The shoreline of this section of the impoundment is also bordered by steep vegetated banks similar to the lower reach, but overbank cover in this section is less than that found on the lower reach. The many boulders located in this section of the impoundment provide more cover and refuge for resident species (CMP, 1991).

MDIFW primarily manages the Weston impoundment for a coldwater and warmwater fishery, however, very limited creel information for this section of the river exists that verifies the state’s management of this impoundment. The cold water fish population of the impoundment consists of dropdowns from upstream river segments and tributaries, and from stocking by the MDIFW. Since 1987, the MDIFW has been stocking 2000 yearling brown trout annually in the project impoundment (CMP, 1991). The warmwater fishery is primarily smallmouth bass.

The Weston bypassed reach is approximately 282 meters long and ranges from 20 to 40 meters wide (Figure 10). The bypassed reach is basically a small gorge with ledge outcroppings on both shores. Depths within the bypassed reach are variable depending on flow conditions.

Brunswick Project Aquatic Habitat

There are three main types of aquatic habitat at the Brunswick Project; impoundment habitat, tailwater habitat, and an area of ledge and pool habitat downstream of the spillway section of the dam. The current condition of each is discussed below.

The Brunswick impoundment extends approximately 4.5 miles upstream of the dam to the Pejepscot Project. The impoundment is relative uniform in nature, with one large island approximately 2 miles upstream of the Brunswick dam and a number of smaller islands just upstream of the dam.

The Brunswick tailrace is an excavated channel that extends downstream from the powerhouse approximately 500 ft (Figure 11). Due to the excavation in the tailrace, few natural features remain with the majority of the channel bed consisting of scoured ledge. Just downstream of the excavated portion of the tailrace, the channel bed consists of boulders and cobble before the river makes a sharp northward bend.

Downstream of the dam spillway, the riverbed consists of broad ledges interspersed with several deep pools and many smaller pools (Figure 12). Immediately to the south of the spillway is a barrier dam situated along the ledge, which separates the tailwater area from the spillway ledge area. This barrier serves to prevent fish from being drawn up into the ledges near the dam during periods of large spill. This barrier also limits foot access to this area thereby limiting any inspections of the spillway or downstream habitat. However, during unregulated spill periods, river herring have been observed on the ledges below the barrier dam.

The Brunswick impoundment is generally managed by MDIFW as a warmwater fishery with smallmouth bass being the primary species, but creel information for this section of the river is very limited.

Lewiston Falls Aquatic Habitat

Designated critical habitat for listed Atlantic salmon starts downstream of the Lewiston Falls dam and powerhouse complex. The tailrace downstream of the Monty Station powerhouse is a deep excavated run, with few natural river features remaining (Figure 13). The remaining habitat downstream of the Lewiston Falls Project dam is a large area of ledge across the center of the river and along the western shoreline (Figure 14). During periods when river flows are below the hydraulic capacity of the Project, flow across these areas of ledge is limited to seepage flows from various dam sections, and the ledge is interspersed with abundant shallow pools. During periods of river flow in excess of the hydraulic capacity of the project, water spills along several sections of dam, including sections to the south and west of the ledge area. Water spilled from these sections accumulates in a sizeable pool in the ledge along the western shore of the river, and then spills out through a number of narrow cascades that eventually flow back into the river below the original Lewiston Falls. Habitat in and throughout the ledge area is limited to ledge pools. Over the past three years, the Licensee has inspected these ledged pools in the spring, summer and fall for evidence of Atlantic salmon; although limited numbers of smallmouth bass have been observed, no Atlantic salmon have been found to be present. From the ledges and powerhouse tailrace, the Project discharge flows through a short, free-flowing riverine reach to the upstream end of the Worumbo impoundment.

4.5 Fisheries

The Kennebec and Androscoggin river basins support both warm water and cold water fish communities, including resident, anadromous and catadromous species. Historically, the fish communities of both rivers looked somewhat different than today, as a number of species (both games species and invasive species) have been introduced to the rivers over the years. With respect to the listed species covered under this ISPP portions of both river systems have historically supported Atlantic salmon.

For many years, state and federal agencies have placed significant fisheries management focus/efforts on the Kennebec and Androscoggin river basins. In Maine, the MDIFW is responsible for freshwater fisheries management, while the MDMR is responsible for diadromous fish management. In the case of any species listed under the ESA, the Services are responsible for ensuring the protection of these species and their habitats. In such cases, the Services work closely with state fishery management agencies. With respect to fish passage efforts, Maine state agencies (MDIFW and MDMR) work with dam owners to install and review fish passage measures at dams. For these projects, the USFWS has historically been the lead agency in determining fish passage needs and design, as required under Section 18 of the Federal Power Act.

Kennebec River

The Kennebec River in the vicinity of the Lockwood, Shawmut and Weston projects supports a warmwater fish community of smallmouth bass, white sucker, pumpkinseed and redbreast sunfish, black crappie, yellow perch, fallfish, blacknose dace, and other “minnow” species.

Smallmouth bass dominate the Lockwood impoundment fish community, comprising 66.2 percent of the species collected during fisheries surveys conducted in 2000 (FERC, 2005). Brown trout also occur in the Lockwood, Shawmut and Weston impoundments, but the few individuals that exist are likely the result of dropdowns from prior stockings upstream of the projects (FERC, 2005; CMP, 1991). Smallmouth bass also inhabit the Shawmut and Weston impoundments.

Kennebec River basin diadromous fish restoration goals target striped bass, rainbow smelt, Atlantic sturgeon, shortnose sturgeon, American shad, river herring (blueback herring and alewife), American eel, and Atlantic salmon. Of these species, only American shad, river herring, American eel, and Atlantic salmon have historically migrated upstream of Ticonic Falls (Merimil, 2002). The 1998 KHDG Agreement addresses restoration and passage measures for American shad, alewife, blueback herring, Atlantic salmon, and American eel. However, the Agreement is set to be reassessed in 2014, and the fish restoration goals of the agreement have not been met.

The target diadromous species that currently ascend the Kennebec River to the base of the Lockwood dam during annual spawning migrations include river herring (alewife, and blue back herring), American shad, American eel, and, Atlantic salmon. During a 2001 Merimil study, alosids (shad and river herring) were first detected in the lower bypassed reach and tailwater area on May 8th and were last seen on June 17th. No American shad were observed during that study. However, as part of the Kennebec River anadromous fish restoration program, Merimil collected several shad via gill nets set in the lower tailwater area of the project in a separate study effort (FERC, 2005). In addition, evidence of successful spawning of American shad was found by MDMR in net sets conducted downstream from the project tailwaters during the late spring/early summer (May/June) of 2001 (FERC, 2005). Striped bass, which are considered anadromous, also have been documented below the Lockwood Project, although they are not known to spawn in the project area (FERC, 2005). Other migratory species in the lower Kennebec River with access to the Lockwood Project include shortnose sturgeon and the Atlantic sturgeon.

The Kennebec River watershed supports a small run of Atlantic salmon. Restoration efforts in the Kennebec watershed have utilized egg, fry, and parr stocking to promote returning adult salmon. Most stocking efforts have focused on the Sandy River, which joins the mainstem Kennebec approximately 6.5 miles upstream of Norridgewock and supports the largest concentration of quality salmon habitat within the Merrymeeting Bay SHRU. In its 2009 biological valuation, NMFS estimated the Sandy River including some of its tributaries, have 15,000 units of functional equivalent habitat (NMFS, 2009b). However, more recently MDMR estimated that there are at least 23,223 functional equivalent habitat units in the Sandy River and its tributaries (Christman, MDMR, personal communication). Due to this concentration of quality spawning and rearing habitat, MDMR's salmon restoration efforts have focused on the Sandy River, and since 2003, the agency has stocked the Sandy River with Atlantic salmon fry and eggs.

Initial stocking efforts focused on fry stocking, but in recent years, the focus has shifted to egg stocking. In addition, in 2008 MDMR stocked 106 excess brood stock adult salmon. Initial egg stocking started in 2004 with 12,000 planted and in 2011, MDMR stocked an estimated 859,000 eggs (Table 4.5-1). In addition to the Sandy River stockings, in the spring of 2010, MDMR stocked 80,000 Atlantic salmon fry in Togus Stream and 40,000 fry in Bond Brook. In the fall of 2011, 90 excess brood stock adults, originally captured in the Sheepscot River, were stocked in Togus Stream. (MDMR, 2011).

Table 4.5-1. Atlantic Salmon Stockings in the Sandy River

Year	Fry	Eggs	Adults
2003	39,000	0	0
2004	55,000	12,000	0
2005	30,000	18,000	0
2006	6,500	41,800	0
2007	15,400	18,000	0
2008	0	245,500	106
2009	0	166,494	0
2010	0	567,920	0
2011	0	859,000	0
2012	0	920,888	0

Source: Christman, MDMR, 2011, 2012 (personal communication)

In addition to these stocking efforts, some amount of natural reproduction is likely occurring in the Sandy River. Since the fishway at the Lockwood Project became operational in 2006, adults have been captured and transported to the Sandy River. The estimated eggs contributed to the Sandy River from these adults has ranged from 11,250 in 2006 to 247,500 in 2011. Estimated production from this natural spawning would be between 169 and 3,735 smolts annually (NMFS, 2012a).

Counts for Atlantic salmon in the Kennebec River are available since the 2006 fishlift installation was completed at the Lockwood Project. Adult Atlantic salmon are trapped, and biological data (e.g., fork lengths) are collected before the salmon are trucked and released in the Sandy River (MDMR 2011a). Returning adult salmon at Lockwood are shown in Table 4.5-2.

Table 4.5-3 shows the number of adult Atlantic salmon captured and transported to the Sandy River during the years 2009-2011 (NMFS, 2012a).

Table 4.5-2. Adult Atlantic Salmon Returns by Origin to the Kennebec River Recorded from 1975 to 2012

Year	Hatchery Origin				Wild Origin				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
1975-2001	12	189	5	1	0	9	0	0	216
2006	4	6	0	0	3	2	0	0	15
2007	2	5	1	0	2	6	0	0	16
2008	6	15	0	0	0	0	0	0	21
2009	0	16	0	6	1	10	0	0	33
2010	0	2	0	0	1	2	0	0	5
2011	0	21	0	0	2	41	0	0	64
2012	0	1	0	0	0	4	0	0	5
Total	24	255	6	7	9	74	0	0	375

Source: USASAC, 2011 (as provided in NMFS, 2012a)

Table 4.5-3. Adult Atlantic Salmon Captured at the Lockwood Project Fishlift and Translocated to the Sandy River

Year	**Maturity**	**Month of Capture**						**Total**
		May	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	
2009	MSW Wild ♂	0	2	0	0	01	1	3
	MSW Wild ♀	0	2	3	0	0	2	7
	MSW Hatchery ♂	0	0	5	0	1	0	6
	MSW Hatchery ♀	1	0	6	1	0	0	8
	Domestic ♂	1	0	0	0	0	0	1
	Domestic ♀	3	0	0	0	0	0	3
	Domestic Unknown	0	1	0	0	0	0	1
	Total	**5**	**5**	**14**	**1**	**1**	**3**	**29**
2010	MSW Wild ♂	0	0	0	0	0	0	0
	MSW Wild ♀	0	2	0	0	0	0	2
	MSW Hatchery ♂	0	0	0	0	0	0	0
	MSW Hatchery ♀	0	2	0	0	0	0	2
	1SW Wild ♂	0	0	0	0	0	1	1
	1SW Wild ♀	0	0	0	0	0	0	0
	1SW Hatchery ♂	0	0	0	0	0	0	0
	1SW Hatchery♀	0	0	0	0	0	0	0
	Total	**0**	**4**	**0**	**0**	**0**	**1**	**5**
2011	MSW Wild ♂	0	9	5	0	1	0	15
	MSW Wild ♀	0	12	12	0	0	1	25
	MSW Hatchery ♂	0	4	8	0	0	0	12
	MSW Hatchery ♀	0	5	3	0	0	0	8
	1SW Wild ♂	0	2	0	0	0	0	2
	1SW Wild ♀	0	0	0	0	0	0	0
	1SW Hatchery ♂	0	0	0	0	0	0	0
	1SW Hatchery♀	0	0	0	0	0	0	0
	MSW Hatchery Unknown	0	1	1	0	0	0	2
	Total	**0**	**33**	**29**	**0**	**1**	**1**	**64**

2012	MSW Wild ♂	0	1	0	0	0	0	1
	MSW Wild ♀	1	2	0	0	0	0	3
	MSW Hatchery ♂	0	1	0	0	0	0	1
	MSW Hatchery ♀	0	0	0	0	0	0	0
	1SW Wild ♂	0	0	0	0	0	0	0
	1SW Wild ♀	0	0	0	0	0	0	0
	1SW Hatchery ♂	0	0	0	0	0	0	0
	1SW Hatchery♀	0	0	0	0	0	0	0
	MSW Hatchery Unknown	0	0	0	0	0	0	0
	Total	**1**	**4**	**0**	**0**	**0**	**0**	**5**

Sources: MDMR 2010, 2011a, 2012 (as provided in NMFS, 2012a).
NextEra, 2013.
Note: Unknown = Sex Unknown of Domestic Atlantic salmon

Following spawning in the fall, Atlantic salmon kelts may immediately return to the sea, or overwinter in freshwater habitat and migrate in the spring, typically April or May (Baum, 1997). Spring flows resulting in spillage at the dams facilitate out-migration of adult salmon (Shepard, 1988). The number of kelts in the Kennebec River is proportional to the number of adults entering the river each year to spawn. As such, the number of kelts in the Kennebec River is likely to be a few dozen annually (NMFS, 2012a).

Of the other lifestages of Atlantic salmon, only smolts would be expected to be found in the project areas. No spawning or rearing habitat has been identified directly upstream or downstream of the Shawmut or Weston projects, and the nearest mapped rearing habitat upstream of the projects is in the Sandy River above the Weston Project. Nor is there spawning habitat in the immediate vicinity of the Lockwood Project, although there is some mapped rearing habitat downstream (NMFS, 2012a). Based on available habitat, neither fry nor parr would be expected to occur in the project areas. However, the Kennebec River in the vicinity of the three projects, does serve as a migration corridor for salmon smolts, and Atlantic salmon smolts originating in the Sandy River do occur in the Weston, Shawmut and Lockwood project areas as they migrate to the ocean. Most data concerning the emigration of smolts in Maine have been collected in the Penobscot River. Based on unpublished data from smolt-trapping studies in 2000 – 2005 by NMFS, smolts migrate from the Penobscot between late April and early June. The majority of the smolt migration appears to take place over a three to five week period after water temperatures rise to 10°C.

In the spring of 2012, a smolt-trapping study was conducted on the Sandy River by the Licensee. This was the first year of rotary screw trap (RST) operation on the Sandy River since MDMR first started stocking eggs in 2005 and it was the first time that smolts were documented migrating out of the river. A total of 52 Atlantic salmon smolts were captured in 2012, with no mortalities. The first smolts were captured on April 18, 2012 with a water temperature of 15 °C, and the last smolt was caught on May 21, 2012 with a water temperature of 17 °C. The most smolts captured in one night were seven on May 7, with a river temperature of 10.5 °C. The smallest smolt was 120 mm and the largest was195 mm. Scale samples were taken from each smolt captured and samples were given to MDMR for age determination. The majority (75%) of the smolts were age two, but 25% were age three.

Androscoggin River

The Androscoggin River originates at Umbagog Lake near Errol, New Hampshire and flows roughly 260 km past several towns including, Rumford, Dixfield, Jay, Livermore Falls, and Brunswick as well as the cities of Lewiston and Auburn (MDEP, 1999). The upper portions of the Androscoggin, like the Kennebec, are high gradient. In the Androscoggin watershed, Rumford Falls was the historic upper extent of Atlantic salmon migration, while Lewiston Falls was believed to be the upper extent of alewife and shad migrations. The Little Androscoggin River is the largest major subbasin of the Androscoggin with historically important salmon habitat that was accessible to Snow's Falls located 3.2 km outside of West Paris. Prior to dam construction, the Androscoggin River provided access to a large and diverse aquatic habitat for great numbers of diadromous and resident fish species (Foster and Atkins, 1867).

The State of Maine has been pursuing restoration of anadromous fish on the Androscoggin River for many years. Historically, alewife reproduced in lake and pond habitat throughout the Little Androscoggin River and the mainstem Androscoggin River basins below Lewiston Falls, while American shad and blueback herring reproduced in the riverine portions of these watersheds (MDMR, 2010). Atlantic salmon, which could ascend the earliest built low-head dams, were caught in Lewiston as late as 1815 (MDMR, 2010). However, a dam built at head-of-tide in Brunswick in 1807 excluded river herring and American shad from the sections of the Androscoggin River above this project.

In 1982, Central Maine Power Company (CMP[2]) reconstructed the Brunswick Project, which is the first dam on the river, located near the head of tide of Merrymeeting Bay. During project reconstruction, CMP constructed an agency-approved, vertical slot fishway, with a trapping and sorting facility and MDMR agreed to operate the facility. CMP also installed a downstream passage facility capable of passing anadromous and resident fish species. Concurrently, the MDMR initiated a concerted anadromous fish restoration program for the lower Androscoggin River. The target species for the initial restoration effort were American shad and alewife for restoration to spawning and nursery habitat in the lower main stem and tributaries below Lewiston Falls (MDMR, 2009).

Historically, Atlantic salmon were reportedly abundant in the Androscoggin River, but over time, adult returns have dwindled. Dams, pollution, and over-fishing have contributed to the decline of Atlantic salmon in the Androscoggin River. The returns of adult Atlantic salmon to the Androscoggin River in recent years have been small, and mostly comprised of stray, hatchery origin fish from active restoration programs on other rivers (MDMR, 2010; as provided in NMFS, 2012b).

Since 1983, MDMR has operated a fish trap at the Brunswick Project fishway. Adult Atlantic salmon captured in the fishway are released upstream. Total enumerations of adult Atlantic salmon captured at Brunswick since operation of the fishway began are provided in Table 4.5-4.

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[2] FPL Energy Maine Hydro LLC purchased Brunswick in 1999.

Table 4.5-4. Adult Atlantic Salmon Returns by Origin to the Androscoggin River at the Brunswick Project from 1983 to 2012

Year	Hatchery Origin				Wild Origin				
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Total
1983-2000	26	507	6	2	6	83	0	1	631
2001	1	4	0	0	0	0	0	0	5
2002	0	2	0	0	0	0	0	0	2
2003	0	3	0	0	0	0	0	0	3
2004	3	7	0	0	0	1	0	0	11
2005	2	8	0	0	0	0	0	0	10
2006	5	1	0	0	0	0	0	0	6
2007	6	11	0	0	1	2	0	0	20
2008	8	5	0	0	2	1	0	0	16
2009	2	19	0	0	0	3	0	0	24
2010	2	5	0	0	0	2	0	0	9
2011	2	25	0	0	1	16	0	0	44
2012	0	1	0	0	0	0	0	0	1
Total	57	597	6	2	10	108	0	1	738

Source: USASAC, 2011 (as provided in NMFS, 2012b)

According to MDMR, prior to 2007, there was no indication that the Androscoggin River had a reproducing population of Atlantic salmon (MDMR, 2010; as provided in NMFS, 2012b). Documented annual runs of returning adult salmon consisted primarily (98%) of fish originating as hatchery smolts released into Maine rivers. In 2007 and 2008 several returning adults captured at the Brunswick fishway were determined to be fry-stocked or naturally reared fish. As stocking efforts in other DPS rivers increases, so does the number of strays captured at the Brunswick Dam.

Adult Atlantic salmon that ascend the Brunswick fishway are released above the Brunswick Dam to continue upstream migration after biological data (e.g., length) are collected. The mean fork length of returning adults was 603 mm in 2008 and 735 in 2009 (MDMR, 2010). Several adult salmon have been captured at the Brunswick fishway with fin-clips or tags, indicating that these fish are strays or stocked salmon from other rivers (MDMR, 2010).

5.0 RECENT AND CURRENT PROTECTION AND ENHANCEMENT MEASURES FOR ATLANTIC SALMON

The Project licensees have undertaken a number of actions to protect and enhance conditions for Atlantic salmon and its habitat at the Brunswick, Lewiston Falls, Lockwood, Shawmut and Weston projects. The following are descriptions of measures already undertaken by the Licensees that avoid and minimize impacts to Atlantic salmon, and the attached ISPP outlines additional measures to be undertaken to further protect the species at these projects.

5.1 Lockwood Project

Project Operations

The Lockwood Project normally operates in a run-of-river mode resulting in the protection of fish resources, riparian vegetation and aquatic habitat in the Kennebec River. The Lockwood Project is normally operated with outflow approximately equal to inflow, except during flashboard failure or replacement, or other abnormal events. During normal run-of-river operation when all flashboards are in place, the headpond level is maintained within six inches of full pond elevation 52.16 feet msl (top of flashboards). During times of flashboard failure, water levels are normally maintained above the spillway crest. During those times when flashboards are being replaced, the pond level is maintained at or above one foot below the spillway crest.

During flashboard replacement and subsequent refilling of the project impoundment, the Licensee releases a minimum flow of 2,114 cubic feet per second, or inflow to the project if less, into the Kennebec River for the protection of aquatic resources. When the flashboards are in place a minimum flow of 50 cubic feet per second (cfs), is released into the bypassed reach of the Kennebec River. The purpose of the minimum flow is to protect aquatic resources utilizing scour pools located in the bypassed reach immediately downstream of the east and west spillways of the project dam.

Upstream Fish Passage Measures

In accordance with the FERC license and the KHDG Agreement, Merimil Limited Partnership (Merimil), licensee for the Lockwood Project, completed construction of a fish lift, trap, sort and transport system in the spring of 2006. The system was completed and became operational on May 5, 2006. In consultation with resource agencies, owners developed operational and effectiveness study plans for the new fish lift. These plans were filed with FERC on January 30, 2006, and approved on April 26, 2006.

The Lockwood fish lift facility is located on the west side of the powerhouse adjacent to Unit 7. The sorting and trucking portion of the facility includes: one 2,500 gallon, 12 ft diameter, round discharge tank, which collects fish discharged from the 1,800 gallon fish lift hopper; two 1,250 gallon, 10 ft diameter, round holding tanks that sluice fish into stocking trucks; and one 250 gallon, rectangular holding tank for Atlantic salmon. The 2,500 gallon discharge tank is also equipped with piping that can discharge fish back into the tailrace.

The lift operates with an attraction flow of 150 cubic feet per second (cfs). Fish lift entrance water velocities are 4 to 6 ft per second (fps). The lift has an approximate 10 minute cycle time and is operated as described below.

The attraction flow draws the fish through the fish lift entrance gate into the lower flume of the fish lift. The fish then swim through a vee-gate crowder and remain in the lower flume of the lift. During the cycling process, the vee-gate crowder closes to hold the fish in the hopper area. The 1,800 gallon water-filled hopper lifts the fish to the holding tank elevation, and the fish are sluiced into the 2,500 gallon round discharge tank. Liquid oxygen is introduced into all tanks via carbon micro porous stones to reduce stress and mortality. Two auxiliary water pumps provide a constant flow of ambient river water to all the tanks. These pumps also provide ambient river water to the stocking trucks. The fish lift operates to accommodate all target species, and attraction flows are passed continuously during lift operation. The fish lift is designed to pass up to 164,640 alewives, 228,470 American shad and 4,750 Atlantic salmon per year.

The Lockwood fish passage facility is typically operated by one full time employee and three seasonal employees. The Licensee staffs the facility as necessary to ensure that there are an adequate number of personnel on site to effectively operate the facility. Under a cooperative agreement, the Licensee is responsible for capturing shad, river herring and Atlantic salmon, and the Maine Department of Marine Resources (MDMR) is responsible for collecting biological data and trucking fish to upstream spawning locations.

During the fish lift operation season, the Licensee coordinates daily with the MDMR regarding sorting, counting and trucking operations. During the river herring, American shad and Atlantic salmon migration season (approximately May through mid-July), the fish lift is generally manned seven days a week, as necessary, to meet resource agency trap and truck requirements. During the run, the fish lift is generally operated from early morning to late afternoon.

During other times of the season, the fish lift is generally operated three to five times a day, seven days a week for Atlantic salmon capture. The precise timing of the fish lift operation is determined by the Licensee, in consultation with the MDMR, based on factors such as the number of migrating fish, water temperature, time of year and river flow.

During periods of fish lift operation, Licensee staff routinely monitor four underwater cameras that are connected to a monitor and DVD recorder. The monitor and DVD recorder are located in the control room of the fish lift and typically record from dawn until dusk. The cameras are also used in real time to help determine the presence of fish in the lift and maximize fishing effectiveness.

Camera 1 is located just downstream of the vee-gates and provides a good view of fish moving through the vee-gates into the hopper area. Camera 2 is located just upstream of the entrance gate and provides a good view of fish swimming towards and into the fish lift. Camera 3 is located in the river just downstream of the fish lift entrance gate. This location provides a view of the tailrace area below the entrance gate. Camera 4 is positioned between the entrance gate and sorting tank sluice pipe on the edge of the river. This camera offers another good view of the fish lift entrance gate vicinity. Since all four cameras show good detail, fishway personnel are able to identify species, obtain an approximate number of fish, and initiate the lift cycle manually, if appropriate.

Since the Lockwood fish lift was installed in 2006, the Licensee, in consultation with MDMR and other state and federal fishery agencies, has made operational adjustments to the fishway each season to help to maximize its effectiveness.

Downstream Fish Passage Measures

In accordance with the existing KHDG Agreement, the Licensee is also providing interim measures for downstream Atlantic salmon passage at Lockwood. In 2006, the MDMR began transporting adult Atlantic salmon from the Lockwood fish lift to above the Weston Project. In addition, the MDMR has been stocking Atlantic salmon eggs in the Sandy River above the Weston Project since 2003.

In 2009, the Licensee installed a new downstream fish passage facility in the Lockwood power canal. This facility consisted of a 10 ft deep floating boom leading to a new 7 ft wide by 9 ft deep fish sluice and associated mechanical over-flow gate. Maximum flow through the gate is 6% of station capacity, or 340 cfs. The sluice is located on the river side of the power canal just upstream of the Unit 1 trash rack and discharges directly into the river.

The boom was 300 ft long and secured on the land side of the canal and angles downstream to the new sluice gate. The boom had flotation, and was suspended in the water column. The boom was constructed of 4 ft of impervious rubber material manufactured by Slickbar Inc. followed by six ft of 7/16-inch Dyneema netting.

In 2009, the Licensee evaluated the guidance boom and surface sluice gate and found that the boom was not buoyant and strong enough to handle existing unit flows and would not meet requirements. In the winter of 2010, the Licensee reviewed available floating boom products on the market and subsequently selected the "Tuffboom" product for installation at Lockwood. By early April 2010, the Licensee, in consultation with agencies, had developed a new guidance boom design. The new design consists of two ten ft long plastic cylindrical “Tuffboom” brand floats per section (i.e. 30 sections which equate to 300 ft long) with a four ft deep section of 5/16 inch metal punch plate located in between the floats. Attached to the punch plate is 6 ft of 5/16 inch Dyneema netting which had been used in the 2009 system. All gaps between the panels are covered by rubber flanges.

The new boom was installed in May 2010, and was evaluated using Atlantic salmon smolts and PIT tags. The results of the PIT tag tests were suspect due to issues associated with PIT tag antenna interference, limited PIT tag antenna range, and non-detection of fish.

Licensee subsequently conducted another evaluation using radio telemetry techniques in the spring of 2011. Based on review of the 2011 study results, a number of recommendations for enhancing the downstream bypass by Atlantic salmon smolts at Lockwood were developed.

In the spring of 2012, the Licensee conducted a second Atlantic salmon smolt radio telemetry downstream passage study at Lockwood. The purpose of the study was to evaluate the effectiveness of the guidance boom modification completed in the spring of 2012. These modifications included the replacement of 32 feet of the downstream section of the boom so as to replace the vulnerable portion of the existing netting with 10 foot deep metal punch plate panels. This modification also included the use of a new flexible attachment point and new larger floats. In addition, the existing trash rack exclusion bars at the entrance of the bypass, which were causing noise and vibration, were removed.

In addition to the new surface sluice gate and guidance boom, the Lockwood Project also includes an 875 ft long spillway section with 15-inch wood flashboards. Three orifices, 3 ft long by 8 inches high, are placed annually along the spillway. The purpose of the orifices is to pass a 50 cfs minimum flow to the bypass reach, and to provide downstream passage routes along the spillway, even when the project is not spilling over the top of the flashboards.

In accordance with the interim downstream passage requirements of the 1998 KHDG Agreement, the Licensee uses the existing sluices and unregulated spill as a means of providing downstream passage for anadromous species at the Lockwood Project.

5.2 Shawmut Project

Project Operations

The Shawmut Project is normally operated as run-of-river resulting in the protection of fish resources, riparian vegetation and aquatic habitat in the Kennebec River. Normal operations maintain the impoundment within about a foot of normal full pond.

There is currently no minimum flow requirement for the Shawmut Project. However, as a result of the run-of-river operation, and in coordination with the Licensee's other projects, current project operation generally ensures an average minimum flow of about 2,000 cfs. Provision of a minimum flow below the Shawmut project helps to protect and enhance fish and wildlife resources, riparian vegetation, aquatic habitat and water quality in the Kennebec River downstream of the Project.

Upstream Passage Measures

The Shawmut Project uses the Lockwood fish lift and transport system as its means of interim upstream fish passage. Atlantic salmon (and other anadromous species) are captured at the Lockwood lift and transported in trucks by the MDMR to areas of suitable habitat, primarily the Sandy River, upstream of the Shawmut Project.

Downstream Measures

Interim downstream passage for Atlantic salmon at Shawmut is provided through a sluice located on the right-hand side of the intake structure next to Unit 6. The sluice next to Unit 6 is a manually-adjustable sluice containing three stoplogs. The sluice is 4-feet-wide by 22-inches-deep. With all stoplogs removed, this sluice passes flows in the range of 30 to 35 cfs. Flows from this sluice discharge over the face of the dam and drain into a man-made 3 ft deep plunge pool connected to the river.

In addition, a Taintor gate next to this sluice, measuring 7 feet high by 10 feet wide, can pass 600 cfs and is used to pass debris and excess water. Flows from this gate also discharge over the face of the dam into a shallow plunge pool connected to the river.

In 2009, Maine Hydro engineers. operations personnel, and biologists investigated options to resolve debris issues and downstream anadromous and catadromous fish passage needs at Shawmut. It was agreed that the options for debris resolution could be designed to also address downstream fish passage needs. In 2010, Maine Hydro subsequently hired a team of consultants including Wright Pierce Engineers, Alden Research Labs and Blue Hill Hydraulics to design a new facility at the Project that would address both the debris and fish passage needs.

In 2011, the Licensee in consultation with resource agencies was developing designs for a new combined intake structure and downstream fish bypass facility at the Project. At that time, the proposed facility included the use of new full depth one inch angled trashracks and a new surface sluice and flume leading to the river. The proposed location and design of this facility, which resulted from significant efforts in hydraulic modeling and evaluation of alternatives by both the Licensee and resource agencies, was just upstream of the existing intake structure.

However, the need for this proposed facility is being re-evaluated in the light of favorable results from a 2012 downstream smolt study conducted at Shawmut. This study indicated that the majority of study smolts (over 80%) used the existing forebay Taintor gate for successful downstream passage. The Licensee will continue evaluations of downstream smolt passage at Shawmut and discussions with the resource agencies regarding how to provide safe and efficient passage to downstream migrants at the project.

The sluice and Taintor gate will continue to be opened for smolt and kelt passage generally from April 1 through December 31, as river and ice conditions allow. Interim downstream passage is also provided along the Shawmut spillway during periods of excess river flow that results in spill.

5.3 Weston Project

Project Operations

The Weston Project is normally operated in a run-of-river mode resulting in the protection of fish resources, riparian vegetation and aquatic habitat protection in the Kennebec River. Normal operations will maintain the pond within about a foot of normal full pond.

The Weston Project maintains a minimum flow of 1,947 cfs, or inflow, whichever is less, for the protection and enhancement of fish and wildlife resources, riparian vegetation, aquatic habitat and water quality in the Kennebec River downstream of the Project.

Upstream Fish Passage Measures

The Weston Project uses the Lockwood fish lift and transport system as its means of interim upstream fish passage. Atlantic salmon (and other anadromous species) are captured at the Lockwood lift and transported in trucks by the MDMR f to areas of suitable habitat, primarily the Sandy River, upstream of the Weston Project.

Downstream Fish Passage Measures

Interim passage at the Weston Project is provided through a sluice gate and associated concrete flume located on the South Channel dam. The gate and flume was formerly used as a log sluice during river log drives and is located near the Unit 4 intake. The sluice is 18-feet-wide by 14-feet-high and discharges into a deep plunge pool. Maximum flow through the gate at full pond is 2,250 cfs. During the downstream migration period, the gate is opened approximately 1.5 ft to pass 2% of station capacity (i.e.120 cfs). The sluice is opened for smolt and kelt passage generally from April 1 through June 15 and from November 1 through December 31 if river and ice conditions allow. In 2010, the Licensee made some major structural repairs to the existing structure which included resurfacing of the concrete flume.

On the North Channel side of the Weston Project, there are two Taintor gates, an inflatable rubber dam section, and stanchion gate sections. Interim passage is provided on the North Channel side via spillage.

The Licensee in consultation with resource agencies, has designed a new downstream bypass facility for the Weston Project. The new facility consists of a 250-300 ft long floating boom with ten ft deep sections of 5/16 inch metal punch plate screens located under the boom. The boom leads to the existing log sluice gate which discharges via an existing concrete flume to a deep pool in the river. The Licensee installed the new guidance boom in 2011, and it was fully deployed and operational during the 2012 smolt migration season. The Licensee also conducted effectiveness studies with salmon smolts in April and May of 2012 after resource agency consultation and approval of the study plan.

5.4 Brunswick Project

Project Operations

The Brunswick Project is normally operated in a run-of-river mode. The Brunswick headpond typically fluctuates about two feet while the units cycle on and off to approximately average inflow over the course of each day. This adequately protects fish resources, riparian vegetation and aquatic habitat in the tidal Androscoggin River below the project.

Upstream Fish Passage Measures

Upstream passage at Brunswick is provided via a vertical slot fishway and associated trap, sort and truck facility that was installed in 1983. The fishway is 570 ft long and consists of 42 individual pools, with a one-foot drop between each. The trapping facility, located at the upstream end of the fishway, provides biologists the opportunity to collect data on migratory and resident fish species that use the fishway. As fish swim to the top of the fishway, fixed grating guides them past a viewing window and into a 500-gallon capacity fish hoist (trap). The hoist elevates the fish to overhead sorting tanks where staff sort and pass fish upstream. Atlantic salmon pass upstream above the 40-foot dam after biological data are collected. During fishway operation from May 1 to October 30, an attraction flow of 100 cfs is provided.

The Brunswick facility is maintained by the Licensee, but since its construction MDMR personnel have operated the fishway each season under prior agreement.

Downstream Fish Passage Measures

Downstream passage is provided at the Brunswick Project via a surface sluice and associated pipe that discharges fish into the tailrace. The existing sluice gate and pipe was installed in 1983. The sluice is located between units 1 and 2. The sluice is opened for smolt and kelt passage generally from April 1 through December 31, as river and ice conditions allow.

5.5 Lewiston Falls Project

Project Operations

The Lewiston Falls Project is operated to maintain a minimum flow resulting in the protection and enhancement of fish and wildlife resources, riparian vegetation, aquatic habitat and water quality in the Androscoggin River downstream of the Project. Flow releases provide 850 cfs downstream of the powerhouse (Monty Station), and 150 cfs immediately below the discharge of the Lower Androscoggin facility.[3]

Fish Passage

There are no fish passage facilities at the Lewiston Falls Project, and the Licensee has no specific fish passage measures implemented or planned at this project. However, to reduce the potential effects of stranding of Atlantic salmon or other fish species at the Lewiston Falls Project, the Licensee monitors the Great Falls area after significant spill events and during flashboard replacement. Any stranded listed species that are collected are released back into the Androscoggin River.

6.0 ATLANTIC SALMON

6.1 Life History

Anadromous Atlantic salmon are a wide ranging species with a complex life history. The historic range of Atlantic salmon occurred on both sides of the North Atlantic. Along the North American Coast Atlantic salmon ranged from Connecticut to Ungava Bay.

Numerous reviews detailing the life history of U.S. origin Atlantic salmon exist (NRC, 2004; Fay et al., 2006; NMFS, 2009b) and their life cycle is summarized here. Adult Atlantic salmon begin to return to freshwater rivers during the spring. Redds (nests) are constructed and fertilized eggs are buried during the late fall. Following the fall spawn, approximately 20% of spent adult salmon (kelts) move back downstream and into the ocean but the majority move back downstream and into the ocean the following spring (Baum, 1997). Eggs remain in the gravel

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[3] It is noted that the canal system may be retired in the future and such flows through the canal may be reduced in that event. A total of minimum flow of 1000 cfs or inflow, if less, will continue to be maintained from the Lewiston Falls Project.

until hatching during the early spring. Following a three to six week period, the young salmon emerge from the gravel as fry and begin to actively seek food. As fry begin to feed, they develop cryptic vertical stripes and are then known as parr. Atlantic salmon remain in the parr stage for one to three years and remain resident to the freshwater river during that period. Following that period, each parr undergoes a series of physiological and morphological changes known as smoltification. It is at that time that these fish move downstream through the freshwater river system and into the ocean. This downstream migration takes place during the spring season (April-June) with the majority of Maine smolts entering the ocean during May (NFMS, 2009). Those individuals remain in the ocean for a period of 1-3 years prior to returning as adults and continuing the cycle. An adult that has been out to sea for 1 year and returns to its' spawning ground is considered a 1 sea winter (SW) adult and an adult that has been out to sea for two years is referred to as a 2SW adult.

6.2 Status and Distribution

In 2005, the Atlantic Salmon Biological Review Team (BRT) completed its status review of the Gulf of Maine Distinct Population Segment (GOM DPS) of Atlantic salmon (*Salmo salar*). The BRT found that the GOM DPS is comprised of all anadromous Atlantic salmon whose freshwater range occurs in the watersheds from the Androscoggin northward along the Maine coast to the Dennys River, including all associated conservation hatchery populations used to supplement natural populations. Currently, such populations are maintained at the Green Lake and Craig Brook National Fish Hatcheries (Fay et al., 2006).

The BRT concluded that the present abundance levels of the GOM DPS are substantially lower than historic levels. Fewer than 1,500 adults have returned to spawn each year since 1998 (Fay et al., 2006). Returns have been highest in the Penobscot River, which has a large amount of available habitat and large-scale stocking program that includes smolt, parr, fry, and restocking of captured sea-run adults after hatchery spawning. Returns to smaller rivers where fry were stocked or that had some natural spawning in previous years also had very low documented returns. Adult returns to rivers and streams that were not stocked and did not have spawning escapement in previous years were extremely low (Fay et al., 2006).

Overall, adult returns to the GOM DPS have been very low for many years and remain extremely low in terms of adult abundance in the wild. Moreover, adult returns to a single river, the Penobscot accounted for 91% of all adult returns in 2007 (NMFS, 2009a). Among these a large percentage of returning adults were the result of smolt stocking and only a small percent were naturally reared (NMFS, 2009a).

With respect to juveniles, the BRT found that Atlantic salmon juveniles are present in rivers where there has been recent spawning escapement or where fry, parr, or smolts have been stocked. During the period 1961 to 1978 on rivers where electrofishing surveys captured primarily natural reproduction, juvenile densities for many river systems had, on average, between 4 and 10 parr per habitat unit (Fay et al., 2006). These surveys generally targeted areas thought to contain high parr densities. In recent years, sampling has been conducted in a wide variety of habitat types, and not just riffle habitat that was typically sampled in the 1960s and

1970s. The density of juveniles in stocked rivers in 2004 was comparable to that reported in the 1960s and 1970s (Fay et al., 2006).

Low abundances of both hatchery-origin and naturally-reared adult salmon returns to Maine demonstrate continued poor marine survival. Estimates of marine mortality are generally based on an assessment of return rates or total marine survival. Estimates of total mortality are generally made by relating either hatchery smolt stocking rates or estimates of wild smolt production to the return of adult spawners. This method integrates all natural mortality factors, as well as fishing mortality. If smolts are counted as near the marine environment, the return rate indexes only marine survival. If the smolts are counted as they are stocked into upstream, freshwater reaches, then assessment of return rates include outmigration mortality (Fay et al., 2006).

In general, returns rates for Atlantic salmon across North America have declined over the last 30 years. Atlantic salmon marine survival rates prior to the 1990s range from 0 to 20%, based upon a review of 20 studies. Since this initial estimate of Atlantic salmon marine survival made in the late 1980s, marine survival rates for many southern North American monitored rivers have either remained low or continued to decline (ICES, 2005).

Marine survival rates for U.S. Atlantic salmon populations remain at historically low levels (NMFS, 2009a). NMFS (2009) concluded that estimated rates of return of generally less than 1.5% for U.S. Atlantic salmon. For the period of 2001 – 2005, 2SW return rates for wild Narraguagus River smolts ranged from 0.2 to 1.2% (mean 0.7%). Returns rates for 2000 - 2008 from hatchery Penobscot River smolts ranged between 0.096 and 0.428% for 1SW, 2SW, and 3SW (Dubé et al., 2010). Wild stocks and stocks returning after one sea winter typically return at higher rates (Bley and Moring, 1988; ICES, 2005). NMFS (2009) notes that lower return rates might be expected for U.S. stocks, which are primarily 2SW fish and have been the result of smolt releases for most of the restoration period.

Some researchers have suggested that Atlantic salmon stocks with longer migration routes typically experience lower marine survival rates, resulting in a north to south decreasing marine survival gradient in North America (Fay et al., 2006). The lower return rates of U.S. stocks compared to Canadian stocks may be a result of their relatively long migrations and be reflective of the geographic location of these stocks in the southern extent of the range of Atlantic salmon. However, the decline in non U.S. Atlantic salmon return rates suggest that other environmental factors may be playing a role in the observed decline. As summarized in the status review, recent research has demonstrated some correlations between environmental parameters and survival rates, but clear causal relationships have yet to be determined (Fay et al., 2006).

6.3 Habitat Characteristics and Use

Atlantic salmon have a complex life history that ranges from territorial rearing in rivers to extensive feeding migrations on the high seas. During their life cycle, Atlantic salmon go through several distinct phases that are identified by specific changes in behavior, physiology, morphology, coloration, and habitat requirements. Atlantic salmon are quite capable of surviving in and adapting to a wide range of habitat types, and their success as a species is determined by their ability to adapt to and utilize an array of foraging and defensive strategies that maximize survival. For example, juvenile salmon have been documented utilizing riverine, lake, and estuarine habitats; incorporating opportunistic and active feeding strategies; defending territories from competitors including other parr; and working together in small schools to actively pursue prey (Kircheis, 2007).

Kircheis (2007) provides a detailed assessment of the habitat requirements of Atlantic salmon and the effect of various forces on habitat. The following summarizes some of the specific freshwater habitat requirements of adult and juvenile salmon.

Adult Atlantic salmon returning to their natal streams require sufficient energy reserves and sufficiently unobstructed passage to reach their spawning grounds at the proper time for effective spawning. Physical and biological barriers can prevent adult salmon from effectively spawning, either by preventing access to spawning habitat or impairing a fish’s ability to spawn effectively by delaying migration or impairing the health of the fish. The amount of spawning habitat needed for adults is a function of the amount of habitat needed to adequately seed the habitat to maintain sustained populations into the future.

Adult Atlantic salmon are strong swimmers and can swim at sustained speeds of 2.2 km/hr and a burst speed of 24 km/hr. However, Atlantic salmon require a minimum stream velocity of 0.3 to 0.6 m/sec to stimulate upstream migration. In lakes, ponds or dead waters, where flows may fall below the minimum velocities needed to stimulate upstream migration, salmon will enter an active search mode, where salmon actively seek out moving water that would stimulate continued migration. In areas where water velocity exceeds 1.25 m/s adult salmon require resting areas (Kircheis, 2007).

During migration adult salmon require holding and resting areas that provide the necessary cover, temperature, flow, and water quality conditions needed to survive. Holding areas can include areas in rivers and streams, lakes, ponds, and even the ocean. Holding areas are necessary below temporary seasonal migration barriers such as those created by flow, temperature, turbidity, and temporary obstructions (such as debris jams and beaver dams), and adjacent to spawning areas.

Adult salmon can become fatigued when ascending high velocity riffles or falls and require resting areas within and around high velocity waters where they can recover. Adult salmon that return to rivers in the spring often spend several months in the river before spawning. During this time, the adult salmon often seek cool water refuge, with sufficient cover to provide shade, reduce velocities and provide protection from predators.

Adult salmon migratory behaviors are significantly influenced by temperature and dissolved oxygen. Most migratory movement is conducted when temperatures range between 14 – 20^{o}C, and increased temperatures can also significantly affect the movement of adult salmon through fishways (Kircheis, 2007). In addition, temperatures between 20^{o}C and 27^{o}C reduces resistance to disease and are therefore can be lethal (Kircheis, 2007). Dissolved oxygen requirements for Atlantic salmon depend on the activity of the fish and water temperature, but it is generally recognized that sustained DO concentrations of 5 mg/l or below are inadequate for Atlantic salmon and block migration (Kircheis, 2007).

Spawning activity for GOM DPS Atlantic salmon typically occurs between mid-October and mid-November. Research suggests that light (photoperiod) and water temperature are the key triggers for spawning activity. Adult Atlantic salmon generally spawn in streams that host clean, cool, well oxygenated, water. Moderately low to moderately steep gradients, and assorted gravel up to cobble and boulder substrate, characterize most spawning habitat. Preferred salmon spawning habitat contains gravel substrate with adequate water circulation to keep buried eggs well oxygenated (NMFS, 2009b).

DO is critical for proper embryonic development and hatching. Embryos can survive at DO concentrations below saturation, but their development under low DO conditions is abnormal due to delayed growth or maturation.

After hatching, fry remain buried in the gravel for about six weeks, and then emerge in about mid-May when they begin to feed on plankton and small vertebrates. When the fry leave the red, they move through interstitial spaces to reach the surface. If interstitial spaces become embedded with silt or fine materials, emergence can be delayed or prevented. Newly emerged fry prefer shallow, low velocity riffle habitat, with clean gravel substrate.

Emergent fry quickly disperse from redds within the gravel. The young fish develop camouflaging stripes along their sides and enter the parr stage. Parr habitat, also known as nursery habitat, is typically riffle areas characterized by adequate cover, shallow water depth, and moderate to fast water flow. Though parr prefer riffle habitat, they are not limited to this type of habitat and can move great distances to find habitat that provides them with sufficient cover and food. Parr occupy pools, backwater areas, and lakes as habitat, and may seek out such areas during periods of low flow or high water temperatures.

Parr require cool, well oxygenated water for optimal growth. Optimal water temperatures for parr feeding and growth is between 15-19^{o}C. Parr also require high oxygen levels to support their feeding strategy. Though salmon parr can tolerate DO concentrations below 6 mg/l, at lower DO concentrations both swimming activity and growth rates are restricted. Parr rely mostly on invertebrate drift as a food source, and they actively defend territories to assure adequate food resources. Par feed on a variety of invertebrates and will occasionally eat small fishes (Kircheis, 2007).

Salmon parr spend 2-3 years in their freshwater stream, and then undergo a physiological transformation called smoltification that prepares them for life in a marine environment. The process of smoltification is triggered in response to environmental conditions; most notably photoperiod and water temperature. Throughout New England most smoltification occurs between first of May and the first week in June. However the time it takes to complete the smoltification process appears to be related to water temperature. Warmer water temperatures have been shown to accelerate the physiological changes in the smolts. Flow does not appear to affect the smoltification process, but it does seem to play a role in stimulating a migration response. The timing of warmer water temperatures in combination with higher flows to trigger migration is important as elevated water temperatures that occur in advance of a smolts' diurnal cues to migrate can result in a decreased migration window during which smolts are capable of transitioning into a marine environment (Kircheis, 2007).

6.4 Critical Habitat

Coincident with the June 19, 2009 endangered listing, NMFS designated critical habitat for the GOM DPS of Atlantic salmon (74 FR 29300; June 19, 2009). The final rule was revised on August 10, 2009. Figure 15 shows the watersheds designated as Atlantic Salmon Critical Habitat within the GOM DPS.

To establish critical habitat, NMFS identified specific areas within the geographic area occupied by Atlantic salmon at the time of its listing. Atlantic salmon currently inhabiting the GOM DPS historically occupied accessible freshwater habitat ranging from the Androscoggin River watershed in the south to the Dennys River watershed in the north, as well as adjacent estuaries and bays through which the smolts and adults migrate.

In designating specific areas of critical habitat, NMFS utilized Hydrologic Unit Code (HUC) 10[4] (Level 5 watersheds) as the appropriate "specific areas" within the geographic area of the GOM DPS for designation of critical habitat. In addition, in the Androscoggin River basin, NMFS recognized Rumford Falls to be the upstream extent of the historic range of Atlantic salmon on the mainstem, and Snow Falls in the town of West Paris, to be extent of the historic range on the Little Androscoggin River. In the Kennebec River basin, NMFS recognized Grand Falls on the Dead River and the unnamed falls (impounded by Indian Pond Dam) to be the historic upstream extent of Atlantic salmon habitat.

Each HUC 10 watershed within the range of the GOM DPS was evaluated to determine if that area is "occupied" by Atlantic salmon. Inclusion of a particular HUC10 as critical habitat does not imply that the *entire* HUC is occupied by Atlantic salmon. NMFS considered that an HUC 10 watershed was occupied if either of the following criteria were met:

(a) Redds or any life stage of salmon have been documented within the HUC10 in the last 6 years, or the HUC 10 is believed to be occupied and contain primary constituent elements (PCEs) based on the best scientific information and the best professional judgment of state and Federal biologists;

(b) The HUC is currently managed by the MDMR and the USFWS through an active stocking program in an effort to enhance or restore Atlantic salmon populations, or the area has been stocked within the last 6 years and juvenile salmon could reasonably be expected to migrate to the marine environment and return to that area as an adult and spawn.

Under Section 4(b)(2) of the ESA, NMFS is required to consider the economic, national security and other impacts of designating a particular area as critical habitat. NMFS may, at its discretion, exclude an area from critical habitat if it determines that the benefits of exclusion outweigh the benefits of specifying the area as critical habitat, until it has been determined that

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[4] The HUC system was developed by the U.S. Geological System (USGS) Office of Water Data coordination (Seaber et al., 1994) to provide (1) a nationally accessible, coherent system of water-use data exchange; (2) a means of grouping hydrographical data; and (3) a standardized scientifically grounded reference system. The HUC system currently includes six nationally consistent hierarchical levels of divisions with HUC 2 (Level 1) being the largest and HUC 12 (Level 6) being the smallest.

the failure to designate the area as critical habitat will result in the extinction of the species (NMFS, 2009b).

As a means of appropriately considering such exclusions, in its evaluation of critical habitat for Atlantic salmon, NMFS assigned a biological value based on habitat quantity and quality needed to support spawning, rearing and migration of Atlantic salmon. The final biological value developed by NMFS for each of the three GOM DPS SHRUs indicates the current value of the habitat to Atlantic salmon spawning, rearing and migrations activities (NMFS, 2009b).

Under NMFS' designation of critical habitat, a habitat unit represents 100 m^3 of spawning and rearing habitat. A numeric model predicted habitat quantity; for each HUC 10 NMFS calculated the amount of habitat. NMFS scored each HUC 10 based on a set of criteria including temperature, biological communities, water quality, and substrate and cover to then determine habitat quality.

In the Merrymeeting Bay SHRU there are an estimated 372,600 units of historically accessible spawning and rearing habitat for Atlantic salmon, found among approximately 5,950 km^2 of historically accessible rivers, streams and lake. Of these units, 136,000 units of habitat are considered to be critical habitat. Of these, NMFS estimates there to be nearly 40,000 functional equivalents of habitat or approximately 11 percent of the historical functional potential. This estimate is based on the configuration of dams within the SHRU that limit migration and degradation of physical and biological features from land use activities which reduce the productivity of habitat within each HUC 10. NMFS has further determined that for each SHRU to achieve recovery objectives for Atlantic salmon, 30,000 fully functional units of habitat are needed (NMFS, 2009b).

6.5 Primary Constituent Elements of Atlantic Salmon Critical Habitat

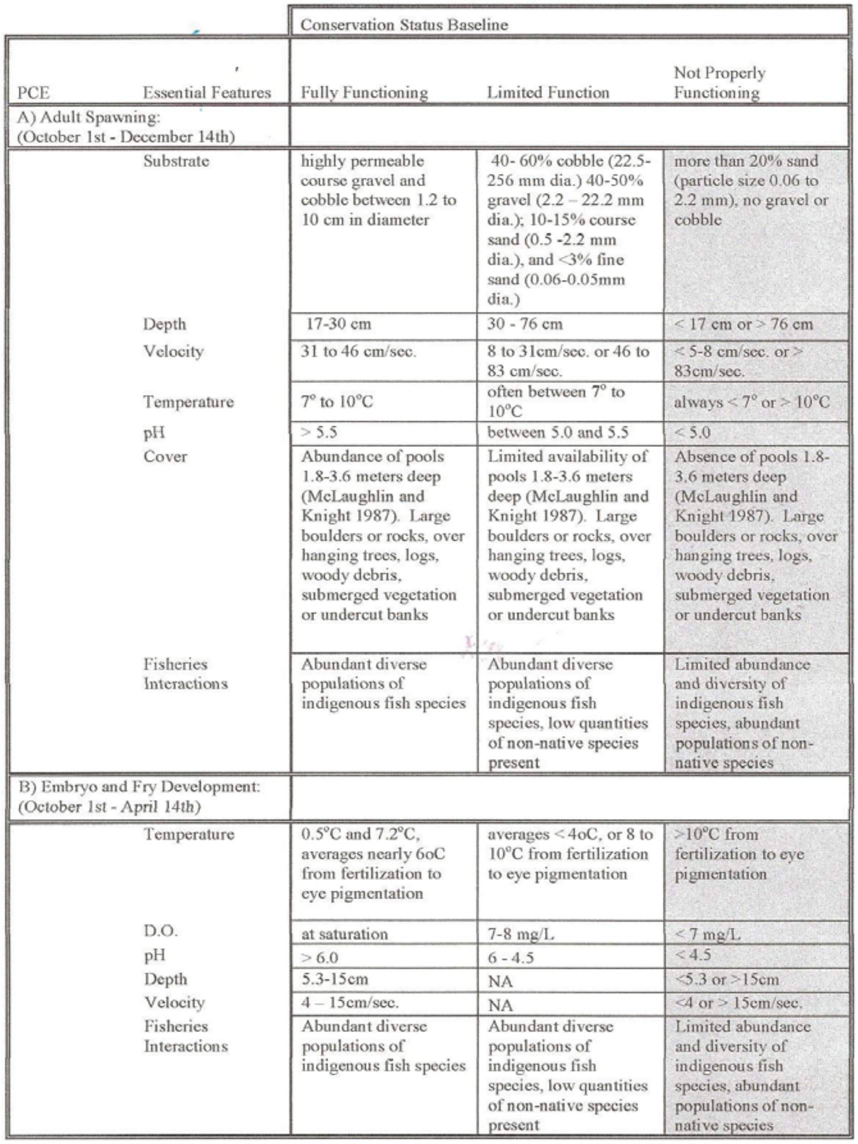
Designation of critical habitat is focused on the known primary constituent elements (PCEs), that are deemed essential to the conservation of the species. NMFS has established physical and biological features (essential features) of each PCE, with respect to Atlantic salmon critical habitat. The PCEs for Atlantic salmon include spawning and rearing, and migration, and are described in regards to five distinct Atlantic salmon life stages: (1) adult spawning; (2) embryo and fry development; (3) parr development; (4) adult migration; and, (5) smolt migration.

Habitat areas designated as critical habitat must contain one or more PCEs within the acceptable range of values required to support the biological processes for which the species uses that habitat. 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 has only been designated in areas (HUC-10 watersheds) considered currently occupied by the species. 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 bankful elevation in the absence of a defined high-water line.

For an area containing PCEs to meet the definition of critical habitat, the ESA also requires that the physical and biological features essential to the conservation of Atlantic salmon in that area "may require special management considerations or protections." Activities within the GOM

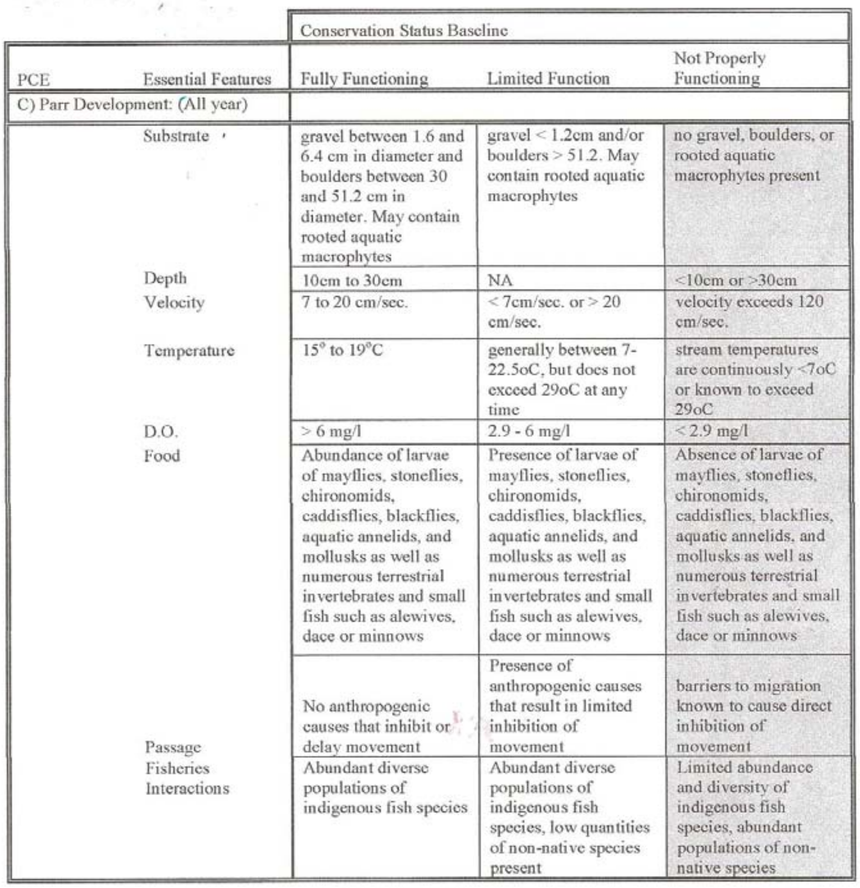
DPS that were identified as potentially affecting the physical and biological features of salmon habitat and, therefore, requiring special management considerations or protections include agriculture, forestry, changing land-use and development, hatcheries and stocking, roads and road-stream crossings, mining, dams, dredging, and aquaculture.

Table 6.5-1. Matrix of Primary Constituent Elements (PCEs) and Essential Features for Assessing the Status of Atlantic Salmon Critical Habitat (Source: NMFS, 2012a)



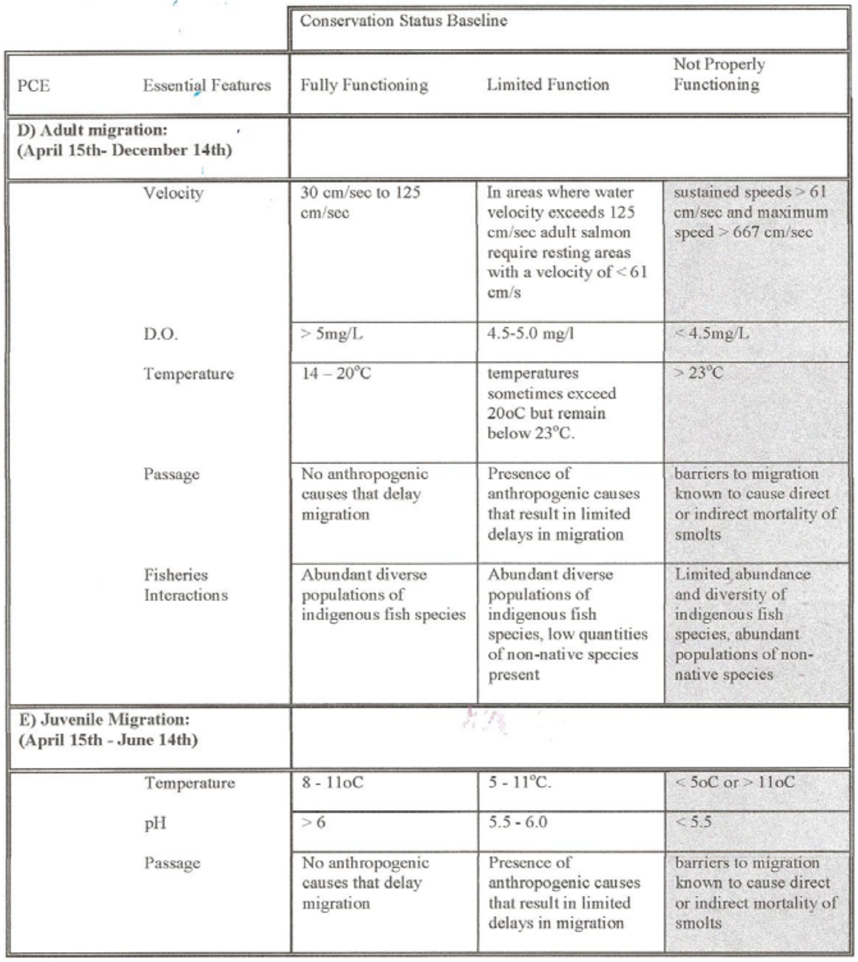
		Conservation Status Baseline		
PCE	Essential Features	Fully Functioning	Limited Function	Not Properly Functioning
A) Adult Spawning: (October 1st - December 14th)				
	Substrate	highly permeable course gravel and cobble between 1.2 to 10 cm in diameter	40- 60% cobble (22.5-256 mm dia.) 40-50% gravel (2.2 – 22.2 mm dia.); 10-15% course sand (0.5 -2.2 mm dia.), and <3% fine sand (0.06-0.05mm dia.)	more than 20% sand (particle size 0.06 to 2.2 mm), no gravel or cobble
	Depth	17-30 cm	30 - 76 cm	< 17 cm or > 76 cm
	Velocity	31 to 46 cm/sec.	8 to 31cm/sec. or 46 to 83 cm/sec.	< 5-8 cm/sec. or > 83cm/sec.
	Temperature	7° to 10°C	often between 7° to 10°C	always < 7° or > 10°C
	pH	> 5.5	between 5.0 and 5.5	< 5.0
	Cover	Abundance of pools 1.8-3.6 meters deep (McLaughlin and Knight 1987). Large boulders or rocks, over hanging trees, logs, woody debris, submerged vegetation or undercut banks	Limited availability of pools 1.8-3.6 meters deep (McLaughlin and Knight 1987). Large boulders or rocks, over hanging trees, logs, woody debris, submerged vegetation or undercut banks	Absence of pools 1.8-3.6 meters deep (McLaughlin and Knight 1987). Large boulders or rocks, over hanging trees, logs, woody debris, submerged vegetation or undercut banks
	Fisheries Interactions	Abundant diverse populations of indigenous fish species	Abundant diverse populations of indigenous fish species, low quantities of non-native species present	Limited abundance and diversity of indigenous fish species, abundant populations of non-native species
B) Embryo and Fry Development: (October 1st - April 14th)				
	Temperature	0.5°C and 7.2°C, averages nearly 6oC from fertilization to eye pigmentation	averages < 4oC, or 8 to 10°C from fertilization to eye pigmentation	>10°C from fertilization to eye pigmentation
	D.O.	at saturation	7-8 mg/L	< 7 mg/L
	pH	> 6.0	6 - 4.5	< 4.5
	Depth	5.3-15cm	NA	<5.3 or >15cm
	Velocity	4 – 15cm/sec.	NA	<4 or > 15cm/sec.
	Fisheries Interactions	Abundant diverse populations of indigenous fish species	Abundant diverse populations of indigenous fish species, low quantities of non-native species present	Limited abundance and diversity of indigenous fish species, abundant populations of non-native species

Table 6.5-1. Continued



		Conservation Status Baseline		
PCE	Essential Features	Fully Functioning	Limited Function	Not Properly Functioning
C) Parr Development: (All year)				
	Substrate	gravel between 1.6 and 6.4 cm in diameter and boulders between 30 and 51.2 cm in diameter. May contain rooted aquatic macrophytes	gravel < 1.2cm and/or boulders > 51.2. May contain rooted aquatic macrophytes	no gravel, boulders, or rooted aquatic macrophytes present
	Depth	10cm to 30cm	NA	<10cm or >30cm
	Velocity	7 to 20 cm/sec.	< 7cm/sec. or > 20 cm/sec.	velocity exceeds 120 cm/sec.
	Temperature	15° to 19°C	generally between 7-22.5oC, but does not exceed 29oC at any time	stream temperatures are continuously <7oC or known to exceed 29oC
	D.O.	> 6 mg/l	2.9 - 6 mg/l	< 2.9 mg/l
	Food	Abundance of larvae of mayflies, stoneflies, chironomids, caddisflies, blackflies, aquatic annelids, and mollusks as well as numerous terrestrial invertebrates and small fish such as alewives, dace or minnows	Presence of larvae of mayflies, stoneflies, chironomids, caddisflies, blackflies, aquatic annelids, and mollusks as well as numerous terrestrial invertebrates and small fish such as alewives, dace or minnows	Absence of larvae of mayflies, stoneflies, chironomids, caddisflies, blackflies, aquatic annelids, and mollusks as well as numerous terrestrial invertebrates and small fish such as alewives, dace or minnows
	Passage	No anthropogenic causes that inhibit or delay movement	Presence of anthropogenic causes that result in limited inhibition of movement	barriers to migration known to cause direct inhibition of movement
	Fisheries Interactions	Abundant diverse populations of indigenous fish species	Abundant diverse populations of indigenous fish species, low quantities of non-native species present	Limited abundance and diversity of indigenous fish species, abundant populations of non-native species

Table 6.5-1. Continued



		Conservation Status Baseline		
PCE	Essential Features	Fully Functioning	Limited Function	Not Properly Functioning
D) Adult migration: (April 15th- December 14th)				
	Velocity	30 cm/sec to 125 cm/sec	In areas where water velocity exceeds 125 cm/sec adult salmon require resting areas with a velocity of < 61 cm/s	sustained speeds > 61 cm/sec and maximum speed > 667 cm/sec
	D.O.	> 5mg/L	4.5-5.0 mg/l	< 4.5mg/L
	Temperature	14 – 20°C	temperatures sometimes exceed 20oC but remain below 23°C.	> 23°C
	Passage	No anthropogenic causes that delay migration	Presence of anthropogenic causes that result in limited delays in migration	barriers to migration known to cause direct or indirect mortality of smolts
	Fisheries Interactions	Abundant diverse populations of indigenous fish species	Abundant diverse populations of indigenous fish species, low quantities of non-native species present	Limited abundance and diversity of indigenous fish species, abundant populations of non-native species
E) Juvenile Migration: (April 15th - June 14th)				
	Temperature	8 - 11oC	5 - 11°C.	< 5oC or > 11oC
	pH	> 6	5.5 - 6.0	< 5.5
	Passage	No anthropogenic causes that delay migration	Presence of anthropogenic causes that result in limited delays in migration	barriers to migration known to cause direct or indirect mortality of smolts

7.0 POTENTIAL EFFECTS ON ATLANTIC SALMON

Within the Merrymeeting Bay SHRU there are roughly 104 dams of which 15 are FERC licensed mainstem dams used for power generation or storage, resulting in over 59 km of impounded river (Maine DEP, 1999). Within the Kennebec River basin, there are currently 18 hydroelectric dams in the Kennebec watershed and 15 of these dams are impassable due to the lack of fishways. The Lockwood Project is the first dam on the Kennebec River. There are 9 hydroelectric dams upstream of the Lockwood Project on the mainstem Kennebec River and an additional 4 on upstream tributaries. The vast majority of salmon habitat (nearly 90%) in the Kennebec River watershed is located above Lockwood Project (NMFS, 2012a).

On the Androscoggin below Rumford (the upper extent of the range of Atlantic salmon), major hydroelectric facilities include the upper and lower stations at the Rumford Falls project in Rumford; Riley/Jay/Livermore Projects in Jay, Riley and Livermore; Gulf Island/Deer Rips project in Lewiston-Auburn; Lewiston Falls project in Lewiston/Auburn; the Worumbo Project in Lisbon/Durham; Pejepscot in Topsham/Brunswick; and the Brunswick project in Brunswick/Topsham. Today, the upper extent of fish passage in the Androscoggin River is Lewiston Falls 32 km upstream from Merrymeeting (NMFS, 2012b).

Hydroelectric dams are known to impact Atlantic salmon through habitat alteration, fish passage delays, and entrainment and impingement (NMFS, 2012a).

7.1 Habitat Alteration

Within the Merrymeeting Bay SHRU, dams have altered or eliminated significant reaches of historic rearing habitat in the Kennebec River watershed. The Kennebec River consists of 254,558 historic habitat units, with 44,402 units considered to be accessible by the Services (NMFS, 2012a). On the Kennebec River, because Atlantic salmon cannot volitionally access habitat upstream of the Lockwood Project, habitat in the upper areas of the Kennebec River including the Sandy River is not considered accessible by the Services, notwithstanding the trap and truck program in place.

The Androscoggin River consists of 70,249 historic habitat units, with 16,978 units considered to be occupied. Because Atlantic salmon cannot volitionally access habitat upstream of the Lewiston Falls Project on the mainstem and the Barker Mill Dam on the Little Androscoggin, habitat in the upper areas of the Androscoggin River watershed are not accessible (NMFS, 2012b).

Dams generally limit access to habitat and the impoundments created by these dams alter habitat, and degrade water quality through increased temperatures and lowered dissolved oxygen levels. Additionally, 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. Coincidently, these moderate to high gradient reaches, if free-flowing, would likely constitute the highest value as Atlantic salmon spawning, nursery, and adult resting habitat within the context of all potential salmon habitat within these reaches (NMFS, 2012a).

7.2 Habitat Connectivity

Pre-spawned adults

For pre-spawned adults, high quality spawning and rearing habitat on the Kennebec River is not presently accessible volitionally to Atlantic salmon. Since there are currently no upstream fish passage facilities at any of the projects upstream of Lockwood, to access high quality spawning and rearing habitat in the Kennebec River watershed, Atlantic salmon must utilize the existing fish lift and be trapped at the Lockwood Project and transported by trucks to upstream areas. While trap and truck fish passage can successfully move migrants to upstream areas, trap and truck operations to transport migratory fish species can result in adverse impacts including injury, disorientation, disease and mortality, delay in migration, and interruption of the homing instinct, which can lead to straying (OTA, 1995). Other disadvantages to trap and truck passage include: holding and handling stress, reduced passage by other species that will not enter traps, and the need for long-term, guaranteed operational funding for dedicated biological staff, equipment, supplies, vehicles and tanks, etc. (NMFS, 2012a).

In 1982, CMP installed a vertical slot fishway, together with a trapping and sorting facility at the Brunswick project, the first dam on the mainstem Androscoggin River. In 1987, the Pejepscot Project, the second dam on the Androscoggin River, had upstream fish passage (fish lift) installed. In 1988, upstream passage facilities (fish lift) were also installed at the Worumbo Project, the third upstream dam on the river. The addition of upstream fishways at Pejepscot and Worumbo provided an opportunity for anadromous species, including pre-spawned Atlantic salmon to migrate upstream as far as Lewiston Falls (NMFS, 2012b).

Outmigrating Smolts

Smolts from the upper Kennebec River and the Androscoggin River have to navigate through multiple dams on their migrations to the estuary every spring. The route that a salmon smolt takes when passing a project is a major factor in its likelihood of survival. In general, fish that pass through a properly designed downstream bypass have a better chance of survival than a fish that goes over a spillway, which, in turn, has a better chance of survival than a fish swimming through the turbines. However, this is not always the case, and survival is largely dependent on site-specific conditions. According to NMFS, it can be assumed that close to 100% of smolts will survive when passing through a properly designed downstream bypass. Survival through turbines varies significantly based on numerous factors, but as described above can be significantly lower than the other two routes (NMFS, 2012a).

Although some smolt studies have been conducted at hydroelectric dams in the lower Kennebec River (including the Weston, Shawmut, Hydro-Kennebec and Lockwood projects) to assess downstream passage effectiveness for smolts, the survival rates of smolts migrating past dams in the Kennebec River are based on modeled estimates, and exact survival rates are currently unknown (NMFS, 2012a). Survival of smolts migrating past dams in the Androscoggin River is also presently unknown (NMFS, 2012b). However, smolt studies conducted by Holbrook (2007) on the Penobscot River documented significant losses of smolts in the vicinity of mainstem dams. Of the tagged salmon smolts used in the study in 2005 and 2006, 43% and 60%, respectively, were lost in the vicinity of the West Enfield, Howland, and Milford Dams.

Although these data do not definitively reveal sources of mortality, these losses may be attributable to the direct and indirect effects of the dams (e.g., physical injury, predation). Alden Research Laboratory (Alden, 2012) modeled the smolt survival rates of 15 hydroelectric dams in the Penobscot River. The average of the mean survival rates at the 15 projects (accounting for both direct and indirect mortality) was 89.5%, but survival at individual dams fell as low as 61.5% (NMFS, 2012b).

Outmigrating Kelts

Atlantic salmon kelts move downstream after spawning in November or, alternatively, overwinter in freshwater and outmigrate early in the spring (mostly mid-April through late May). As reported by NMFS (2012b), Lévesque *et al.* (1985) and Baum (1997) suggest that 80% of kelts overwinter in freshwater habitat prior to returning to the ocean. No kelt survival studies have been conducted on the Kennebec or Androscoggin river, however, downstream passage success at dams on the Penobscot has been studied. Kelt passage occurred during periods of spill at most dams, and a large portion of study fish used the spillage route. Kelt attraction to, and use of, downstream passage facilities was highly variable depending on facility, year of study, and hydrological conditions (e.g., spill or not). According to NMFS (2012b), Shepard (1989) documented that kelts relied on spillage flows to migrate past the Milford and Veazie Dams on the Penobscot River during a study conducted in 1988. In fact, some kelts spent hours to days searching for spillway flows to complete their downstream migration during the 1988 study.

NMFS reported that Alden Lab has modeled the current survival rates of kelts at the dams on the Penobscot River, based on turbine entrainment, spill mortality estimates, and bypass efficiency. Alden Lab's analysis accounted for both immediate and delayed mortality associated with dam passage. Through the three months of outmigration, Alden Lab indicates that mean survival rates at 14 of the dams (Medway is excluded) on the Penobscot range between 61% and 93% (NMFS, 2012b).

7.3 Predation

In addition to the direct impacts fish that may occur during downstream passage, kelts and smolts are exposed to indirect mortality caused by sub-lethal injuries, increased stress, and/or disorientation. NMFS (2012a) reports that a large proportion of indirect mortality is a result of disorientation caused by downstream passage, which can lead to elevated levels of predation immediately downstream of the project.

Smallmouth bass and chain pickerel are each important predators of Atlantic salmon within the range of the GOM DPS (Fay *et al.* 2006). Smallmouth bass are a warm-water species that are now found in much of Maine. Smallmouth bass are very abundant in the Kennebec River, and inhabit much of the main stem migratory corridor and areas containing juvenile Atlantic salmon (NMFS, 2012a). Smallmouth bass likely feed on fry and parr though little quantitative information exists regarding the extent of bass predation upon juvenile salmon. Smallmouth bass are thought to be significant predators of smolts in main stem habitats.

Chain pickerel are known to feed upon smolts within the range of the GOM DPS and likely also feed upon fry and parr (NMFS, 2012a). As reported by NMFS (2012a), Van den Ende (1993) found that smolts were, by far, the most common item observed in the diet of chain pickerel. 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.

Northern pike have been illegally stocked in Maine, and their range now includes portions of the lower Kennebec River. Northern pike are ambush predators that rely on vision and thus, predation upon smolts occurs primarily in daylight with the highest predation rates in low light conditions at dawn and dusk. As reported by NMFS (2012a), hatchery smolts experience higher rates of predation by fish than wild smolts, particularly from northern pike.

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 items in cormorant sampled at Penobscot mainstem dam foraging sites. Common mergansers, belted kingfishers cormorants, and loons prey would likely prey upon Atlantic salmon in the Kennebec River. The abundance of alternative prey resources such as upstream migrating alewife, likely minimizes the impacts of cormorant predation on the GOM DPS (Fay *et al.* 2006).

7.4 Latent Effects of Downstream Passage

In addition to direct mortality sustained by Atlantic salmon at hydroelectric projects, Atlantic salmon may also sustain delayed mortality as a result of repeated passage events at multiple hydroelectric projects. NMFS (2012a) reports that studies have investigated what is referred to as latent or delayed mortality, which occurs in the estuary or ocean environment and is associated with passage through one or more hydro projects. This “hydrosystem stress”, is due to factors such as dam passage (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 (NMFS, 2012a).

Although latent mortality following passage through a hydro system has been demonstrated by certain studies described in NMFS (2012a), effectively quantifying such losses remains difficult, mainly because of practical limitations in directly measuring mortality after fish have left a river system (i.e., during time spent in estuaries and the marine environment). Evaluations of latent mortality have generally produced indirect evidence to support the link between hydrosystem experience and estuary and marine survival rates (and smolt-to-adult returns) (NMFS, 2012a). Currently there is insufficient data to specifically assess the effect of hydrosystem-related mortality in the Kennebec and Androscoggin Rivers. However, considering the number of mainstem dams on both Androscoggin and Kennebec rivers, the effects of “hydrosystem stress” on salmon during migration could be significant (NMFS, 2012a).

7.5 Contaminants and Water Quality

Pollutants discharged from point sources can affect Atlantic salmon. Common point sources of pollutants include publicly operated waste treatment facilities, overboard discharges, and industrial sites and discharges. NMFS (2012a) reports that the impacts of point source pollution are generally greater in the larger rivers of the GOM DPS (NMFS, 2012a). In the Kennebec River watershed, the mainstem of the Kennebec River downstream of Augusta has restricted fish consumption advisory 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. 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.

Poor water quality is of particular concern for fisheries restoration in the Androscoggin River watershed. According to NMFS (2012b), the U.S. Environmental Protection Agency (USEPA) has noted that two segments of the Androscoggin River, including the lower four miles of the Gulf Island dam impoundment and the Livermore Falls impoundment do not attain water quality standards for class C waters (USEPA 2005). The non-attainment status is caused by point source discharges from upstream paper mills and municipal treatment plants, as well as non-point sources.

Although water quality is an issue for Atlantic salmon as a result of releases from non-hydroelectric sources, there are no direct discharges of pollutants from the hydropower projects that would affect Atlantic salmon or its critical habitat.

7.6 Potential for 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. The effects of future state and private activities in the action area that are reasonably certain to occur are continuation of recreational fisheries, discharge of pollutants, and development and/or construction activities resulting in excessive water turbidity and habitat degradation.

Impacts to Atlantic salmon from non-federal activities are largely unknown in the Kennebec and Androscoggin River basins. It is possible that occasional recreational fishing for anadromous fish species may result in incidental takes of Atlantic salmon. According to NMFS (2012b), despite strict state and federal regulations, both juvenile and adult Atlantic salmon remain vulnerable to injury and mortality due to incidental capture by recreational anglers and incidental catch in commercial fisheries.

Pollution from point and non-point sources has historically been a major problem in these river systems, which continues to receive discharges from sewer treatment facilities and paper production facilities. Atlantic salmon are vulnerable to the impacts of pollution and are likely to continue to be impacted by water quality impairments in both the Kennebec and Androscoggin rivers, and their tributaries.

8.0 DETERMINATION OF EFFECTS

Based on the analysis contained in this draft BA, the Determination of Effect of ongoing operations of the five projects on Atlantic salmon and its designated critical habitat, is provided below.

8.1 Avoidance and Minimization of Effects

The Licensees have undertaken significant measures at the five hydropower projects addressed in this BA to avoid and minimize effects on Atlantic salmon. Section 5 details the measures that the Licensees have already carried out with respect to improving upstream and downstream passage for salmon at the Lockwood, Shawmut, Weston and Brunswick projects. The Licensees have also developed an ISPP, which spells out enhancement measures and activities with respect to fish passage, project operations, studies, and monitoring that the Licensees will undertake through the term of the ISPP to further avoid and minimize effects to Atlantic salmon. The Licensees practice adaptive management, and will continue informal consultation efforts under Section 7 of the ESA with the Services to implement additional enhancement measures that will serve to further minimize effects to Atlantic salmon.

8.2 Estimate of Incidental Mortality

Atlantic salmon smolts

Migratory fish restoration efforts on the Kennebec River have focused on alewife and American shad. Because of the few salmon returns and limited amount of juvenile stocking efforts, studies to evaluate smolt survival are limited for the Kennebec River. Therefore, the Licensee conducted an analysis of immediate whole station survival using industry standard methodology for estimating turbine survival as described below. The whole station survival combines smolt distributions and survival estimates for all passage routes (e.g., spillway, turbines, and fishway) through the Project. This was performed using April, May, and June median (50% exceedence), low (90% exceedance), and high (10% exceedance) flows.

A detailed assessment of the potential for injury and mortality to outmigrating Atlantic salmon smolts was conducted for the Weston, Shawmut and Lockwood projects on the Kennebec River and the Brunswick Project on the Androscoggin River (see Attachment B)[5]. At each individual Project, downstream passage of outmigrating smolts must occur via one of three routes: (1) unregulated spillage, (2) permanent or interim downstream bypass facilities, or (3) the project turbines. These three potential routes of passage were considered and incorporated into each of the whole station smolt survival models. Prior to construction of the whole station smolt survival

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[5] Attachment B includes January, 2012 versions of the White Papers that were developed for each of the four projects: Lockwood, Shawmut, Weston, and Brunswick. Modeled estimates of Atlantic salmon smolt and kelt survival included in the January, 2012 versions of the White Papers was based on project data that was current at that time, but has since been revised/updated, as reflected in the tables provided in Section 3 of this Draft BA. However, the differences in project unit specifications were very small, and the January 2012 survival estimates utilized more conservative unit data.

models, information related to smolt run timing, spill effectiveness, downstream bypass effectiveness, immediate and delayed survival rates for smolts passed via spill, and Francis, Kaplan and propeller turbines at each Project was obtained.

Seasonal distribution and timing data for smolts migrating downstream in both the Kennebec and Androscoggin rivers is unavailable. Smolt outmigration from Maine rivers takes place during the months of April, May, and June (Baum, 1997). Based on available data from salmon rivers in Maine (Penobscot and Narraguagus) an average percentage of the outmigrating smolt run was estimated for each of those three months. The whole station smolt survival estimates generated for the four projects relied on a calculated monthly distribution of Atlantic salmon smolts of 1.8% during April, 77.0% during May, and 21.2% during June.

River discharge during the spring migration period dictates the proportion of Atlantic salmon smolts passed via unregulated spill and conversely, through the project facilities (via either a permanent or interim downstream bypass facility or turbine unit). Spill effectiveness, defined as the proportion of smolts passed through spill relative to the total number passing the project, was calculated for each of the four projects. In the absence of site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (.e.g., spilling 50% of total river flow results in 50% of smolts passing via the spillway). An overall spill effectiveness rate for the period April through June was calculated using the site-specific Project capacity, the monthly distribution of Atlantic salmon smolt outmigration, site-specific monthly median river flow conditions and the assumption of 1:1 spill effectiveness. Spill effectiveness rates under median flow conditions (i.e., the value with 50% flow exceedence) were determined to be 23.6% at Weston, 20.6% at Shawmut, 30.1% at Lockwood, and 9.6% at Brunswick.

Where available, the detailed assessments of smolt passage at the Weston, Shawmut and Lockwood Projects on the Kennebec River and the Brunswick Project on the Androscoggin River (prepared during January 2012 and included as Attachment B) relied onsite-specific downstream bypass effectiveness rates for the calculation of whole station smolt survival estimates. As of January, 2012, the site-specific downstream bypass effectiveness rate at Lockwood (18.8%) was calculated based on the results of a radio-telemetry study conducted during May and June, 2011. In cases where a site-specific downstream bypass effectiveness rate was not available, smolts passing through the powerhouse and associated downstream bypass structure were partitioned by assuming an equal distribution to that of outflow. In these cases, the downstream bypass efficiency rate was allowed to vary by month to account for occasions when river discharge was less than the Project operating flow (Table 8.2-1) [6].

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[6] Downstream bypass effectiveness rates for Atlantic salmon smolts at the Weston, Shawmut and Lockwood Projects were assessed by radio-telemetry during spring 2012. Observed bypass effectiveness rates were 68.4% (at 6% of station flow) at Weston, 82.8% (over all flow conditions) at Shawmut, and 66.4% (at 6% of station flow) at Lockwood. Results from the spring 2012 radio-telemetry study are not reflected in the most recent detailed assessment of smolt passage at the Weston, Shawmut and Lockwood Projects on the Kennebec River (Attachment B).

Table 8.2-1. Downstream Bypass Effectiveness Rates for Atlantic Salmon Smolts Determined for the Months of April, May and June at the Weston, Shawmut, Lockwood and Brunswick Projects

	Downstream Bypass Effectiveness Rate		
Project	**April**	**May**	**June**
Weston [2]	2.0%	2.0%	2.2%
Shawmut [2]	0.5%	0.5%	0.6%
Lockwood[1]	18.8%	18.8%	18.8%
Brunswick [2]	0.8%	0.8%	1.1%

1 - Based on radio-telemetry study
2 - Based on assumption of equal distribution to outflow

Site-specific injury and mortality rates for Atlantic salmon smolts passed via unregulated spill or via a downstream bypass were not available for the Weston, Shawmut, Lockwood or Brunswick projects. As a result, estimates for passage survival of Atlantic salmon smolts through Project spillways and downstream bypasses were developed based on existing empirical studies conducted at other hydroelectric projects with similar characteristics. Since the principal causes of potential injury and mortality for fish passed through either a spillway or bypass sluice are shear forces, turbulence, rapid deceleration, terminal velocity, impact against the base of the spillway, scraping against the rough concrete face of the spillway and rapid pressure changes, empirical studies related to spillway and bypass survival were pooled into a single data set. Injury and survival rates for Atlantic salmon smolts passed via spill from comparable hydroelectric projects were reviewed and the whole station smolt survival estimates generated for the four projects relied on an average initial (1-hr) injury rate of 18.4%, an average initial (1-hr) survival rate of 97.1%, and an average delayed (48-hr) survival rate of 96.3%.

Site-specific injury (initial; 1-hr) and mortality (initial; 1-hr and delayed; 48-hr) rates for Atlantic salmon smolts passed via turbine units were not available for the Weston, Shawmut, Lockwood or Brunswick projects. As a result, estimates for passage survival of Atlantic salmon smolts through Francis, Kaplan and propeller units were developed based on existing empirical studies conducted at other hydroelectric projects with similar characteristics. Average turbine injury and survival rates varied among projects due to differences in turbine types as well as their differing site characteristics. Survival estimates for turbine passage were also generated using the Advanced Hydro Turbine model developed by Franke et al. (1997). The Franke blade strike model predicts the probabilities of leading edge strikes, considered the primary mechanism of mortality when fish pass through turbines (Eicher Associates Inc., 1987; Cada, 2001). Turbine passage survival was calculated using site-specific turbine parameters and for a range of body lengths (5-9 inches) considered to be representative of outmigrating salmon smolts in Maine rivers (NRC, 2004; Fay et al., 2006). The average survival of salmon smolts passing through a particular turbine type was determined by averaging the modeled survival estimates for each similar type unit at a Project (Table 8.2-2).

Table 8.2-2. Initial (1-hr) Injury, Initial (1-hr) Survival, Delayed (48-hr) Survival and Calculated Survival Rates for Atlantic Salmon Smolts Passed Via Turbine Units at the Weston, Shawmut, Lockwood and Brunswick Projects

Project	Unit Type	Initial (1-hr) Injury	Initial (1-hr) Survival	Delayed (48-hr) Survival	Calculated Survival
Weston	Francis	16.2%	91.5%	91.3%	88.2%
Shawmut	Propeller	7.5%	94.7%	92.8%	94.3%
	Francis	23.8%	85.1%	85.1%	84.7%
Lockwood	Kaplan	7.5%	94.7%	92.8%	91.6%
	Francis	23.8%	85.1%	85.1%	82.0%
Brunswick	Propeller	7.5%	94.7%	92.8%	92.7%

Whole station smolt survival estimates for each of the projects were calculated by integrating river flows, Project operating flows, spill effectiveness, downstream bypass effectiveness rates, turbine entrainment rates, and spillway and turbine survival rates. Three models intended to estimate whole station survival of smolts passing each project were constructed using the available empirical and modeled survival estimates for both spill and turbine passage:

1) Initial Survival Rate Model (Model A): Spill survival based on 1-hr empirical survival data and turbine survival based on 1-hr empirical survival data.
2) Delayed Survival Rate Model (Model B): Spill survival based on 48-hr empirical survival data and turbine survival based on 48-hr empirical survival data.
3) Delayed/Calculated Survival Rate Model (Model C): Spill survival based on 48-hr empirical survival data and turbine survival based on Franke estimates.

A fourth model (Model D) was evaluated, using spill and turbine survival based on 1-hr empirical injury data. Comparisons of initial injury assessment and delayed survival rates for Atlantic salmon smolts subjected to mark-recapture spill and turbine passage studies suggest that not all injuries sustained by smolts during dam passage will result in mortality. Accordingly the results of this model were used to establish an absolute “worst case” scenario that assumes that any fish subjected to an injury (regardless of the severity of that injury) suffered mortality.[7] As Model D was decidedly over-conservative, it was inappropriate in estimating the existing level of mortality, if any is found, at the projects. However, for reference purposes, the Model D results are provided in Appendix B.

Whole station smolt survival estimates at each of the four projects under median flow conditions (i.e. the value with 50% flow exceedence) are presented in Table 8.2-3[8].

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[7] Evidence collected for Atlantic salmon smolts passed via spill suggests that a relatively high percent (18.4%) of individuals are subject to some degree of injury. The delayed survival rate was 96.3% at 48-hr for these fish.

[8] When Model C for the whole station survival estimate for Atlantic salmon smolts at the Weston, Shawmut and Lockwood Projects is updated to reflect the most recent assessment of downstream bypass effectiveness at those locations (spring 2012), survival estimates (under median flow conditions; i.e., 50% flow exceedence) increase from 90% to 94% at Weston, 90% to 95% at Shawmut and 92% to 94% at Lockwood.

Table 8.2-3. Whole Station Survival Estimates for Atlantic Salmon Smolts Passing the Weston, Shawmut, Lockwood and Brunswick Projects under Median Flow Conditions (50% Flow Exceedence)

Project	Model A	Model B	Model C
Weston	93%	92%	90%
Shawmut	91%	90%	90%
Lockwood	94%	93%	92%
Brunswick	95%	93%	93%

Variation of the bypass effectiveness rate, spill effectiveness rate and monthly flow assumption (i.e., 50% exceedence) was examined for potential impacts to the whole station smolt survival models at each project. Table 8. 2-4 presents the change (Δ%) to whole station smolt survival estimates (Models A, B, C) when the bypass effectiveness rate is set to a range of values from 25% to 100%. As would be expected, an increase in bypass effectiveness leads to an increase in whole station smolt survival as additional smolts are passed via spill through the bypass rather than through the turbines.

Table 8.2-4. Impacts Due to Variation in the Downstream Bypass Effectiveness Rates to the Whole Station Survival Estimates for Atlantic Salmon Smolts Passing the Weston, Shawmut, Lockwood and Brunswick Projects

		Evaluated Downstream Bypass Effectiveness Rates					
Project	Model	***BASE*** [1]	**25%**	**45%**	**65%**	**85%**	**100%**
Weston	A	93%	1%	2%	3%	3%	4%
	B	92%	1%	2%	3%	4%	4%
	C	90%	2%	3%	4%	5%	6%
Shawmut	A	91%	1%	3%	4%	5%	6%
	B	90%	1%	3%	4%	5%	6%
	C	90%	2%	3%	4%	5%	6%
Lockwood	A	94%	0%	1%	2%	3%	3%
	B	93%	0%	1%	2%	3%	3%
	C	92%	0%	1%	2%	3%	4%
Brunswick	A	95%	0%	1%	1%	2%	2%
	B	93%	1%	2%	2%	3%	3%
	C	93%	1%	2%	3%	3%	4%

1 - Bypass effectiveness rates used in construction of the base model are presented in Table 8.2-1.

Table 8.2-5 presents the change (Δ%) to whole station smolt survival estimates (Models A, B, C) when the spill effectiveness rate is set to a range of values from 5% to 90%. In the majority of cases an increase in spill effectiveness leads to an increase in whole station smolt survival as additional smolts are passed via spill rather than through the turbines.

Table 8.2-5. Impacts Due to Variation in the Spill Effectiveness Rates to the Whole Station Survival Estimates for Atlantic Salmon Smolts Passing the Weston, Shawmut, Lockwood and Brunswick Projects

		Evaluated Spill Effectiveness Rates					
Project	Model	***BASE*** [1]	**5%**	**30%**	**50%**	**70%**	**90%**
Weston	A	93%	-1%	0%	1%	2%	4%
	B	92%	-1%	1%	2%	3%	4%
	C	90%	-1%	1%	2%	4%	5%
Shawmut	A	91%	-2%	0%	2%	4%	5%
	B	90%	-1%	1%	2%	4%	5%
	C	90%	-1%	1%	2%	4%	6%
Lockwood	A	94%	-1%	0%	1%	2%	3%
	B	93%	-1%	0%	1%	2%	3%
	C	92%	-2%	0%	1%	2%	4%
Brunswick	A	95%	0%	0%	1%	1%	2%
	B	93%	0%	1%	1%	2%	3%
	C	93%	0%	1%	2%	3%	4%

1 - Spill effectiveness rates for base models are 23.6% at Weston, 20.6% at Shawmut, 30.1% at Lockwood, and 9.6% at Brunswick.

Table 8.2-6 presents the change (Δ%) to whole station smolt survival estimates (Models A, B, C) when the monthly flow is altered from the median condition (i.e. 50% exceedence) to two "low flow" conditions (75 and 90% exceedence) and two "high flow" conditions (10 and 25% exceedence)[9]. The overall trend was for whole station smolt survival to increase with increasing river flow as more smolts are passed via spill.

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[9] When Model C for the whole station survival estimate for Atlantic salmon smolts at the Weston, Shawmut and Lockwood Projects is updated to reflect the most recent assessment of downstream bypass effectiveness at those locations (spring 2012), survival estimates (under low flow conditions; i.e., 90% flow exceedence) increase from 88% to 94% at Weston, 89% to 95% at Shawmut and 90% to 94% at Lockwood.

Table 8.2-6. Impacts Due to Variation in the Monthly River Flow to the Whole Station Survival Estimates for Atlantic Salmon Smolts Passing the Weston, Shawmut, Lockwood and Brunswick Projects

		Percent of Time Flow is Exceeded				
Project	Model	*BASE* [1]	10%	25%	75%	90%
Weston	A	93%	2%	1%	-2%	-1%
	B	92%	3%	2%	-1%	0%
	C	90%	4%	3%	-2%	-2%
Shawmut	A	91%	3%	2%	-2%	-2%
	B	90%	4%	2%	-2%	-2%
	C	90%	4%	2%	-1%	-1%
Lockwood	A	94%	2%	1%	-1%	-1%
	B	93%	2%	1%	-1%	-2%
	C	92%	2%	2%	-2%	-2%
Brunswick	A	95%	1%	0%	0%	0%
	B	93%	2%	1%	0%	0%
	C	93%	2%	1%	0%	0%

1 - Base model is constructed using median river flow (i.e. 50% exceedence).

Atlantic Salmon Kelts

Very limited studies of kelt passage have been conducted on the Kennebec or Androscoggin rivers. Kelt studies conducted in the lower Penobscot River documented that most kelts passed the dams in spilled water, typically over the spillways, but also through gates and sluices (Hall and Shepard, 1990). Observation of the initial approach of kelts at the Veazie and Milford projects reflected the distribution of flow, whereby the proportion of kelts that approached spillways was correlated with spillway flow (Hall and Shepard, 1990). Shepard (1989) made a similar finding at the confluence of the Stillwater Branch and the mainstem Penobscot, where kelts followed routes in approximate proportion to flow in the two channels.

Lacking site specific kelt passage data on the Androscoggin and Kennebec rivers, a detailed assessment of the mortality potential for outmigrating Atlantic salmon kelts was conducted for the Weston, Shawmut and Lockwood projects on the Kennebec River and the Brunswick Project on the Androscoggin River (see Attachment B). At each individual project, downstream passage of outmigrating kelts must occur via one of three routes: (1) unregulated spillage, (2) permanent or interim downstream bypass facilities, or (3) the project turbines. These three potential routes of passage were considered and incorporated into the whole station kelt survival model for each project. Prior to construction of the whole station kelt survival models, information related to kelt run timing, spill effectiveness, downstream bypass effectiveness, trash rack screening, and survival rates for kelts passed via spill and turbine units at each project was obtained.

Baum (1997) indicated that following the fall spawn, approximately 20% of kelts move back downstream with the remainder (80%) moving downstream the following spring. Based on observations during MDMR redd surveys, outmigration of kelts immediately following the fall spawn occurs during the latter half of October, November, and the first half of December with the remainder of kelts departing the following April and May (N. Dube, MDMR, personal communication). For the purposes of estimating whole station kelt survival, it was assumed that the percentage of the total kelt outmigration occurring during the fall (20%) would be partitioned among the known salmon outmigration months of October (5%), November (10%), and December (5%). Likewise, the percentage of the total kelt outmigration occurring during the spring (80%) would be divided between the known salmon kelt outmigration months of April (40%), and May (40%).

River discharge during the fall and spring migration periods approximates the proportion of Atlantic salmon kelts passed via unregulated spill and conversely, through the powerhouse (via either a permanent or interim downstream bypass facility or turbine unit). Spill effectiveness, defined as the proportion of kelts passed through spill relative to the total number passing through the project facilities, was calculated for each of the four projects. In the absence of site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (i.e., spilling 50% of total river flow results in 50% of kelts passing via the spillway). An overall spill effectiveness rate for the months of October, November, December, April and May was calculated using the site-specific Project capacity, the estimated monthly distribution of Atlantic salmon kelt outmigration, site-specific monthly median river flow conditions and the assumption of 1:1 spill effectiveness. Spill effectiveness rates for kelts under median flow conditions (i.e. the value with 50% flow exceedence) were determined to be 32.2% at Weston, 29.6% at Shawmut, 38.7% at Lockwood, and 21.4% at Brunswick.

Lacking site-specific downstream bypass effectiveness rates for outmigrating kelts at the Weston, Shawmut and Lockwood Projects on the Kennebec River and the Brunswick Project on the Androscoggin River, the most recent detailed assessments (prepared during January 2012 and included as Attachment B) relied on site-specific downstream bypass effectiveness rates for smolts in the calculation of whole station kelt survival estimates[10]. A site-specific downstream bypass effectiveness rate at Lockwood (18.8%) was calculated based on the results of a smolt radio-telemetry study conducted during May and June, 2011. In the other cases, where a site-specific downstream bypass effectiveness rate was not available, kelts passing through the powerhouse and associated downstream bypass structure were partitioned by assuming an equal distribution to that of outflow. This is considered an extremely conservative assumption, as described below. In these cases, the downstream bypass efficiency rate was allowed to vary by month to account for occasions when river discharge was less than the Project operating flow (Table 8.2-7).

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[10] At the time of preparation (January 2012), the most recent Lockwood Atlantic salmon white paper relied on bypass effectiveness rates determined by radio-telemetry during spring 2011. Results from the spring 2012 radio-telemetry downstream bypass assessment studies conducted at Weston, Shawmut and Lockwood were not yet available.

Table 8.2-7. Downstream Bypass Effectiveness Rates for Atlantic Salmon Kelts Determined for the Months of October, November, December, April, and May at the Weston, Shawmut, Lockwood and Brunswick Projects

	Bypass Effectiveness Rate				
Project	**October**	**November**	**December**	**April**	**May**
Weston [2]	2.0%	2.0%	2.8%	2.1%	2.2%
Shawmut [2]	0.5%	0.5%	0.8%	0.6%	0.6%
Lockwood[1]	18.8%	18.8%	18.8%	18.8%	18.8%
Brunswick[2]	0.8%	0.8%	1.6%	0.9%	0.9%

1 - Based on Atlantic salmon smolt radio-telemetry study

2 - Based on assumption of equal distribution to outflow

Given the lack of site empirical data related to the route selection of Atlantic salmon kelts through the various turbine units, it was assumed (for modeling purposes) that the distribution of kelt passage through the turbines would be equal to the distribution of outflow through those units at maximum discharge. A fork length – body width relationship was applied to the length-frequency distribution of sea-run returns to the Penobscot River (1978-2009) to determine the proportion of kelts that could fit through the trash rack spacing at the various project intakes. Lacking information regarding the movement of kelts in the Shawmut and Lockwood project forebays, it was assumed that all kelts expected to pass via the Francis units but prevented from doing so by their body widths relative to the trash rack spacing would next attempt passage via the propeller/Kaplan units. The percentages of those individuals which could pass via the second unit type are presented in Table 8.2-8.

Table 8.2-8. Percentage of Atlantic Salmon Kelts Able to Physically Pass Through the Trashracks at the Weston, Shawmut, Lockwood and Brunswick Projects

Project	Unit Type	Trashrack Spacing	Percentage of Kelts that could Pass Through Racks	Percentage of Kelts Initially Denied Passage at Francis that could Pass Through Propeller Racks
Weston	Francis	4.0"	97.6%	-
Shawmut	Propeller	3.5"	70.9%	-
	Francis	1.5"	0.0%	70.9%
Lockwood	Kaplan	3.5"	70.9%	-
	Francis	2.0"	0.8%	70.7%
Brunswick	Propeller	3.5"	70.9%	-

Site-specific injury and mortality rates for Atlantic salmon kelts passed via unregulated spill or via a downstream bypass were not available for the Weston, Shawmut, Lockwood, or Brunswick projects. As a result, estimates for passage survival of Atlantic salmon smolts through project spillways and downstream bypasses, developed based on existing empirical studies conducted at other hydroelectric projects with similar characteristics, were used as a surrogate. Since the principal causes of potential injury and mortality for fish passed through either a spillway or bypass sluice are shear forces, turbulence, rapid deceleration, terminal velocity, impact against the base of the spillway, scraping against the rough concrete face of the spillway and rapid pressure changes, empirical studies related to spillway and bypass survival were pooled into a single data set. A delayed (48-hr) survival rate for Atlantic salmon kelts passed via spill of 96.3% was assumed for the generation of whole station kelt survival estimates for each of the four projects.

Estimates for passage survival of Atlantic salmon kelts through Francis, Kaplan and propeller units were made using the Advanced Hydro Turbine model developed by Franke et al. (1997). The Franke blade strike model predicts the probabilities of leading edge strikes, considered the primary mechanism of mortality when fish pass through turbines (Eicher Associates Inc., 1987; Cada, 2001). Turbine passage survival was calculated using site-specific turbine parameters and for a range of body lengths considered to be representative of outmigrating salmon kelts in Maine rivers as well as not physically excluded by project trashracks. The average survival of salmon kelts passing through a particular turbine type was determined by averaging the modeled survival estimates for each similar type unit at a project (Table 8.2-9).

Table 8.2-9. Calculated Turbine Survival Rates for Atlantic Salmon Kelts Passed Via Turbine Units at the Weston, Shawmut, Lockwood and Brunswick Projects

Project	Unit Type	Calculated Survival
Weston	Francis	59.6%
Shawmut	Propeller	81.1%
	Francis	*
Lockwood	Kaplan	72.1%
	Francis	53.8%
Brunswick	Propeller	75.9%

*Kelts physically excluded by unit trashracks

Whole station kelt survival estimates for each of the projects were calculated by integrating river flows, project operating flows, spill effectiveness, downstream bypass effectiveness rates, turbine entrainment rates and spillway and turbine survival rates. Whole station kelt survival estimates at each of the four projects under median flow conditions (i.e. the value with 50% flow exceedence) are presented in Table 8.2-10.

Table 8.2-10. Whole Station Survival Estimates for Atlantic Salmon Kelts Passing the Weston, Shawmut, Lockwood and Brunswick Projects Under Median Flow Conditions (50% Flow Exceedence)

Project	Whole Station Survival
Weston	73%
Shawmut	89%
Lockwood	88%
Brunswick	85%

As with the smolt survival estimates, variation of the bypass effectiveness rate, spill effectiveness rate and monthly flow assumption (i.e., 50% exceedence) was examined for potential impacts to the whole station kelt survival model for each project. Results of these sensitivity analyses are provided in Appendices to the White Papers provided in Appendix B. In general, the results were similar to those observed for smolts. As expected, an increase in bypass effectiveness leads to an increase in whole station kelt survival as additional kelts are passed via spill rather than through the turbines. When the spill effectiveness rate is increased to a ratio greater than 1:1, an increase in whole station kelt survival is observed as additional kelts are passed via spill rather than through the turbines. In contrast, when the spill effectiveness rate is decreased to a ratio less than 1:1, a decrease in whole station kelt survival is observed. With respect to river flow, whole station kelt survival increases with increasing river flow (i.e. those exceeded only 10 or 25% of the time) as a greater number of kelts are passed via spill. In contrast, when the monthly flow rate decreases to less than median flow conditions (i.e., those exceeded 75 and 90% of the time), a decrease in whole station kelt survival is observed.

The modeled estimates of current kelt survival rates at each of the four projects are very conservative estimates, for a number of reasons. First, the kelt model assumes that like smolts, kelt passage routes are directly proportional to flow. While kelt studies are limited, the few that have been done, strongly suggest that this is not the case. As noted by NMFS in the Black Bear Hydro Project's Biological Assessment (Black Bear BA), kelt studies in the lower Penobscot (Hall and Shepard, 1990; GNP, 1989) documented that most kelts passed the dams in spilled water, typically over the spillways, but also through gates and sluices. The studies found that in their initial approach to a hydro project kelts were typically apportioned with the flow. However, as the kelts approached the powerhouse, they were deterred by racks, even racks with course spacing, and sought alternative routes, sometimes for hours or days, until they located a spillage route. Overall, the Penobscot studies found that most kelts were found to pass a dam on spillage, and in two years of telemetry studies at the Veazie and Milford dams, the majority of the kelts tagged (35 of 49) were delayed less than 2 hours before finding a safe route of passage via spilled water. Moreover, no kelt mortalities were recorded in two years of kelt studies.

Similar to the behavior recorded on the Penobscot River, anecdotal observations by Normandeau personnel working on the Merrimack River, NH have noted adult salmon to remain within the forebay canal of the Garvins Falls Project and individuals are often visible within the upper portion of the water column at that site (Normandeau, 2011). Kelts are not thought to sound frequently and on the Penobscot, that notion was supported through the reduction in turbine passage at Weldon following the installation of tightly spaced 1 in trashracks over the upper portion of the intakes (GNP, 1995).

In addition, adult salmon are strong swimmers and have the ability to avoid turbine intakes. Observed burst speeds for adult salmon range between 14.1 to 19.7 ft/s with a maximum sustained swim speed of 3.4 f/s (Beamish, 1978). When compared to the calculated approach velocities in front of the existing racks at the three Kennebec projects (Lockwood, Shawmut and Weston) which range from 1.6 - 2.9 fps, it is clear that kelts have the ability to avoid passing through the racks.

8.3 Proposed Measures and Monitoring

This section describes measures proposed by the Licensees in the attached ISPP to provide additional enhancements and protection measures for GOM DPS Atlantic salmon at the Lockwood, Shawmut, Weston, Brunswick and Lewiston Falls projects. The ISPP is provided in Attachment A. Based on consultation with NMFS, the basic components of the ISPP are as follows:

1) ISPP would cover GOM DPS Atlantic salmon for a period of seven (7) years 2013-2019
2) ISPP would be replaced in 2020 with a final Species Protection Plan (SPP) to cover GOM DPS Atlantic salmon.
3) ISPP measures included herein would be subject to revision through adaptive management and agency consultation, and FERC approval.

Table 8.3-1 provides an overview summary the proposed measures, and each is discussed further below.

Table 8.3-1. Overview of Interim Species Protection Plan

Year	Activity
2013	• Licensees develop Atlantic salmon ISPP and draft BA and file them with FERC • Licensees file protection measures for Atlantic sturgeon and shortnose sturgeon in an amendment to the ISPP. • FERC issues BA • NMFS issues BO and ITS covering Lockwood, Shawmut, Weston, Brunswick, and Lewiston Falls projects for the period 2013 – 2019 • FERC issues license amendments for the Lockwood, Shawmut, Weston, Brunswick and Lewiston Falls projects • Licensees conduct Atlantic salmon smolt downstream passage monitoring studies (paired release) at Lockwood, Shawmut, Weston, and Brunswick projects (year 1)* • Licensee extends period that upstream and downstream bypass facilities are operated at Brunswick Project • Licensee conducts Atlantic salmon adult upstream passage effectiveness monitoring studies at Brunswick Project, in cooperation with licensees for the Pejepscot and Worumbo projects (year 1) • Licensees operate rotary screw trap in cooperation with NMFS and MDMR to collect smolt out-migration data in Sandy River (year 1)**

Year	Activity
2014	• Licensees conduct Atlantic salmon smolt downstream passage monitoring studies (paired release) at Lockwood, Shawmut, Weston and Brunswick projects (year 2) • Licensees conduct Atlantic salmon kelt downstream passage monitoring studies at Lockwood, Shawmut, Weston and Brunswick projects, in cooperation with upstream projects (year 1) • Licensees operate rotary screw trap to collect smolt out-migration data in Sandy River (year 2) • Licensee designs new volitional upstream fish passage component for the existing Lockwood fishway and investigates upstream passage improvement opportunities at the development • Licensee conducts Atlantic salmon adult upstream passage effectiveness monitoring studies at Brunswick Project, in cooperation with licensees for the Pejepscot and Worumbo projects (year 2)
2015	• Licensees conduct Atlantic salmon smolt downstream passage monitoring studies (paired release) at Lockwood, Shawmut, Weston and Brunswick projects (year 3) • Licensees conduct Atlantic salmon kelt downstream passage monitoring studies at Lockwood, Shawmut, Weston and Brunswick projects, in cooperation with upstream projects (year 2) • Licensees operate rotary screw trap to collect smolt out-migration data in Sandy River (year 3) • Licensee constructs new upstream volitional fish passage component for existing Lockwood fishway • Licensee conducts Atlantic salmon adult upstream passage effectiveness monitoring studies at Brunswick Project, in cooperation with licensees for the Pejepscot and Worumbo projects (year 3)
2016	• Licensee operates new volitional upstream fishway at Lockwood • Licensee conducts Atlantic salmon adult upstream passage effectiveness monitoring studies at Lockwood (year 1) • Licensees conduct Atlantic salmon kelt downstream passage monitoring studies at Lockwood, Shawmut, Weston and Brunswick, in cooperation with upstream projects (year 3) • Licensee designs new upstream fish passage facility for Shawmut Project • Licensee initiates FERC relicensing process for Shawmut Project
2017	• Licensee conducts Atlantic salmon adult upstream passage effectiveness monitoring studies at Lockwood (year 2) • Licensee constructs new upstream fish passage facility at Shawmut
2018	• Licensee conducts Atlantic salmon adult upstream passage effectiveness monitoring studies at Lockwood (year 3) • Licensee operates new upstream fish passage facility at Shawmut • Licensee designs new upstream fish passage facility for Weston Project • Licensee and FERC reinitiate Section 7 consultation

Year	Activity
2019	• Licensee constructs new upstream fish passage facility at Weston Project • Licensees develop final SPP covering the period from 2020 to issuance of new FERC project licenses, including additional Atlantic salmon, Atlantic sturgeon, and shortnose sturgeon enhancement/protection measures, if determined necessary, based on interim SPP monitoring results • Licensees file final SPP with FERC in 2019 • NMFS issues ITS to cover period of subsequent SPP (through FERC license expiration date)

Notes:
* Incidental take authorization for studies expected to be undertaken by the Licensees in 2013, prior to NMFS' issuance of a BO, will be covered under a Section 10 research permit issued to the Licensees.
** Incidental take authorization for proposed operation of the RST expected to occur in 2013, prior to NMFS' issuance of a BO, will be covered under a Section 10 research permit issued to MDMR.

In addition to the measures outlined above, certain activities and measures would be undertaken by the project Licensees every year:

- Licensees continue to operate the existing downstream bypass facilities at each project.
- Licensees provide interim upstream fish passage at Lockwood, Shawmut, and Weston by trapping and trucking fish from Lockwood upriver to the Sandy River. Licensee will also consult with and assist MDMR, as necessary, with trucking Atlantic salmon from Lockwood.
- Licensee monitors Lewiston Falls during flashboard replacement and after spill events, and implements rescue and handling plan for adult Atlantic salmon.
- Licensee implements sturgeon handling plan at the Lockwood Project in accordance with NMFS's Biological Opinion (January 14, 2005).
- Licensees provide annual reports during the term of the ISPP and holds annual agency consultation meetings.

8.3.1 Upstream Passage

Lockwood

The Lockwood Project has an existing fish lift facility installed in 2006 that provides upstream passage for Atlantic salmon, as well as a number of other anadromous and resident species. Currently, the fish lift is operated in conjunction with a manned trap/sort/truck facility, which allows fisheries managers to transfer upstream migrating fish to any up-river location deemed appropriate. Until such time that volitional upstream fish passage is installed and utilized at Lockwood the existing fish lift and trap and truck facility will provide interim upstream passage for Atlantic salmon. It is anticipated that the fish lift at Lockwood will continue to be operated, during the interim period, with a trap and sort component, so as to be able to manage undesirable species, including those that compete with Atlantic salmon.

The Licensee will design a new volitional upstream fish passage component for Atlantic salmon at the Lockwood Project in 2014. It is anticipated that permanent upstream fish passage will be provided at the Lockwood Project by adding an exit flume to the existing fish lift facility, developed in consultation with the agencies. The Licensee will target construction of the volitional fishway component at Lockwood, incorporating the biological needs of Atlantic salmon, for 2015. Fishway construction would be completed such that the fishway is operational during the upstream migration season in 2016.

Shawmut

The Shawmut Project currently has no upstream passage facilities located at the site. Until such time that permanent upstream fish passage is installed at Shawmut, the Licensee will utilize the existing Lockwood fish lift to provide interim upstream passage for Atlantic salmon at the Shawmut Project.

The Licensee will design a new upstream passage facility for the Shawmut project, incorporating the biological needs of Atlantic salmon, in 2016. The design of the fishway will be developed in consultation with the agencies. The Licensee will then target construction of the upstream fish passage facility at Shawmut for 2017. Fishway construction would be completed such that the fishway is operational during the upstream migration season in 2018.

Weston

The Weston Project currently has no upstream passage facilities located at the site. Until such time that permanent upstream fish passage is installed at Weston, the Licensee will utilize the existing Lockwood fish lift to provide interim upstream passage for Atlantic salmon at the Weston Project.

The Licensee will design a new upstream passage facility for the Weston project, incorporating the biological needs of Atlantic salmon, in 2018. The design of the fishway will be developed in consultation with the agencies. The Licensee will then target construction of the upstream fish passage facility at Weston for 2019. Fishway construction would be completed such that the fishway is operational during the upstream migration season in 2020.

Brunswick

The Brunswick Project has an existing vertical slot fishway that provides upstream passage for Atlantic salmon, as well as other anadromous and resident species. Currently the fishway is operated in conjunction with a manned trap and sort facility which allows MDMR fisheries managers to trap, sort and or truck upstream migrating fish, depending on the species/lifestage. During the term of the ISPP, the Brunswick fishway will continue to be operated during the salmon migration period April 15- November 15.

Lewiston Falls

As there is no critical habitat for Atlantic salmon upstream of Lewiston Falls, and no plans under the current Atlantic Salmon Recovery Plan to restore salmon above Lewiston Falls, there is no need during the term of the ISPP to provide upstream passage for Atlantic salmon at the Lewiston Falls Project.

8.3.2 Downstream Passage

Lockwood

The Lockwood Project has an installed downstream passage facility consisting of a bypass gate located in the power canal, with a 10 foot deep floating guidance boom. During the term of the ISPP, the downstream passage facilities will be operated as specified in the ISPP during the smolt and kelt migration seasons (April 1 - December 31), as river conditions allow.

Shawmut

The Shawmut Project has existing downstream passage through a Taintor gate located in the power canal. During the term of the ISPP, the downstream passage facilities at Shawmut will be operated as specified in the ISPP during the smolt and kelt migration seasons (April 1 - December 31), as river conditions allow.

Weston

The Weston Project has a downstream passage facility that was installed in 2011 consisting of an existing sluice gate located on the South Channel dam and a 10 foot deep floating guidance boom. During the term of the ISPP, the downstream passage facilities at Weston will be operated as specified in the ISPP during the smolt and kelt migration seasons (April 1 - December 31), as river conditions allow.

Brunswick

The Brunswick Project provides downstream passage via a bypass located between the intakes on the powerhouse, as well as through the existing vertical slot fishway and via spill. During the term of the ISPP, the downstream passage facilities at Brunswick will be operated as specified in the ISPP from April 1 - December 31, as river conditions allow, which encompasses the migration seasons for smolts, kelts and other diadromous fish.

Lewiston Falls

As there is no critical habitat for Atlantic salmon upstream of Lewiston Falls, and no plans under the current Atlantic Salmon Recovery Plan to restore salmon above Lewiston Falls, there is no need during the term of this ISPP to provide downstream passage for Atlantic salmon at the Lewiston Falls Project.

8.3.3 Studies and Monitoring

Downstream Passage Studies

The Licensees will conduct up to three years of downstream passage studies at the Lockwood, Shawmut, Weston, and Brunswick projects. To provide an estimate of smolt survival, the Licensees will conduct paired-release radio telemetry studies at all four projects in 2013-2015. For all of the smolt studies it is anticipated that hatchery-reared Atlantic salmon smolts will be used and will be supplied by Green Lake National Fish Hatchery (GLNFH), in Ellsworth, Maine. It is also anticipated that the paired-release studies at each project will use between 100-200 smolts per year. Any remaining smolts not tagged at the end of the study will be released into the Kennebec River downstream of the project. The Licensee will consult with NMFS, USFWS and MDMR on the development of detailed study plans for these efforts.

The Licensees will also conduct downstream passage studies involving kelts between2013 and 2015 at the Lockwood, Shawmut, Weston and Brunswick projects. The intent of these studies is to determine passage routes and the existing downstream survival for Atlantic salmon kelts at each of the four projects. The studies will be up to three years in length and will coincide with smolt monitoring. It is anticipated that these studies will involve the handling and radio-tagging of no more than 20 male kelts per project per year. The Licensees will consult with NMFS on the development of study plans for these efforts.

On the Kennebec, the Licensees will cooperate with NMFS, USFWS, and MDMR on the installation and operation of a rotary screw trap (RST) in the Sandy River, for a period of up to three years (2013-2015). The purpose of the RST would be to improve knowledge and to target and narrow the periods of likely downstream migration of smolts on the Kennebec River. The Sandy River RST monitoring will be a collaborative effort between the Licensees, NMFS, USFWS, and MDMR.

Upstream Passage Studies

Due to the small numbers of returning adult salmon, and the current lack of upstream fishways above the Lockwood Project, only limited studies are planned to evaluate upstream passage effectiveness during the term of the ISPP. Once the volitional components of the upstream fish passage facility have been installed at Lockwood, upstream effectiveness studies will be conducted at Lockwood starting no earlier than 2016 (the first season of volitional fishway operation). The Licensee will conduct upstream passage salmon monitoring studies for up to three years (2016-2018). For this study, it is anticipated that the Licensee will utilize radio tags, and the study would require that a portion of adult Atlantic salmon collected in the Lockwood fishway collection facility over the three-year period be radio tagged. The Licensee will consult with NMFS in the development of a detailed study plan for this effort.

In addition, as part of the design of the volitional components for the Lockwood fishway that will occur in 2014, the Licensee will also investigate potential opportunities for upstream passage improvements at Lockwood. The Licensees will also cooperate with the agencies on any studies of upstream migrating adult salmon that are coordinated for the projects on the lower river, after upstream passage is added to one or more of the three upstream projects.

On the Androscoggin River, upstream effectiveness studies will be conducted between 2013 and 2015 at the Brunswick Project. The Licensee will conduct upstream passage salmon monitoring studies for up to three years (2013-2015) using PIT tagging. The upstream monitoring study is expected to be conducted in cooperation with other dam owners on the Androscoggin River (Pejepscot and Worumbo projects) to the extent practicable. The Licensee will install PIT tag detection equipment at the Brunswick Project fishway entrance and exit to evaluate salmon success in using the fishway. This study would require that Atlantic salmon collected in the Brunswick fishway collection facility over the three-year period be PIT tagged. The Licensee will consult with NMFS, USFWS and MDMR in the development of a detailed study plan for this effort.

The Licensees will also continue to monitor use of the upstream fish passage facilities at both Brunswick and Lockwood. At Lockwood, the Licensee will 1) continue to use underwater cameras in and around the fish lift to observe Atlantic salmon behavior and identify any issues with salmon movement into the fish lift; 2) monitor areas of the tailrace that can be visually observed for the presence of holding Atlantic salmon and collect information on numbers and time periods; 3) monitor angler activity near the fish lift and collect available information on numbers of Atlantic salmon accidentally captured or observed; 4) monitor the bypass reach ledge area during flashboard replacement; and 5) maintain records of all fish moved via the fish lift, including detailed records of Atlantic salmon (size, age, condition, etc.).

At Brunswick, the Licensee and MDMR will maintain records of all fish moved via the fishway. MDMR will maintain detailed records of Atlantic salmon moved via the fishway, including an assessment of size, age, and condition.

There are no plans for upstream fish passage facilities at Lewiston Falls during the period of the ISPP. However, since Atlantic salmon have access to the area downstream of the project, it is possible that salmon could be attracted into the Great Falls, during periods of spill. At the cessation of spill events, it is possible that salmon could become trapped on the ledges and in pools. To further reduce the potential effects of stranding on Atlantic salmon and other fish species at the Lewiston Falls Project, the Licensee will monitor the Great Falls area after significant spill events and during flashboard replacement and collect any stranded Atlantic salmon and release them back into the Androscoggin River. The Licensee will record its monitoring actions following each significant spill event, and the records of any Atlantic salmon found stranded, will be reported annually.

8.3.4 Adaptive Management

The proposed ISPP is based on an adaptive management approach. The agreed upon fish passage measures and activities are laid out within an adaptive management framework, with integration of management and research in order to provide feedback and the ability to adapt measures, as necessary. Since the proposed interim process is intended to be adaptive, the Licensees will be coordinating and consulting with NMFS throughout the 2013-2019 interim period. If early study results indicate that study designs are not adequately measuring passage efficiency, the Licensees will work with NMFS to correct it. Likewise, if the early study results indicate that the upstream and downstream fish passageways are not highly efficient at passing Atlantic salmon, the Licensees will coordinate with NMFS and modify operations as appropriate to avoid and minimize effects to Atlantic salmon, to the extent practicable. To that end, the Licensees will meet with NMFS annually to discuss study results, potential modifications to the study designs, and/or potential changes to the operation of the facilities that may be necessary to reduce adverse effects to the species.

The cornerstone of the adaptive management provisions included in this ISPP are the annual reports and annual agency meetings. Annual reports will be used to report on interim fishway operations, and on fish passage studies being conducted at each of the projects. Annual reports will be provided to the agencies in advance of the proposed annual consultation meeting, and will form the basis of discussion at the annual meeting. The annual meeting will provide an opportunity for the Licensees and agencies to discuss study results, and potential opportunities to make adjustments to fishway operations that might improve passage for Atlantic salmon during the interim period. The meetings will also be used to make adjustments to ongoing fish passage studies, and to modify study plans, as appropriate, for the upcoming study season.

The annual agency meetings will also be used to discuss other issues related to GOM DPS Atlantic salmon restoration and management activities that may be related to the Kennebec and Androscoggin rivers. Examples of issues that could be discussed and may have a bearing on Kennebec and Androscoggin Atlantic salmon restoration efforts include availability of hatchery stocks for studies and restoration efforts, and the potential need to collect Kennebec or Androscoggin River adults at Lockwood or Brunswick as brood stock; the need for continued trap, sort and /or truck of Atlantic salmon from Lockwood or Brunswick to support restoration goals; coordination of fish passage study efforts with agency studies or the studies being conducted by other hydropower project owners in the watersheds; modifications to existing fishway operations or project spills during the interim period; or the need for support for other types of Atlantic salmon restoration efforts throughout the Merrymeeting Bay SHRU. Using an adaptive management approach, any of these examples, as well as numerous others, may lead to modification of the proposed measures and provisions contained in this ISPP, with the overarching goal of continually working to improve fish passage for Atlantic salmon and enhance the overall GOM DPS Atlantic salmon restoration effort.

8.4 Potential for Adverse Effects on Species or Critical Habitat

Based on the assessment of existing conditions and Project operations at the Lockwood, Shawmut, Weston, Brunswick and Lewiston Falls projects, and on information regarding the likely presence of GOM DPS Atlantic salmon in the project areas, their biology and habitat requirements, it is concluded in this draft BA that operation of the five projects may adversely affect individual listed Atlantic salmon and its critical habitat, but is not likely to jeopardize the continued existence of the species or adversely modify its designated critical habitat. Complete site-specific information on Atlantic salmon and project effects is lacking, and thus the measures outlined in the attached ISPP are designed to provide enhanced protections for Atlantic salmon and to quantify the potential affect.

The Licensees will continue to avoid and minimize Project effects through the continued implementation of improved fish protection and enhancement measures outlined in this draft BA, such as operating existing and recently improved downstream fish passage facilities at the Lockwood, Shawmut and Weston projects, conducting site-specific studies of Atlantic salmon smolts and adults outlined in the ISPP, and continuing to consult with resource agencies in preparation for design and installation of upstream passage facilities at Lockwood, Shawmut, and Weston. Through the planned study efforts, the Licensees will evaluate downstream passage survival and, based on empirical data, develop protection and enhancement measures, as appropriate and in consultation with the agencies, for incorporation into a final SPP, to be submitted to FERC in 2019.

Designated critical habitat for GOM DPS Atlantic salmon occurs in the vicinity of all five projects that are the subject of this draft BA. The primary constituent elements of critical habitat in the project areas include sites for successful migration of the species. With the installation of upstream fishways at the Lockwood, Shawmut and Weston projects, and the continued operation of existing upstream and downstream fishways at the Brunswick, Lockwood, Shawmut and Weston projects, it is concluded that, with implementation of the ISPP, designated critical habitat for GOM DPS Atlantic salmon will not be adversely modified or destroyed.

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10.0 FIGURES

Figure 1. Lockwood Project

Figure 2. Shawmut Project

Figure 3. Weston Project

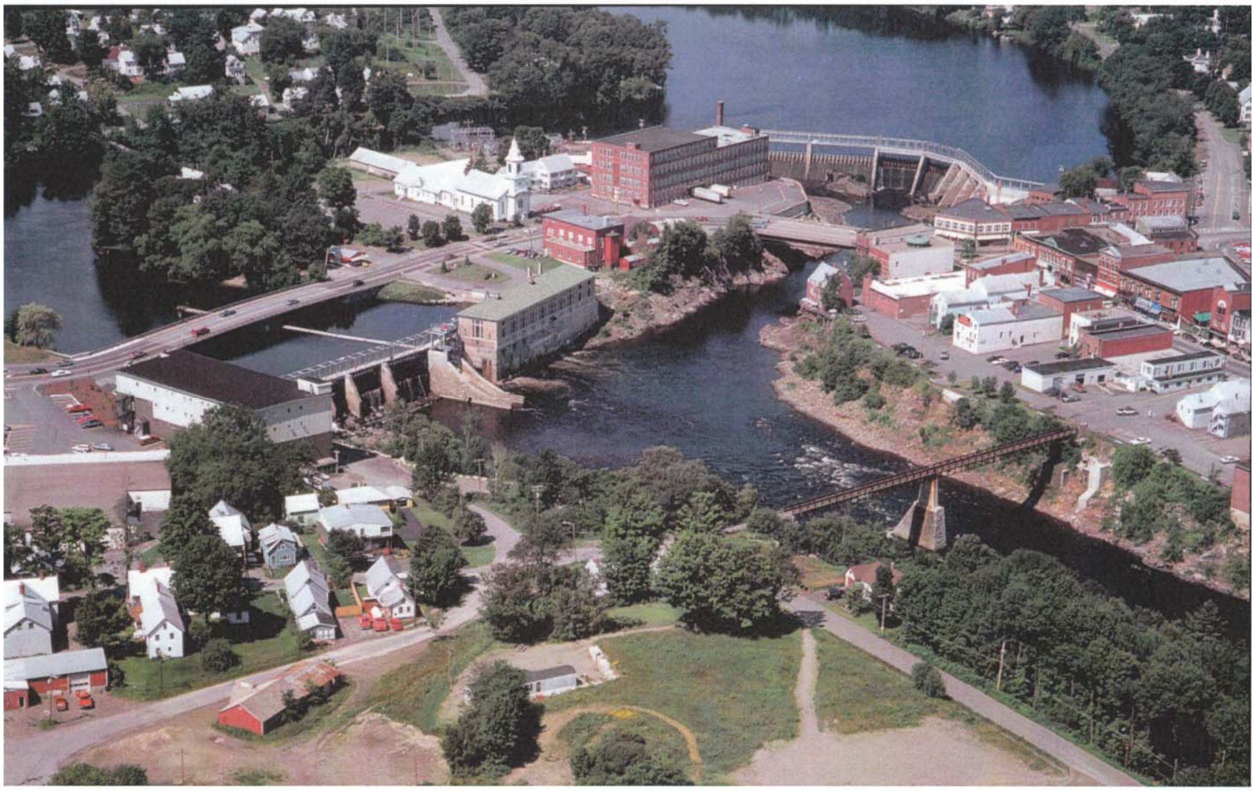


Figure 4. Brunswick Project

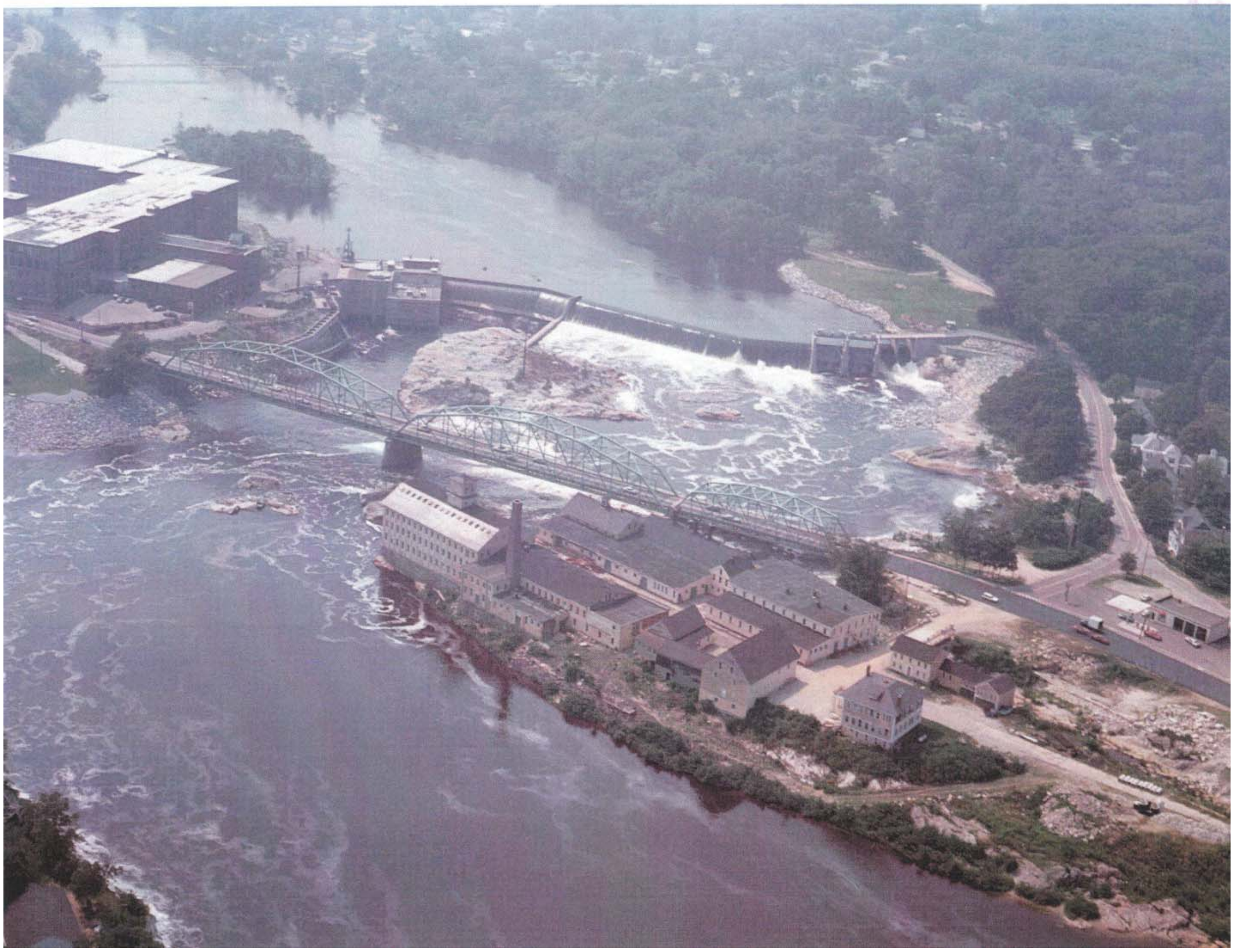


Figure 5. Lewiston Falls Project

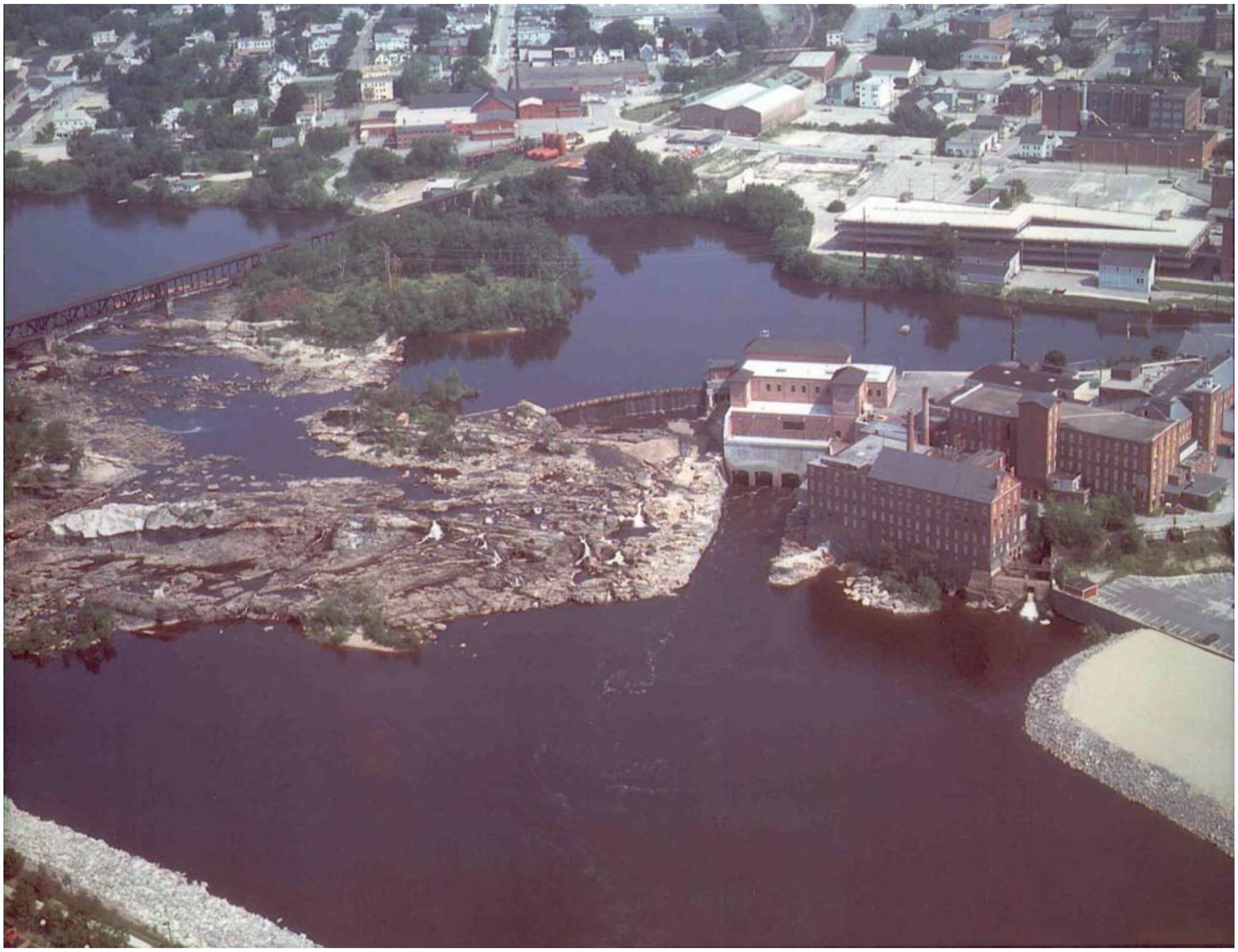


Figure 6. Lockwood Project Bypassed Reach (looking downstream)

Figure 7. Lockwood Project Bypassed Reach (looking upstream)

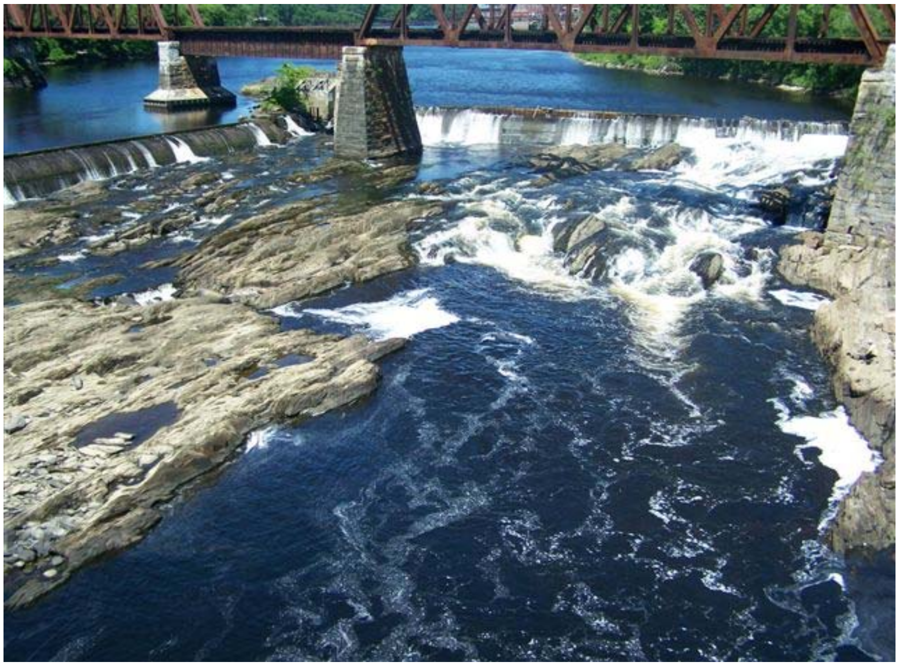


Figure 8. Shawmut Project Tailwater Area (looking from the eastern shore)

Figure 9. Shawmut Project Tailwater Area (looking from the western shore)

Figure 10. Weston Project Bypassed Reach (looking upstream)

Figure 11. Brunswick Project Tailrace (looking upstream)

Figure 12. Brunswick Project Tailwater Area (looking toward the north shore)

Figure 13. Lewiston Falls (Monty Station) Tailrace (looking upstream)

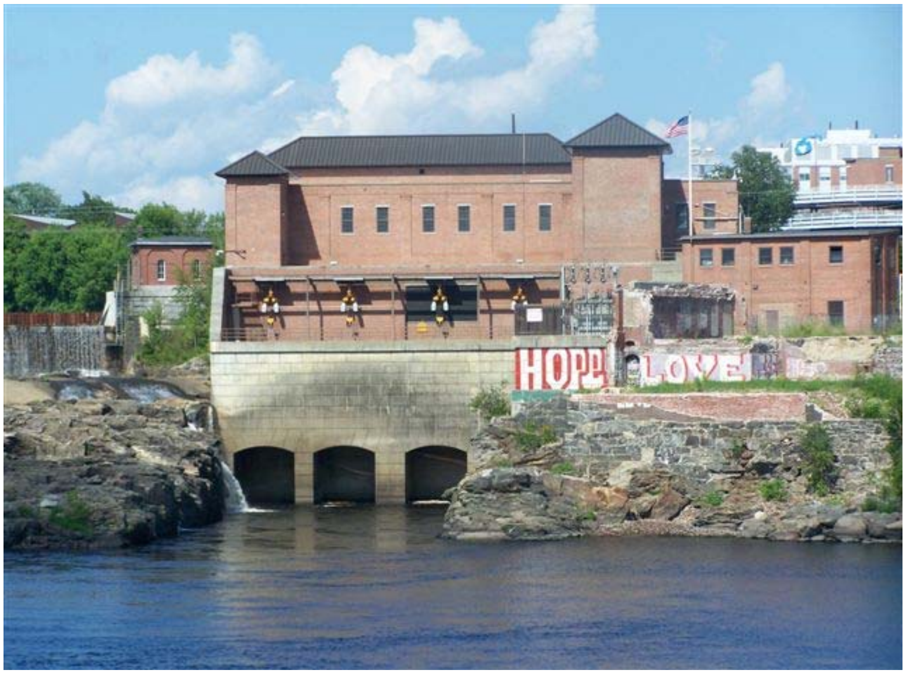
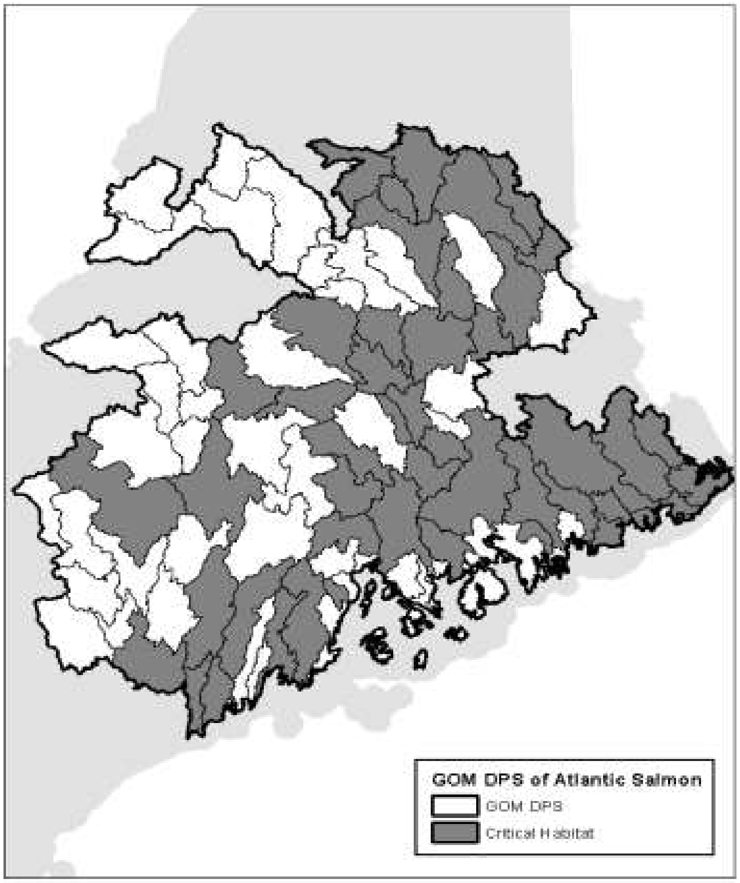


Figure 14. Lewiston Falls Tailwater Area (looking upstream)

Figure 15. HUC-10 Watersheds Designated as Atlantic Salmon Critical Habitat within the GOM DPS



Source: NMFS, 2012b

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ATTACHMENT A: INTERIM SPECIES PROTECTION PLAN

Interim Species Protection Plan for Atlantic Salmon at the Lockwood, Shawmut, Weston, Brunswick and Lewiston Falls Hydropower Projects
on the
Kennebec and Androscoggin Rivers, Maine

FPL Energy Maine Hydro LLC
and
Merimil Limited Partnership

February 21, 2013

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1.0 BACKGROUND AND PURPOSE OF INTERIM SPECIES PROTECTION PLAN

FPL Energy Maine Hydro LLC (Maine Hydro) owns, or indirectly partially owns through its interest in the Merimil Limited Partnership, five hydropower projects located on the Androscoggin and Kennebec Rivers in Maine, including the Brunswick and Lewiston Falls projects on the Androscoggin River, and the Lockwood (owned by the Merimil Limited Partnership), Shawmut and Weston projects on the Kennebec River.

All five of the hydropower projects are licensed to the project owners (collectively, "Licensees") by the Federal Energy Regulatory Commission (FERC). The expiration years for the current FERC licenses for the projects are Brunswick (2029), Lewiston Falls (2026), Shawmut (2021), Weston (2036) and Lockwood (2036).

Each of the five hydroelectric projects covered under this Interim Species Protection Plan (ISPP) occur within the range of the endangered Gulf of Maine Distinct Population Segment (GOM DPS) of Atlantic salmon (*Salmo salar*), and four of the five are located entirely in designated critical habitat for salmon (Lewiston Falls is partially in critical habitat). The continued operation of these projects may have adverse effects on the GOM DPS of Atlantic salmon and its designated critical habitat.

As discussed in the draft Biological Assessment (BA), with the expanded listing of Atlantic salmon and its designated critical habitat within the areas of these projects, FERC is required to engage in endangered species consultation with the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) pursuant to Section 7 of the Endangered Species Act (ESA) when a federal action is pending. Section 7 of the ESA mandates that federal agencies consult with the Secretaries of Commerce (through NMFS) and Interior (through USFWS), to determine whether a proposed action is likely to jeopardize listed species and/or adversely affect designated critical habitat for such species. Maine Hydro is being proactive in conducting Section 7 consultation ahead of any pending federal action, such as relicensing of the projects. Section 7 consultation between FERC and NMFS is expected to result in NMFS issuing a Biological Opinion (BO) that determines the continued operation of the projects will not jeopardize the continued existence of GOM DPS Atlantic salmon, or result in the destruction or adverse modification of any designated critical habitat for the species.

In cooperation with NMFS, the USFWS, and Maine Department of Marine Resources (MDMR), the Licensees have developed this ISPP for incorporation of the applicable portions into the FERC project licenses for the five projects. The purpose of the ISPP is to identify studies and enhancements to be made by the Licensees at the five hydropower projects to avoid and minimize impacts related to the continued operation of the projects, and to protect listed GOM DPS of Atlantic salmon. Amendment of the FERC project licenses to incorporate the applicable portions of the ISPP will 1) protect the listed species in the project areas, and 2) allow the development by NMFS of an Incidental Take Statement (ITS) to account for any unavoidable "takings" of GOM DPS Atlantic salmon. The ISPP is valid for a seven (7) year period (2013-2019) to allow the Licensees time to study existing measures to protect downstream migrating Atlantic salmon and to construct additional passage measures, as needed, at the projects. Measures to be undertaken by the Licensees and related activities expected to occur during the interim period are outlined in Table 1. As part of the measures to be undertaken during the interim period, the Licensees will work with NMFS and USFWS (collectively, the "Services") to develop a final Species Protection Plan (SPP). The final SPP will include any measures or enhancements necessary to further protect the listed species, and will cover the period from 2019 through the FERC license expiration date for each of the five projects as defined previously. The final SPP will be submitted to FERC for incorporation into the project licenses, at which time Section 7 consultation will need to be reinitiated.

The following ISPP outlines the Licensees' commitments for protection of GOM DPS Atlantic salmon. Atlantic salmon will be protected through a combination of enhanced upstream and downstream passage, avoiding and minimizing delay, injury and predation, and protection of critical habitat in the project areas.

Shortly after filing this ISPP with FERC, Maine Hydro will file an amendment detailing plans for protecting listed shortnose sturgeon and Atlantic sturgeon at the Lockwood and Brunswick projects. Maine Hydro will request FERC initiate a single, comprehensive consultation for all three species (Atlantic salmon, Atlantic sturgeon, and shortnose sturgeon) with NMFS. Accordingly, it is anticipated that NMFS will issue a single Biological Opinion (BO) for all species and projects of Maine Hydro considered in this ISPP. In addition, the final Species Protection Plan (SPP) that will be filed by Maine Hydro with FERC in 2019 will also contain protection measures for sturgeon at the projects, as applicable.

1.1 Interim Species Protection Plan Overview

Based on consultation with NMFS, the Licensees have developed this ISPP, the basic components of which are as follows:

1) ISPP would cover GOM DPS Atlantic salmon for a period of seven (7) years 2013 – 2019.
2) ISPP would be replaced in 2020 with a final Species Protection Plan (SPP) to cover GOM DPS Atlantic salmon.
3) ISPP measures included herein would be subject to revision through adaptive management and agency consultation and FERC approval.

An overview of the primary features of the ISPP are provided in Table 1.

Table 1. Overview of Interim Species Protection Plan

Year	Activity
2013	• Licensees develop Atlantic salmon ISPP and draft BA and file them with FERC • Licensees file protection measures for Atlantic sturgeon and shortnose sturgeon in an amendment to the ISPP. • FERC issues BA • NMFS issues BO and ITS covering Lockwood, Shawmut, Weston, Brunswick, and Lewiston Falls projects for the period 2013 – 2019 • FERC issues license amendments for the Lockwood, Shawmut, Weston, Brunswick and Lewiston Falls projects • Licensees conduct Atlantic salmon smolt downstream passage monitoring studies (paired release) at Lockwood, Shawmut, Weston, and Brunswick projects (year 1)* • Licensee extends period that upstream and downstream bypass facilities are operated at Brunswick Project • Licensee conducts Atlantic salmon adult upstream passage effectiveness monitoring studies at Brunswick Project, in cooperation with licensees for the Pejepscot and Worumbo projects (year 1) • Licensees operate rotary screw trap in cooperation with NMFS and MDMR to collect smolt out-migration data in Sandy River (year 1)**
2014	• Licensees conduct Atlantic salmon smolt downstream passage monitoring studies (paired release) at Lockwood, Shawmut, Weston and Brunswick projects (year 2) • Licensees conduct Atlantic salmon kelt downstream passage monitoring studies at Lockwood, Shawmut, Weston and Brunswick projects, in cooperation with upstream projects (year 1) • Licensees operate rotary screw trap to collect smolt out-migration data in Sandy River (year 2) • Licensee designs new volitional upstream fish passage component for the existing Lockwood fishway and investigates upstream passage improvement opportunities at the development • Licensee conducts Atlantic salmon adult upstream passage effectiveness monitoring studies at Brunswick Project, in cooperation with licensees for the Pejepscot and Worumbo projects (year 2)

Year	Activity
2015	• Licensees conduct Atlantic salmon smolt downstream passage monitoring studies (paired release) at Lockwood, Shawmut, Weston and Brunswick projects (year 3) • Licensees conduct Atlantic salmon kelt downstream passage monitoring studies at Lockwood, Shawmut, Weston and Brunswick projects, in cooperation with upstream projects (year 2) • Licensees operate rotary screw trap to collect smolt out-migration data in Sandy River (year 3) • Licensee constructs new upstream volitional fish passage component for existing Lockwood fishway • Licensee conducts Atlantic salmon adult upstream passage effectiveness monitoring studies at Brunswick Project, in cooperation with licensees for the Pejepscot and Worumbo projects (year 3)
2016	• Licensee operates new volitional upstream fishway at Lockwood • Licensee conducts Atlantic salmon adult upstream passage effectiveness monitoring studies at Lockwood (year 1) • Licensees conduct Atlantic salmon kelt downstream passage monitoring studies at Lockwood, Shawmut, Weston and Brunswick, in cooperation with upstream projects (year 3) • Licensee designs new upstream fish passage facility for Shawmut Project • Licensee initiates FERC relicensing process for Shawmut Project
2017	• Licensee conducts Atlantic salmon adult upstream passage effectiveness monitoring studies at Lockwood (year 2) • Licensee constructs new upstream fish passage facility at Shawmut
2018	• Licensee conducts Atlantic salmon adult upstream passage effectiveness monitoring studies at Lockwood (year 3) • Licensee operates new upstream fish passage facility at Shawmut • Licensee designs new upstream fish passage facility for Weston Project • Licensee and FERC reinitiate Section 7 consultation
2019	• Licensee constructs new upstream fish passage facility at Weston Project • Licensees develop final SPP covering the period from 2020 to issuance of new FERC project licenses, including additional Atlantic salmon, Atlantic sturgeon, and shortnose sturgeon enhancement/protection measures, if determined necessary, based on interim SPP monitoring results • Licensees file final SPP with FERC in 2019 • NMFS issues ITS to cover period of subsequent SPP (through FERC license expiration date)

Notes: * Incidental take authorization for studies expected to be undertaken by the Licensees in 2013, prior to NMFS' issuance of a BO, will be covered under a Section 10 research permit issued to the Licensees.

** Incidental take authorization for proposed operation of the RST expected to occur in 2013, prior to NMFS' issuance of a BO, will be covered under a Section 10 research permit issued to MDMR.

In addition to the measures outlined above, certain activities and measures would be undertaken by the project Licensees every year:

- Licensees continue to operate the existing downstream bypass facilities at each project.
- Licensees provide interim upstream fish passage at Lockwood, Shawmut, and Weston by trapping and trucking fish upriver to the Sandy River. Licensee will also consult with and assist MDMR, as necessary, with trucking Atlantic salmon from Lockwood.
- Licensee monitors Lewiston Falls during flashboard replacement and after spill events, and implements rescue and handling plan for adult Atlantic salmon.
- Licensee implements sturgeon handling plan at the Lockwood Project in accordance with NMFS's Biological Opinion (January 14, 2005).
- Licensees provide annual reports during the term of the ISPP and holds annual agency consultation meetings.

2.0 BACKGROUND

2.1 Kennebec River Background

The Kennebec River basin is the largest of the watersheds that comprise the Merrymeeting Bay SHRU. The Kennebec River watershed covers an area of 5,910 square miles, approximately 1/5 of the state of Maine, and flows 138 miles from Moosehead Lake to Merrymeeting Bay where it joins the Androscoggin River. The Kennebec watershed is bordered on the west by the Androscoggin River Basin, on the north and east by the Penobscot River Basin, and by coastal streams and the Gulf of Maine on the south.

The Kennebec River's mainstem originates at the outlet of Moosehead Lake and flows generally southward through the towns and cities of Bingham, Solon, Anson, Madison, Norridgewock, Skowhegan, Waterville, and Augusta. The river transitions from a high gradient cold water river from upstream of Indian Pond to Madison, to a warmwater river from Skowhegan to Augusta. A 24 mile long, mostly freshwater tidal segment of the river exists downstream from Augusta, and slightly brackish conditions exist periodically in Merrymeeting Bay (CABB, 2006).

The Kennebec River basin has been extensively developed for over a century for industrial use, including driving of logs and pulp, mills, and hydroelectric power production. The Lockwood Project, located at river mile 63, is the lowermost dam and hydroelectric plant on the mainstem river. The drainage area above the Lockwood Project is 4,228 square miles. Other mainstem projects upstream of Lockwood include Hydro-Kennebec (FERC Project No. 2611), Shawmut (FERC Project No. 2322), Weston (FERC Project No. 2325), Abenaki (FERC Project No. 2364), Anson (FERC Project No. 2365), Williams (FERC Project No. 2335), Wyman (FERC Project No. 2329), and Harris (FERC Project No. 2142). The Fort Halifax Project (FERC No. 2552), which was removed in 2008, was formerly located near the mouth of the tributary Sebasticook

River, only about 0.5 miles downstream of Lockwood. Edwards dam (FERC Project No. 2389), which was removed in 1999, was located about 18 miles downstream of Lockwood on the main stem.

Historically, the Kennebec River provided access to a large and diverse aquatic habitat for diadromous and resident fish species. American shad and river herring migrated into the Sandy River and Atlantic salmon migrated to Grand Falls on the Dead River and to the unnamed falls (presently impounded by Indian Pond Dam) on the Kennebec River.

Diadromous fish restoration efforts have been underway on the Kennebec River for several decades. In 1982, the State of Maine adopted a Statewide River Fisheries Management Plan which established a goal to "restore, maintain, and enhance anadromous fish resources for the benefit of the people of Maine." Since then, the State's fishery management agencies have adopted a series of management plans aimed at restoring anadromous stocks to their historic ranges within the Kennebec River basin, with an emphasis on the anadromous American shad (*Alosa sapidissima*), alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), and sea-run Atlantic salmon, as well as the catadromous American eel (*Anaguilla rostrata*).

During the 1980s and 1990s, anadromous fish restoration efforts focused primarily on river herring and American shad. During the same timeframe, there were a succession of management initiatives undertaken by state and federal agencies that culminated in significant advances in diadromous fish restoration efforts in the Kennebec River basin, including specifically the Weston, Shawmut and Lockwood projects. In 1987, a group of hydropower project owners established an agreement with state and federal fishery agencies to address anadromous fish and fish passage issues at a number of the hydropower projects located on the Kennebec mainstem and the tributary Sebasticook River. The agreement was revised in 1998, and became the primary guide for anadromous fish restoration activities in the Kennebec.

KHDG Fish Passage Agreement

In 1987, the owners of several hydropower projects on the Kennebec and Sebasticook rivers, including the owners of the Kennebec River projects addressed under this ISPP, reached an agreement with state and federal fishery agencies on anadromous fish passage initiatives that dam owners would undertake. The agreement, known as the Kennebec Hydro Developer Group[1] (KHDG) agreement, was designed to facilitate the restoration of American shad, river herring (primarily alewife), and Atlantic salmon in the Kennebec River basin. The 1998 KHDG Agreement (or 1998 Accord), modified the original KHDG agreement to include provisions for supporting the removal of Edwards dam and for providing fish passage for Atlantic salmon, American shad, river herring and American eel at the Lockwood, Shawmut and Weston projects, as well as other hydroelectric projects located on the mainstem Kennebec and Sebasticook rivers. Under KHDG, the Licensees directly funded restoration efforts, including dam removals at Edwards and Fort Halifax. To date, the owners of the dams addressed in this ISPP have invested

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[1] KHDG includes Central Maine Power Company (now FPL Energy Maine Hydro LLC), Scott Paper Company, Pittsfield Hydro Company, Benton Falls Associates, and the Merimil Limited Partnership.

millions of additional funds into direct measures and facilities to improve fish passage at their dams on the Kennebec River.

2.2 Androscoggin River Background

The Androscoggin River is Maine's third largest river with a watershed area covering 3,500 square miles; the river flows 161 miles from Umbagog Lake to Merrymeeting Bay. The Androscoggin River basin is bordered on the west by the Presumpscott River basin and on the east by the Kennebec River basin.

The Androscoggin River basin has also been extensively developed for industrial use for well over a century, including hydroelectric power production. The first dam on the river is the Brunswick Project, located near the Merrymeeting Bay head of tide. Other mainstem hydroelectric projects upstream of Brunswick include the Pejepscot, Worumbo, Lewiston Falls, Deer Rips, Gulf Island, Livermore Falls, Otis, Jay, Riley Lower Rumford Falls, and Upper Rumford Falls projects in Maine, and a number of other hydropower projects in New Hampshire. There are also a number of hydroelectric projects on the Little Androscoggin River, which is a tributary that joins the mainstem just below Lewiston Falls in Auburn Maine, including Barkers Mills Lower, Barkers Mills Upper, Hackett Mills, Marcal, and Biscoe Falls.

Historically, the Androscoggin provided access to a large and diverse aquatic habitat for diadromous and resident fish species. For several species, the natural upstream migration barrier on the main stem of the Androscoggin River was Lewiston Falls, 23 river miles above tidewater. Although this site was an impassable barrier for most species, sea-run Atlantic salmon and American eel were able to ascend the falls and migrate upstream to Rumford, approximately 80 miles above Merrymeeting Bay. Rumford Falls was an impassable barrier to migrating salmon and excluded them from New Hampshire waters of the Androscoggin River (DeRoche, 1967; MDMR, 2010, NMFS, 2009).

The State of Maine has been pursuing restoration of anadromous fish on the Androscoggin River for many years. In 1982, Central Maine Power Company[2] (CMP) reconstructed the Brunswick Project, which is the first dam on the river, located near the head of tide of Merrymeeting Bay. During project reconstruction, CMP constructed an agency-approved, vertical slot fishway, with a trapping and sorting facility, and MDMR agreed to operate the facility. CMP also installed a downstream passage facility capable of passing anadromous and resident fish species. Around the same time, the MDMR initiated a concerted anadromous fish restoration program for the lower Androscoggin River. The target species for the initial restoration effort were American shad and alewife for restoration to spawning and nursery habitat in the lower mainstem and tributaries, below Lewiston Falls (MDMR, 2009).

In 1987, the owners of the Pejepscot Hydropower Project (FERC No. 4784), the second dam on the Androscoggin River, installed upstream and downstream fish passage facilities at that Project. In 1988, upstream and downstream passage was installed at the Worumbo Project

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[2] FPL Energy Maine Hydro LLC purchased the Brunswick Project in 1999.

(FERC No. 3428), the third dam on the river. The completion of these fish passage facilities provided anadromous species the opportunity to migrate upstream as far as Lewiston Falls (MDMR, 2010).

2.3 Listing History

The GOM DPS Atlantic salmon was originally listed as endangered by the Services on November 17, 2000 (65 FR 69459). Subsequently, the Services expanded the endangered listing range for the GOM DPS of Atlantic salmon on June 19, 2009 (74 FR 29344). Coincident with the June 19, 2009 endangered listing, NMFS designated critical habitat for the GOM DPS of Atlantic salmon (74 FR 29300; June 19, 2009). Under a Statement of Cooperation between the Services, NMFS has the responsibility to address the impacts of dams on the GOM DPS of Atlantic salmon.

2.4 Consultation History

Following the listing of GOM DPS Atlantic salmon, on July 30, 2009 Maine Hydro sent a letter to NMFS stating its intention to take measures to protect Atlantic salmon. That letter was followed by another letter in August, 2009, in which Maine Hydro stated its intention to work with NMFS on the Atlantic salmon issue. Over the next several months, Maine Hydro met several times with representatives of NMFS, USFWS and the State of Maine to discuss the Atlantic salmon listing and to review the ITP process. In a letter dated May 21, 2010 Maine Hydro informed NMFS of its intent to initiate formal ITP procedures under ESA Section 10. On September 23, 2010, Maine Hydro met with NMFS regional staff to discuss the Section 10 HCP process and to review the content requirements of an HCP. In October, 2010, Maine Hydro initiated the Section 10 process and formed a Technical Advisory Committee and Steering Committee. The Committees met numerous times in 2011-2012, and Maine Hydro prepared a draft HCP that was provided to the agencies in February, 2012.

In November, 2012, Maine Hydro met again with NMFS to discuss the steps necessary to obtain take authorization at the five projects under Section 7. On January 30, 2013, Maine Hydro met again with NMFS, and NMFS agreed that both initiation of informal consultation under Section 7 and subsequent preparation of an ISPP and draft BA, would be the appropriate steps to allow NMFS to authorize take of Atlantic salmon at the five projects. On January 31, 2013, Maine Hydro requested that FERC designate them the Commission's non-federal representative for informal ESA consultation with NMFS regarding Atlantic salmon; FERC granted this request on February 7, 2013.

3.0 PROJECT DESCRIPTIONS

3.1 Lockwood Project

The Lockwood Project, owned by the Merimil Limited Partnership, is a 6.8 MW hydroelectric project located at river mile 63, and is the first dam on the mainstem Kennebec River. The

Lockwood Project includes a dam with two spillway sections, as well as a forebay headworks section, a forebay canal, and two powerhouses. From the headworks, the forebay canal directs water to two powerhouses located on the west bank of the Kennebec River. The original powerhouse contains six generating units and the second powerhouse contains one generating unit. The Lockwood Project operates as run-of-river (ROR), and is operated to provide a minimum flow of 2,114 cfs, or inflow, whichever is less.

Upstream Fish Passage

The Lockwood Project includes both upstream and downstream fish passage facilities.

An upstream fish passage facility comprised of a fish lift, trap, sort and transport system was completed in the spring of 2006. The Lockwood fish lift facility is located on the west side of the powerhouse adjacent to Unit 7. The lift operates with an attraction flow of up to150 cubic feet per second (cfs). Fish lift entrance water velocities are 4 to 6 ft per second (fps). The lift has an approximate 10 minute cycle time, and the water-filled hopper lifts the fish to a holding tank and are sluiced into a discharge tank. The fish lift operates to accommodate all target species including Atlantic salmon, and attraction flows are passed continuously during lift operation. The fish lift is designed to pass up to 164,640 alewives, 228,470 American shad and 4,750 Atlantic salmon per year.

The Lockwood upstream fish passage facility includes sorting and trucking components, and the fish passage facility is typically operated seasonally as necessary to ensure effective operation of the facility. Under a cooperative agreement, the Licensee is responsible for capturing shad, river herring and Atlantic salmon, and the MDMR is responsible for collecting biological data and trucking fish to upstream spawning locations.

During the fish lift operation season, the Licensee coordinates daily with the MDMR regarding sorting, counting and trucking operations. During the river herring, American shad and Atlantic salmon migration season (approximately May through mid-July), the fish lift is generally manned seven days per week, as necessary, to meet resource agency trap and truck requirements. During the migration run, the lift is generally operated from early morning to late afternoon. During other times of the season, the fish lift will be operated five to eight times per day, seven days per week for Atlantic salmon capture. The Licensee determines the precise timing of the fish lift operation, in consultation with the MDMR, based on factors such as the number of migrating fish, water temperature, time of year, and river flow.

During periods of fish lift operation personnel routinely monitor four underwater cameras that are connected to a monitor and DVD recorder. The monitor and DVD recorder are located in the control room of the fish lift and typically record from dawn until dusk. The cameras are also used in real time to help determine the presence of fish in the lift and maximize fishing effectiveness.

Downstream Fish Passage

Downstream fish passage is also provided at the Lockwood Project. In 2009, the Licensee installed a downstream fish passage facility in the Lockwood power canal. The facility consists of a floating boom leading to a new 7 ft wide by 9 ft deep fish sluice, and associated mechanical over-flow gate. Maximum flow through the gate is 6% of station capacity or 340 cfs. The sluice is located on the river side of the power canal just upstream of the Unit 1 trash rack and discharges directly into the river. To enhance use of the sluice gate, a guidance boom is installed in the power canal seasonally.

In 2009, the Licensee conducted an evaluation of the initial guidance boom and surface sluice gate and found that the boom was not buoyant and strong enough to handle existing unit flows. By early April 2010, the Licensee, in consultation with the agencies, had developed a new guidance boom design. The new design consists of a 300 ft floating boom comprised of 30 sections of “Tuff Boom” brand floats, with a four ft deep section of 5/16 inch metal punch plate located in between the floats. Attached to the punch plate is 6 ft of 5/16 inch Dyneema netting. The new boom was installed in May of 2010 and evaluated using Atlantic salmon smolts and PIT tags. The results of the PIT tag tests were suspect due to issues associated with PIT tag antenna interference, limited PIT tag antenna range, and non-detection of fish.

The Licensee subsequently conducted another evaluation using radio telemetry techniques in the spring of 2011 (Normandeau, 2011). Based upon the 2011 study results, a number of recommendations for enhancing the downstream bypass for Atlantic salmon smolts at Lockwood were developed. These modifications, which were implemented in the spring of 2012, included the replacement of 32 feet of the downstream section of the boom with 10 foot deep metal punch plate panels (to replace the vulnerable portion of the existing netting). The modification also included a new flexible attachment point and new larger floats. And finally, the existing trash rack exclusion bars at the entrance of the bypass, which were causing noise and vibration, were removed.

The Licensee completed a second Atlantic salmon smolt radio telemetry downstream passage study at Lockwood in the spring of 2012. The purpose of the study was to evaluate the effectiveness of the guidance boom modification completed earlier that spring.

In addition to the new surface sluice gate and associated guidance boom, downstream passage is also provided through the three orifices, 3 ft long by 8 inches high, cut into the flashboards along the spillway. The orifices pass approximately 50 cfs, and provide downstream passage routes along the spillway even when the project is not spilling over the top of the flashboards. In addition, river flows exceed the turbine capacity for much of the time period that downstream fish migrations occur, thus providing substantial passage capability via spill over the dam.

3.2 Shawmut Project

The Shawmut Project is located at river mile 66 and is the third dam on the mainstem of the Kennebec River. The Shawmut Project includes a 1,310-acre reservoir, a 1,135 ft long dam with an average height of about 24 feet, headworks and intake structure, enclosed forebay, and two powerhouses. The headworks and intake structure are integral to the dam and the powerhouse. The forebay intake section contains eleven headgates and two filler gates. A non-overflow concrete gravity section of dam connects the west end of the 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 1912 powerhouse located to the east, and the 1982 powerhouse located to the south. Located at the south end of the forebay between the two powerhouses is a 10 ft wide by 7 ft deep Taintor gate and a 6 ft wide by 6 ft deep gate. The 1912 powerhouse contains six generating units and the 1982 powerhouse contains two generating units. The Shawmut Project operates as run-of-river (ROR).

Upstream Fish Passage

The Shawmut Project has historically used the Lockwood fish lift and transport system as its means of interim upstream fish passage since 2006. The MDMR capture Atlantic salmon (and other anadromous species) at the Lockwood lift and transport the fish in trucks to areas of suitable habitat, primarily the Sandy River, which is upstream of the Shawmut Project.

Downstream Fish Passage

Interim downstream passage for Atlantic salmon at Shawmut is provided through a sluice located on the right-hand side of the intake structure next to Unit 6. The sluice, which is manually adjusted and contains three stoplogs, is 4ft wide by 22 in. deep. With all stoplogs removed, this sluice passes flows between 30 and 35 cfs. Flows from this sluice discharge over the face of the dam and drain into a man-made 3 ft deep plunge pool connected to the river.

In addition, there is a Taintor gate located next to this sluice that measures 7 feet high by 10 feet wide and can pass 600 cfs. This gate is used to pass debris and excess flows, which also discharge over the face of the dam into a shallow plunge pool connected to the river.

In 2009, Maine Hydro engineers, operations personnel, and biologists investigated options to resolve both ongoing debris issues and downstream anadromous and catadromous fish passage needs at Shawmut. It was agreed that options for debris resolution could be designed to also address downstream fish passage needs. In 2010, Maine Hydro subsequently hired a team of consultants, including Wright Pierce Engineers, Alden Research Labs and Blue Hill Hydraulics, to design a new facility at the Shawmut Project that would address both the debris and fish passage needs.

In 2011, the Licensee, in consultation with resource agencies, developed designs for a new combined intake structure and downstream fish bypass facility at the Project. At that time, the proposed facility included the use of new full depth one inch angled trashracks and a new surface sluice and flume leading to the river. The proposed location and design of this facility, which resulted from significant efforts in hydraulic modeling and evaluation of alternatives by both the Licensee and resource agencies, was just upstream of the existing intake structure. However, the need for this proposed facility is being re-evaluated in light of favorable results from a 2012 downstream smolt study conducted at Shawmut. This study indicated that the majority of study smolts (over 80%) used the existing forebay Taintor gate for successful downstream passage. The Licensee will continue evaluations of downstream smolt passage at Shawmut and discussions with the resource agencies regarding how to provide safe and efficient passage to downstream migrants at the Shawmut Project.

The sluice and Taintor gate will continue to be opened for smolt and kelt passage generally from April 1 through June 15 and from November 1 through December 31, as river and ice conditions allow. Interim downstream passage is also provided along the Shawmut spillway during periods of excess river flow that results in spill.

3.3 Weston Project

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 930-acre reservoir, 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 of the dam, located adjacent to the north abutment and integral to the Project dam, includes the headworks and four intake bays, one for each of the four turbine generator units.

The Weston Project operates in a ROR 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 provide an instantaneous minimum flow of 1,947 cfs or inflow, whichever is less.

Upstream Fish Passage

The Weston Project has used the Lockwood fish lift and transport system as its means of interim upstream fish passage since 2006. Atlantic salmon (and other anadromous species) are captured at the Lockwood lift and transported in trucks by the MDMR to areas of suitable habitat, primarily the Sandy River, which is upstream of the Weston Project.

Downstream Fish Passage Measures

Interim downstream passage at the Weston Project was provided though a sluice gate and associated concrete flume located on the South Channel dam. The gate and flume were formerly used as a log sluice during river log drives and both are located near the Unit 4 intake. The sluice is 18 ft wide by 14 ft high and discharges into a deep plunge pool. Maximum flow through the gate at full pond is 2,250 cfs

In 2011, the Licensee enhanced the existing downstream passage facility by installing a guidance boom consisting of a 300 ft long floating boom with suspended 10 ft deep sections of 5/16 inch metal punch plate screens. The boom leads to the existing log sluice gate, which in turn discharges via an existing concrete flume to a deep pool in the river. The Licensee had previously (in 2010) made some major structural repairs to the existing sluice gate structure, which included resurfacing of the concrete flume. The existing gate is capable of discharging up to 2,250 cfs which is approximately 38% of station unit flow.

During the downstream migration period, the gate is opened to pass 6% of station unit flow. The sluice is opened for smolt and kelt passage generally from April 1 through June 15 and between November 1 and December 31, if river and ice conditions allow. As detailed in the ISPP, studies to evaluate the effectiveness of the bypass with the new guidance boom will be undertaken after resource agency consultation and approval of a study plan. In 2010, the project owner made some major structural repairs to the existing sluice gate structure which included resurfacing of the concrete flume.

On the North Channel side of the Weston Project, there are two Taintor gates, an inflatable rubber dam section, and stanchion gate sections. Interim passage is provided on the North Channel side via spillage.

3.4 Brunswick Project

The Brunswick Project, is located at river mile 6, at the head of tide, and is the first dam on the mainstem of the Androscoggin River. The dam and powerhouse span the Androscoggin River immediately above the U.S. Route 201 bridge, at a site originally known as Brunswick Falls. The Brunswick Project includes a 300-acre headpond; a 605 ft long and 40 ft high concrete gravity dam; a gate section containing two Taintor gates and an emergency spillway; and a powerhouse and intake.

The Brunswick Project operates primarily as ROR. Due to the on/off nature of units and the small headpond available, the pond fluctuates to allow the units to operate efficiently, but the pond is too small to store water for any significant amount of peaking. Thus, the station is considered run of river. Impoundment drawdowns are generally limited to less than two feet below the top of the spillway.

Upstream Fish Passage Measures

Upstream passage at Brunswick is provided via a vertical slot fishway and associated trap, sort, and truck facility that was installed in 1983. The fishway is 570 ft long and consists of 42 individual pools, with a one-foot drop between each. The trapping facility, located at the upstream end of the fishway, provides biologists the opportunity to collect data on migratory and resident fish species that use the fishway. As fish swim to the top of the fishway, fixed grating guides them past a viewing window and into a 500-gallon capacity fish hoist (trap). The hoist elevates the fish to overhead sorting tanks where staff sort and pass fish upstream. Atlantic salmon pass upstream above the 40-foot dam after biological data are collected. The fishway is operated between May 1 and October 31. During the period of fishway operation, an attraction flow of 100 cfs is provided.

The Brunswick fishway facility is maintained by the Licensee; however, since its construction, MDMR personnel have operated the fishway each season under a prior agreement.

The Brunswick Project also has a fish barrier wall located between the dam and Shad Island and a concrete cap over the ledges at the southern end of the spillway section. These structures were installed in the 1980s in an effort to prevent fish from accessing the spillway section and to prevent spill from entering the tailrace and interfering with fish attraction to the fishway.

Downstream Fish Passage Measures

Downstream passage is provided at the Brunswick Project via a surface sluice and associated 18-inch pipe that discharges fish into the project tailrace. The existing sluice gate and pipe were installed in 1983. The sluice is located along the face of the powerhouse between units 1 and 2. The sluice is generally opened for smolt and kelt passage from April 1 through June 15 and from November 1 through December 31, as river and ice conditions allow.

3.5 Lewiston Falls Project

The Lewiston Falls Project is the fourth dam on the mainstem Androscoggin River and is located at the site of Lewiston Falls at approximately river mile 23. This Project includes a complex dam consisting of several distinct dam sections, including four stone-masonry dam sections (Dams 1-4), a fifth masonry dam section (Dam 5), and an island spillway which is a concrete section located on a small island between Dams 3 and 4. Many of the dam sections are topped by flashboards, some of which were recently replaced with inflatable rubber dam sections.

The Project also includes a canal system that originally served to deliver water to small generating facilities located in several mills. The Project was redeveloped in 1990when a new powerhouse (Monty Station) was added to the project. The Canal generating units are currently out of service and are awaiting final disposition.

The Lewiston Falls Project is licensed to operate with up to four feet of impoundment fluctuation to allow for peaking under normal conditions. The station has a minimum flow requirement of 1,430 cfs at Lewiston Falls, with a minimum flow of 1,280 cfs required at Monty Station and 150 cfs through the canal.

The Lewiston Canal is typically operated at a minimum flow of 150 cfs, which is contractually required to supply Androscoggin Upper, a small generating facility owned and operated by the City of Lewiston under separate license. The City may be considering retirement of this facility in the future. Since the Androscoggin Lower generating facility cannot operate at this low flow, flows are spilled there and released back to the river.

Upstream Fish Passage

There are no upstream fish passage facilities at the Lewiston Falls Project.

Downstream Fish Passage

There are no downstream fish passage facilities at the Lewiston Falls Project.

4.0 INTERIM PROTECTION MEASURES AND MONITORING STUDIES FOR ATLANTIC SALMON

4.1 Lockwood Project

Interim Upstream Passage

The Lockwood Project has an existing fish lift facility installed in 2006 that provides upstream passage for Atlantic salmon, as well as a number of other anadromous and resident species. Currently, the fish lift is operated in conjunction with a manned trap/sort/truck facility, which allows fisheries managers to transfer upstream migrating fish to any up-river location deemed appropriate.

A current objective of the resource agencies for the restoration of Atlantic salmon is to provide permanent volitional fish passage for upstream migrating adults on the Kennebec River. As Lockwood is the first dam on the Kennebec River, and as there are undesirable and/or invasive species in the Kennebec River that state fishery agencies do not want moving upstream of Lockwood, it is anticipated that during the interim period, the fish lift at Lockwood will continue to be operated with a trap and sort component, so as to be able to manage undesirable species.

Until the volitional upstream fish passage is installed at Lockwood in 2015, the existing fish lift and trap and truck facility will provide interim upstream passage for Atlantic salmon. During Atlantic salmon upstream migration periods within May 1 – October 31, the Licensees will operate the upstream fish passage facilities as follows:

- Continue to operate the Lockwood fish lift for utilization by Atlantic salmon.
- Trap and sort all fish species, including Atlantic salmon. Capture and hold Atlantic salmon for MDMR transfer to sites/facilities determined by the fishery management agencies.
- Undertake measures necessary to keep the 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. Maintain records of Atlantic salmon captured via the fish lift. MDMR will continue to collect size, age, and condition data.

Volitional Upstream Passage

The Licensee will design a new volitional upstream fish passage component for Atlantic salmon at the Lockwood Project in 2014. It is anticipated that permanent upstream fish passage will be provided at the Lockwood Project by adding an exit flume, viewing window and sorting facility to the existing fish lift facility. Design of this structure will be developed in consultation with the agencies.

The Licensee will target construction of the volitional fishway component at Lockwood, based on the biological needs of Atlantic salmon, in 2015. Fishway construction would be completed such that the fishway is operational during the upstream migration season in 2016.

Upstream Passage Studies

To date, no studies have been conducted to specifically evaluate the effectiveness of the fish lift for Atlantic salmon. Once the volitional components of the upstream fish passage facility have been installed at Lockwood, upstream effectiveness studies will be conducted starting no earlier than 2016 (the first season of possible volitional fishway operation). The Licensee will conduct upstream passage salmon monitoring studies for up to three years (2016-2019). For this study, it is anticipated that the Licensee will utilize radio telemetry equipment at various locations in the Lockwood fishway, including the entrance and exit, to evaluate the success of Atlantic salmon in using the fishway. This study would require that a portion of adult Atlantic salmon collected in the Lockwood fishway collection facility over the three-year period be radio-tagged. The Licensee will consult with NMFS and other resource agencies in the development of a detailed study plan for this effort.

In addition, as part of the design of the volitional components for the Lockwood fishway that will occur in 2014, the Licensee will also investigate potential opportunities for upstream passage improvement at Lockwood. The Licensee will also cooperate with the agencies on any studies of upstream-migrating adult Atlantic salmon that are coordinated with other projects on the lower Kennebec River during the interim period. Finally, the Licensees will undertake the following monitoring measures related to adult upstream passage:

- Continue to use underwater cameras in and around the fish lift to observe Atlantic salmon behavior and identify any issues with Atlantic salmon movement into the fish lift.
- Monitor areas of the tailrace that can be visually observed for the presence of holding Atlantic salmon and collect information on numbers and time periods.
- Monitor angler activity near the fish lift and collect available information on numbers of Atlantic salmon accidentally captured or observed.
- Monitor the bypass reach ledge area during flashboard replacement. With MDMR assistance, collect adult Atlantic salmon for transfer to Sandy River or release back into the Kennebec depending on fish condition and water temperature.
- Collaborate with Hydro Kennebec Project personnel to gather visual observation data on Atlantic salmon that may migrate to the Hydro Kennebec Project via the Lockwood spillway section.

Downstream Passage

The Lockwood Project has an installed downstream passage facility consisting of a 10 foot deep floating guidance boom leading to a bypass gate located in the power canal. During the smolt and kelt migration periods, the Licensee will undertake the following measures:

- Continue to operate the Lockwood bypass gate and floating guidance boom for utilization by adult and juvenile Atlantic salmon, April 1 through December 31, as river conditions allow.
- Ensure that the bypass gate is open and operating to pass the maximum flow through the gate, which is 6% of station unit flow. 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.

It is recognized that project spill at Lockwood is also a significant means of downstream passage for both adult and juvenile Atlantic salmon. The Project turbine capacity is about 5,660 cfs, and flows in excess of turbine capacity are generally spilled.

In order to further facilitate downstream passage by means of project spill, the Lockwood Project will continue be operated as follows:

- 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.
- When river flow at the Project is less than the available turbine capacity, no significant spillage will normally occur, and downstream passage will be provided through the downstream passage facilities unless it is determined through consultation with NMFS that additional spill is needed for downstream passage.

Downstream Passage Studies

The Licensee will conduct up to three years of downstream passage study at the Lockwood Project. To provide an estimate of smolt survival, the Licensee will conduct paired-release radio telemetry studies at Lockwood from 2013[3] – 2015 using the paired-release methodology described by Skalski et al (2010). Using an upstream release and detections at the upstream side of the dam, a "virtual release" will be constructed of smolts known to have arrived alive at the Project. This "virtual release" group will be used to estimate survival through the dam (or the downstream fishway) and downriver sufficiently far enough to avoid false positive detections due to dead, tagged fish. To account for additional mortality unrelated to dam passage and occurring within the downstream river stretch, a paired release of tagged fish will also be conducted in the Project tailrace. Dam passage survival will then be estimated as the quotient of the reach survival estimate derived from the "virtual release" divided by the paired release survival estimate, from the tailwater to the downstream detection station.

It is anticipated that hatchery-reared Atlantic salmon smolts will be used for the study and will be supplied by the Green Lake National Fish Hatchery (GLNFH) in Maine. It is also anticipated

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[3] Incidental take authorization for studies expected to be undertaken by the Licensees in 2013, prior to NMFS' issuance of a BO, will be covered under a Section 10 research permit issued to the Licensees.

that the Lockwood paired-release study will use between 100-200 smolts per year, between 2013 and 2015. Any remaining smolts not tagged at the end of the study will be released into the Kennebec River downstream of the Project. The Licensee will consult with NMFS, USFWS and MDMR on the development of a detailed study plan for this effort.

The Licensee will also conduct downstream passage studies involving kelts between 2014 and 2016. The intent of this study is to determine the existing downstream survival for Atlantic salmon kelts at the Lockwood Project. The study will be up to three years in length and will generally coincide with smolt monitoring. It is anticipated that the study will involve the handling and radio tagging of no more than 20 male kelts per project per year. The Licensee will consult with NMFS and other resource agencies on the development of a study plan for this effort.

4.2 Shawmut Project

Interim Upstream Passage

The Shawmut Project currently has no upstream passage facilities located at the site. Until such time that permanent upstream fish passage is installed at Shawmut, the Licensee will utilize the existing Lockwood fish lift to provide interim upstream passage for Atlantic salmon at the Shawmut Project. During the critical months, upstream passage will be provided from the Lockwood Project, in accordance with provisions outlined above for Lockwood.

Permanent Upstream Passage

The Licensee will design a new upstream passage facility for the Shawmut Project, incorporating the biological needs of Atlantic salmon, in 2016. The design of the fishway will be developed in consultation with the agencies.

The Licensee will target construction of the upstream fish passage facility at Shawmut for 2017. Fishway construction would be completed such that the fishway is operational during the upstream migration season in 2018.

Upstream Passage Studies

Due to the lack of an upstream fishway at the upstream Weston Project, no specific studies of upstream passage effectiveness are planned for the Shawmut Project during the interim period. During the development of a final SPP, anticipated to occur in 2019, the Licensee will consult with NMFS on upstream passage studies to be undertaken at Shawmut as part of the SPP, after upstream fishways are constructed and operational at the Hydro Kennebec, Shawmut and Weston projects.

Downstream Passage

The Shawmut Project has existing downstream passage through a sluice gate located in the power canal. In addition, there is a power canal Taintor gate located adjacent to this sluice. This gate is 7 feet high and 10 feet wide and can pass 600 cfs. This gate is used to pass debris and excess water, and flows from this gate discharge over the face of the dam into a shallow plunge pool connected to the river. As described in section 3.2 above, in light of the favorable results of the 2012 downstream smolt study that indicated that the majority of study smolts (over 80 %) used this existing Taintor gate for successful passage, Licensee plans to evaluate downstream passage via this gate as part of the ISPP.

It is recognized that project spill at Shawmut is also an important means of downstream passage for both adult and juvenile Atlantic salmon. The Project turbine capacity is about 6,300 cfs, and flows in excess of turbine capacity are generally spilled. To enhance downstream passage during the interim period, the following measures will be undertaken.

- The bypass gate will be operated during the periods April 1 through December 31, as river conditions allow.
- The bypass gate will be operated to maintain an interim flow of 6% of station unit flow through the gate during evening passage hours. Modifications to the bypass flow will be considered as part of the adaptive management approach to the ISPP, based on results of radio telemetry studies and consultation with the agencies.
- Whenever river flow at the Project exceeds 6,300 cfs (except for pond fluctuations allowed by the license), flow in excess of operating turbine capacity 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.
- Whenever river flow at the Project is less than 6,300 cfs, no spillage will occur, and downstream passage will be provided through the downstream bypass, unless it is determined through consultation with NMFS that additional spill is needed for downstream passage.

Downstream Passage Studies

The Licensee will conduct up to three years of downstream passage study at the Shawmut Project. To provide an estimate of smolt survival, the Licensee will conduct paired-release radio telemetry studies at Shawmut from 2013 – 2015 using the paired-release methodology described above for Lockwood. As at Lockwood, it is anticipated that hatchery-reared Atlantic salmon smolts will be used for the Shawmut study and will be supplied by GLNFH. It is also anticipated that the Shawmut paired-release study will use between 100-200 smolts per year, between 2013 and 2015. Any remaining smolts not tagged at the end of the study will be released into the Kennebec River downstream of the Shawmut Project. The Licensee will consult with NMFS, USFWS and MDMR on the development of a detailed study plan for this effort.

The Licensee will also conduct downstream passage studies involving kelts between 2014 and 2016. The intent of these studies is to determine the existing downstream survival for Atlantic salmon kelts at the Shawmut Project. The study will be up to three years in length and will generally coincide with smolt monitoring. It is anticipated that the study will involve the handling and radio-tagging of no more than 20 male kelts per project per year. The Licensee will consult with NMFS on the development of a study plan for this effort.

4.3 Weston Project

Interim Upstream Passage

The Weston Project currently has no upstream passage facilities. Until such time that permanent upstream fish passage is installed at Weston, the Licensee will utilize the existing Lockwood fish lift to provide interim upstream passage for Atlantic salmon at the Weston Project. During the critical months, upstream passage will be provided from the Lockwood Project, in accordance with the provisions outlined above for Lockwood.

Permanent Upstream Passage

The Licensee will design a new upstream passage facility for the Weston Project, incorporating the biological needs of Atlantic salmon, in 2017. The design of the fishway will be developed in consultation with the agencies.

The Licensee will target construction of the upstream fish passage facility at Weston for 2019. Fishway construction would be completed such that the fishway is operational during the upstream migration season in 2020.

Upstream Passage Studies

Due to the lack of an upstream fishway at the Weston Project until at least 2019, no specific studies of upstream passage effectiveness are planned for the Weston Project during the interim period. In addition, during the development of a final SPP, anticipated to occur in 2019, the Licensees will consult with NMFS on potential upstream passage studies to be undertaken as part of the SPP, after an upstream fishway is constructed and operational at the Weston Project.

Downstream Passage

The Weston Project has a downstream passage facility that was upgraded in 2011, consisting of an existing sluice gate located on the South Channel dam and a 10 foot deep floating guidance boom. In addition, it is recognized that project spill at Weston is an important means of downstream passage for both adult and juvenile Atlantic salmon. The Project turbine capacity is 5,930 cfs, and flows in excess of turbine capacity are generally spilled. To enhance downstream passage during the interim period, the following measures will be undertaken.

- The existing sluice gate and floating guidance boom will be operated April 1 through December 31, as river conditions allow.
- The passage facility will be operated to maintain an interim flow of 6% of station unit flow through the sluice gate during evening passage hours. Modifications to the bypass flow will be considered as part of the adaptive management approach to the ISPP, based on results of radio telemetry studies and consultation with the agencies.
- The Licensee will undertake measures necessary to keep the guidance boom in place and in good operating condition. If the guidance boom becomes dislodged or damaged, the

licensee will repair or replace the guidance boom as soon as can be safely and reasonably done.

- Whenever river flow at the Project exceeds 5,930 cfs (except for pond fluctuations allowed by the license), flow in excess of operating turbine capacity 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.
- Whenever river flow at the Project is less than 5,930 cfs, no spillage will occur, and downstream passage will be provided through the downstream passage facilities unless it is determined through consultation with NMFS that additional spill is needed for downstream passage.

Downstream Passage Studies

The Licensee will conduct up to three years of downstream passage study at the Weston Project. To provide an estimate of smolt survival, the Licensee will conduct paired-release radio telemetry studies at Weston from 2013 – 2015 using the paired-release methodology described above for Lockwood. As at Lockwood and Shawmut, it is anticipated that hatchery-reared Atlantic salmon smolts will be used for the Weston study and will be supplied by GLNFH. It is also anticipated that the Weston paired-release study will use between 100-200 smolts per year, between 2013 and 2015. Any remaining smolts not tagged at the end of the study will be released into the Kennebec River downstream of the Weston Project. The Licensee will consult with NMFS, USFWS and MDMR on the development of a detailed study plan for this effort.

The Licensee will also conduct downstream passage studies involving kelts between 2014 and 2016. The intent of this study is to determine the existing downstream survival for Atlantic salmon kelts at the Weston Project. The study will be up to three years in length and will coincide with smolt monitoring. It is anticipated that the study will involve the handling and radio tagging of no more than 20 male kelts per project per year. The Licensee will consult with NMFS and other resource agencies on the development of a study plan for this effort.

4.4 Brunswick Project

Upstream Passage

The Brunswick Project has an existing vertical slot fishway that provides upstream passage for Atlantic salmon, as well as other anadromous and resident species. Currently, the fishway is operated in conjunction with a manned trap and sort facility, which allows MDMR to trap, sort, and release or truck upstream migrating fish, depending on the species/lifestage. During the critical salmon migration period from May 1 – October 31, the vertical slot fishway will be operated as follows:

- MDMR will continue to operate the fishway for use by Atlantic salmon.
- MDMR will trap and sort all fish species, including Atlantic salmon. All Atlantic salmon will be released to Brunswick headpond to continue their upstream migration.

- The Licensee will undertake measures necessary to keep the fishway in good operating condition. If the fishway malfunctions or becomes inoperable during the critical months, the Licensee will repair the fishway and restore it to normal operation as soon as can be safely and reasonably done.
- MDMR will maintain records of all fish moved via the fishway. MDMR will maintain detailed records of Atlantic salmon moved via the fish lift, including an assessment of size, age, and condition.

Upstream Passage Studies

At this time, the existing vertical slot fishway appears to operate effectively for Atlantic salmon, but no studies have been conducted to fully evaluate the effectiveness. Thus, upstream effectiveness studies will be conducted between 2013 and 2015 at the Brunswick Project. The Licensee will conduct upstream passage salmon monitoring studies for up to three years (2013 – 2015) using PIT tagging in cooperation with other dam owners on the Androscoggin River (Pejepscot and Worumbo projects), to the extent practicable. The Licensee will install PIT tag detection equipment at the Brunswick Project fishway entrance and exit to evaluate salmon success in using the fishway. This study would require that Atlantic salmon collected in the Brunswick fishway collection facility over the three-year period be PIT tagged. The Licensee will consult with NMFS in the development of a detailed study plan.

Downstream Passage

The Brunswick Project provides downstream passage through a bypass located between the intakes on the powerhouse. It is recognized that project spill at Brunswick is also an important means of downstream passage for both adult and juvenile Atlantic salmon. The Project turbine capacity is about 6,800 cfs, and flows in excess of turbine capacity are generally spilled. Currently the downstream bypass is operated during the months of April, May, June, November and December. To enhance downstream passage during the interim period, the following measures will be undertaken.

- The Brunswick Project will operate the existing bypass for passage of adult and juvenile salmon during the period April 1 through December 31, as river conditions allow.
- The existing vertical slot fishway for upstream passage will be operated to provide downstream passage for the period April 15 through October 31, as river conditions allow.
- Whenever river flow at the Project exceeds 6,800 cfs (except for pond fluctuations allowed by the license), flow in excess of operating turbine capacity 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.
- Whenever river flow at the Project is less than 6,800 cfs, no spillage will occur, and downstream passage will be provided through the upstream fishway and downstream passage facility unless it is determined through consultation with NMFS that additional spill is needed for downstream passage.

Downstream Passage Studies

The Licensee will conduct up to three years of downstream passage study at the Brunswick Project. To provide an estimate of smolt survival, the Licensee will conduct paired-release radio telemetry studies at Lockwood in 2013 – 2015 using the paired-release methodology described by Skalski et al (2010). Using an upstream release and detections at the upstream side of the dam, a "virtual release" will be constructed of smolts known to have arrived alive at the Project. This "virtual release" group will be used to estimate survival through the dam (or the downstream fishway) and downriver sufficiently far enough to avoid false positive detections due to dead, tagged fish. To account for additional mortality unrelated to dam passage and occurring within the downstream river stretch, a paired release of tagged fish will be conducted in the Project tailrace. Dam passage survival will then be estimated as the quotient of the reach survival estimate derived from the "virtual release" group divided by the paired release survival estimate from the tailwater to the downstream detection station.

It is anticipated that hatchery-reared Atlantic salmon smolts will be used for the study and will be supplied by GLNFH. It is also anticipated that the Brunswick paired-release study will use between 100-200 smolts per year, between 2013 and 2015. Any remaining smolts not tagged at the end of the study will be released into the Androscoggin River downstream of the Brunswick Project. The Licensee will consult with NMFS, USFWS and MDMR on the development of detailed study plan for this effort.

The Licensee will also conduct downstream passage studies involving kelts between 2014 and 2016. The intent of this study is to determine the existing downstream survival for Atlantic salmon kelts at the Brunswick Project. The study will be up to three years in length and will coincide with smolt monitoring. It is anticipated that the study will involve the handling and radio tagging of no more than 20 male kelts per project per year. The Licensee will consult with NMFS on the development of a study plan for this effort.

4.5 Lewiston Falls Project

Upstream Passage

As there is no critical habitat for Atlantic salmon upstream of Lewiston Falls, and no plans under the previous Atlantic Salmon Recovery Plan to restore salmon above Lewiston Falls, there is no need during the term of this ISPP to provide upstream passage for Atlantic salmon at the Lewiston Falls Project. A new recovery plan is expected to be issued by the USFWS in 2013 and any changes in restoration plans will be addressed in the final SPP.

Downstream Passage

As there is no critical habitat for Atlantic salmon upstream of Lewiston Falls, and no plans under the previous Atlantic Salmon Recovery Plan to restore salmon above Lewiston Falls, there is no need during the term of this ISPP to provide downstream passage for Atlantic salmon at the Lewiston Falls Project. A new recovery plan is expected to be issued by the USFWS in 2013 and any changes in restoration plans will be addressed in the final SPP.

Project Spill Program

It is recognized that for the interim period, and the foreseeable future, upstream and downstream fish passage is not required for Atlantic salmon at the Lewiston Falls Project. Nonetheless, it is possible that operation of the Lewiston Falls Project could affect migrating Atlantic salmon, particularly during and after spill events, by inadvertently trapping or stranding fish in the various pools in and around Great Falls.

The turbine capacity at Monty Station is approximately 6,600 cfs. Additional generating capacity exists within the Lewiston Canal system, but is currently not being operated[4]. Flows in excess of available wheel capacity (allowing for licensed pond fluctuations) are normally spilled in accordance with the Project's high water guidelines. The existing wooden flashboards are designed to fail during seasonal high flow events, particularly during the spring freshet. For safety considerations, flashboard replacement must be delayed until the high flow events have subsided.

The Licensee is in the process of replacing approximately 681 feet of flashboards over four sections of the spillway (Dams #1, #2, #3, & #4) with inflatable rubber dams. The work includes resurfacing the cap and upstream face of the dam to provide a base for the new bladder system, and resurfacing and modifying the end piers on either end of the spillways to support the inflatable bladders required to span the flashboard sections. There are two sections of approximately 154 feet of operational rubber dam (Dam #4) currently installed. There will be three more sections (Dams #1, #2, and #3), approximately 578 feet in length installed in 2013. It is anticipated that the project will be completed by the end of 2013.

The addition of rubber dams along the spillways are expected to help reduce the potential impacts to Atlantic salmon in two ways: 1) by allowing better control of the location of spill, and 2) by reducing the time it currently takes to replace failed flashboard sections. Combined, these modifications are anticipated to reduce the potential for stranding of Atlantic salmon in the various pools in and around Great Falls.

To further reduce the potential effects of stranding on Atlantic salmon or other fish species at the Lewiston Falls Project, the Licensee will monitor the Great Falls area after significant spill events and during flashboard replacement. Any stranded listed species will be collected and released back into the Androscoggin River. The Licensee has developed a draft Atlantic salmon Rescue and Handling Plan for the Lewiston Falls Project, which is provided as Attachment A.

The Licensee will record its monitoring actions following each significant spill event, and the records of any Atlantic salmon found stranded will be annually reported.

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[4] It is noted that the canal system may be retired at some point during the term of this ISPP. If so, the canal system may no longer pass flow.

4.6 Other Protection and Enhancement Measures for Atlantic Salmon

In a collaborative effort to improve knowledge about the timing of the downstream migration of smolts on the Kennebec River, the Licensees of the Kennebec projects addressed in this ISPP are collaborating with the fishery agencies to monitor smolt movement in the Sandy River to determine the critical out-migration period for smolts. The Sandy River monitoring effort will be done in collaboration with state and federal fishery agencies. Toward this end, the Licensees will cooperate with NMFS, USFWS, and MDMR on the installation and operation of a rotary screw trap (RST) in the Sandy River for a period of up to three years (2013 – 2015).

If it is determined that there is a long-term need to monitor the timing of the Sandy River smolt run, on an annual basis, or that additional Sandy River smolt monitoring is needed to estimate smolt populations, evaluate egg planting success, or evaluate natural spawning success, such annual monitoring will be considered in the final SPP.

5.0 IMPLEMENTATION PROVISIONS

5.1 Effective Date and Schedule

Agreed upon interim protection measures, outlined herein, will be implemented both prior to and following the issuance of the BO and ITS, expected later in 2013. Downstream fish passage studies will occur during the 2013 salmon smolt migration season, and salmon smolt studies will occur in the April/May timeframe. Kelt studies will also occur in the April/May timeframe. After review with the Services of monitoring results from the first and second years, the Licensees and the Services will determine whether continuation of the smolt and kelt studies is warranted.

Additionally, the Licensees, in consultation with resource agencies, plan to design and construct permanent upstream passage facilities, considering the biological needs of Atlantic salmon, at the Lockwood, Shawmut and Weston Projects. Upstream fishway design and consultation activities are expected to occur between 2014 and 2019 on the following schedule (Table 2), with upstream fishway construction occurring no earlier than 2015 at Lockwood, 2017 at Shawmut, and 2019 at Weston.

Table 2. Schedule for Permanent Upstream Fishway Installation at the Kennebec River Projects

Project	Fishway Design	Fishway Construction	Operational
Lockwood	2014	2015	Spring 2016
Shawmut	2016	2017	Spring 2018
Weston	2017	2019	Spring 2020

5.2 Requirements and Funding

The Licensees shall provide funding for all measures required under the ISPP, with the exception of measures that are indicated otherwise and/or are subject to previous agreements and contracts between the Licensees, agencies, and/or service providers.

5.3 Monitoring and Reporting

The Licensees will prepare annual report(s) on the previous year's study results in consultation with resource agencies, assess the need to continue studies, and detail the progress on design and construction of fishways. A draft annual report will be provided to NMFS, USFWS, MDMR, and other appropriate federal and state agencies by January 31 of each year, reporting on the prior year's activities. A final annual report will be filed with FERC and resource agency personnel by March 31 for each of the five projects

5.4 Agency Consultation

The Licensees will meet annually with NMFS, USFWS, MDMR and other appropriate federal and state agencies to review the draft annual reports, and to consult on anticipated fishway design, construction and study activities planned for the coming year. Annual meetings may be held in person or via teleconference, and the Licensees will endeavor to hold the meeting by March 1 of each year.

In addition to the annual consultation meeting, the Licensees will consult with NMFS on specific aspects of this ISPP, including:

- Design of any plans for the construction of new fishways, or the modification of existing fishways, including 1) volitional upstream passage facilities at Lockwood; 2) upstream passage facilities at Shawmut; 3) upstream passage facilities at Weston.
- Development of detailed study plans for the study of upstream and downstream passage of Atlantic salmon, including 1) downstream paired-release smolt studies at Lockwood, Shawmut, Weston and Brunswick; 2) downstream kelt studies at Lockwood, Shawmut, Weston and Brunswick; 3) and upstream adult studies at Brunswick and Lockwood.
- Modifications to project facilities will be filed with FERC for final approval.

5.5 Adaptive Management

The Licensees are committed to an adaptive management approach to implementing this ISPP. The agreed upon fish passage measures and activities are laid out within an adaptive management framework, with integration of management and research in order to provide feedback and the ability to adapt measures, as necessary, for further protection and enhancement of Atlantic salmon. Since the proposed interim process is intended to be adaptive, the Licensees will be coordinating and consulting with NMFS throughout the 2013 – 2019 interim period. If early study results indicate that study designs are not adequately measuring passage efficiency, the Licensees will work with NMFS to correct it. Likewise, if the early study results indicate that the upstream and downstream fish passageways are not highly efficient at passing Atlantic salmon, the Licensees will coordinate with NMFS and modify operations as appropriate to avoid and minimize effects to Atlantic salmon to the extent practicable. To that end, the Licensees will meet with NMFS annually to discuss study results, potential modifications to the study designs, and/or potential changes to the operation of the facilities that may be necessary to reduce adverse effects to the species.

The cornerstone of the adaptive management provisions included in this ISPP are the annual reports and annual agency meetings. Annual reports will be used to report on interim fishway operations, and on fish passage studies being conducted at each of the projects. Annual reports will be provided to the agencies in advance of the proposed annual meeting, and will form the basis of discussion at the annual meeting. The annual meeting will provide an opportunity for the Licensees and agencies to discuss study results, along with potential opportunities to make adjustments to fishway operations that might improve passage for Atlantic salmon during the interim period. The meetings will also be used to make adjustments to ongoing fish passage studies, and to modify study plans, as appropriate, for the upcoming study season.

The annual agency meetings will also be used to discuss other issues related to the GOM DPS of Atlantic salmon restoration and management activities that may be relevant to the Kennebec and Androscoggin rivers. Examples of issues that could be discussed and may have a bearing on Kennebec and Androscoggin Atlantic salmon restoration efforts include availability of hatchery stocks for studies and restoration efforts; the potential need to collect Kennebec or Androscoggin River adults at Lockwood or Brunswick as brood stock; the need for resources or support for continued trap, sort and /or truck of Atlantic salmon from Lockwood to support restoration goals; coordination of fish passage study efforts with agency studies or the studies being conducted by other hydropower project owners in the watersheds; modifications to existing fishway operations or project spills during the interim period; or the need for support for other types of Atlantic salmon restoration efforts throughout the Merrymeeting Bay SHRU. Using an adaptive management approach, any of these examples, as well as numerous others, may lead to modification of the measures and provisions contained in this ISPP, with the overarching goals of continually working to improve fish passage for Atlantic salmon, protect critical habitat, and support the Services' overall GOM DPS Atlantic salmon restoration efforts.

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ATTACHMENT A

Draft Atlantic Salmon Rescue and Handling Plan, Lewiston Falls Project

ATLANTIC SALMON RESCUE AND HANDLING PLAN, LEWISTON FALLS PROJECT

(FERC No. 2302)

DRAFT

February 21, 2013

Draft Atlantic Salmon Rescue and Handling Plan,

Lewiston Falls Project

1.0 Introduction

This Rescue and Handling Plan (Plan) describes annual processes to avoid Atlantic salmon stranding occurrences on the bedrock terraces in and around Great Falls during flashboard replacement activities and/or during and following spill events. During the annual upstream migration period, Atlantic salmon could be attracted to the Great Falls bedrock terraces due to water spillage associated with the loss of flashboards or rubber dam section spillage. During these occurrences, Atlantic salmon could become stranded on the terraces as water flow over the dam recedes below the crest of the dam or as the rubber dam sections re-inflate. The following plan ensures that adequate numbers of personnel are trained and available to safely remove Atlantic salmon from the ledges during flashboard replacement activities and/or during or following spill events. This plan will be in affect during the adult Atlantic salmon migration season, May 1 through July 31 of each year.

2.0 Project features

The Lewiston Falls Project is the fourth dam on the mainstem Androscoggin River and is located in the towns of Lewiston and Auburn Maine at the site of Great Falls at approximately river mile 23. This Project includes a complex dam consisting of several distinct dam sections, including four stone-masonry dam sections (Dams 1-4), a fifth masonry dam section (Dam 5), and an island spillway which is a concrete section located on a small island between Dams 3 and 4. Many of the dam sections are topped by flashboards, some of which were recently replaced with inflatable rubber dam sections.

The Licensee is in the process of replacing approximately 681 feet of flashboards over four sections of the spillway (Dams #1, #2, #3, & #4) with inflatable rubber dams. The work includes resurfacing the cap and upstream face of the dam to provide a base for the new bladder system, and resurfacing and modifying the end piers on either end of the spillways to support the inflatable bladders required to span the flashboard sections. There are two sections of approximately 154 feet of operational rubber dam (Dam #4) currently installed. There will be three more sections (Dams #1, #2, and #3), approximately 578 feet in length installed in 2013. It is anticipated that the project will be completed by the end of 2013. The spillway discharges to a large exposed series of water falls and bedrock terraces, known as Great Falls. The Project also includes a canal system that originally served to deliver water to small generating facilities located in several mills. The Project was redeveloped in 1990 when a new powerhouse (Monty Station) was added to the project. The Canal generating units are currently out of service and are awaiting final disposition.

The Lewiston Falls Project is licensed to operate with up to four feet of impoundment fluctuation to allow for peaking under normal conditions. The station has a minimum flow requirement of 1,280 cfs required at Monty Station, however there is no minimum flow requirement over Great Falls.

3.0 Agency notification

At least 24 hours prior to the drawdown of the impoundment for flashboard repair or replacement activities, Licensee will notify (by phone call, email or fax) the National Marine Fisheries Service (NMFS), United States Fish and Wildlife Service (USFWS), and Maine Department of Marine Resources (MDMR).

4.0 Education of Atlantic salmon rescue personnel

All rescue personnel will be trained to properly identify, handle, collect biological information and recognize any injuries to rescued Atlantic salmon. Rescue personnel will be trained in Atlantic salmon identification and handling annually by April 1.

5.0 Safety provisions for Atlantic salmon rescue personnel

A safety talk will take place prior to rescue work. All fish rescue personnel must have previous experience or have received training in fish rescue techniques and techniques for safe movement on ledge terraces. Adequate personnel protection equipment (PPE), such as (carbide soles waders or creepers, hard hat, safety glasses, life jacket, work gloves, cell phone, drinking water and first-aid kit) must be available as necessary for fish rescue personnel. The lead fish rescue person must communicate with operations personnel on a regular basis prior to and during fish rescue activities in order to coordinate with flashboard replacement and other maintenance activity and to schedule impacts on generation, dispatch and river flow coordination.

6.0 General Atlantic salmon rescue provisions

It is possible that operation of the Lewiston Falls Project could affect migrating Atlantic salmon, particularly during flashboard replacement and/or during and after spill events, by inadvertently trapping or stranding them in the various pools in and around Great Falls.

The turbine capacity at Monty Station is approximately 6,600 cfs. Flows in excess of available wheel capacity (allowing for licensed pond fluctuations) are normally spilled in accordance with the Project’s high water guidelines. The existing wooden flashboards are designed to fail during seasonal high flow events, particularly during the spring freshet. For safety considerations, flashboard replacement must be delayed until the high flow events have subsided.

The addition of rubber dams along the spillways are expected to help reduce the potential impacts to Atlantic salmon in two ways: 1) by allowing better control of the location of spill, and 2) by reducing the time it currently takes to replace failed flashboard sections.

Combined, these modifications are anticipated to reduce the potential for stranding of Atlantic salmon in the various pools in and around Great Falls.

On the day of the flashboard replacement activities or re-inflation of rubber dams, fish rescue personnel will coordinate the drawdown of the impoundment with operations personnel. Fish rescue personnel will access the bedrock terraces from the West side of the river while the water recedes below the crest of the dam. Fish rescue personnel will then systematically move to the accessible parts of the terraces and capture stranded fish with soft mesh dip nets and return them to the river at the base of the terraces.

There are some pools on the terraces that are large and deep and stay watered during flashboard replacement. The depth and size of these pools may prevent rescue personnel from safely accessing these pools to rescue all the fish. Generally, the depth and size of these pools provides adequate water quality for the fish during the 4-6 hour typical flashboard replacement job. To ensure that the fish in these pools stay alive during flashboard replacement, licensee has the option to temporarily increase the headpond level above the dam crest and spill water into these pools to oxygenate the water. Rescue personnel will stay on the terraces and monitor the fish in large and deep ledge pools until the flashboards are replaced or rubber dams are inflated, and spillage is resumed.

Rescue personnel's main objective is to safely remove Atlantic salmon from the terraces as soon as possible and in the shortest period of time and place them back into the river below Great Falls. Fish rescue personnel will count and collect biological information (length, scale sample, tags and sex) from the Atlantic salmon rescued from the ledges and from any dead specimens. Licensee will provide (via phone call, email or fax) all the above information to NOAA within 72 hours of flashboard replacement.

To further reduce the potential effects of stranding on Atlantic salmon at the Lewiston Falls Project, the Licensee will also monitor Great Falls area after significant spill events and follow the above protocol.

7.0 Reporting

As part of the ISPP, Licensee will record its actions following flashboard replacement or spill events and the records of any Atlantic salmon rescued or found dead or injured will be annually reported.

ATTACHMENT B: WHITE PAPERS (January, 2012)

A REVIEW OF EFFECTS OF THE LOCKWOOD PROJECT ON THE KENNEBEC RIVER, MAINE ON ATLANTIC SALMON (SALMO SALAR) SMOLT AND KELT DOWNSTREAM PASSAGE AND ADULT UPSTREAM PASSAGE

January 20, 2012

A Review of Effects of the Lockwood Project on the Kennebec River, Maine on Atlantic salmon (*Salmo salar*) Smolt and Kelt Downstream Passage and Adult Upstream Passage

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R-22794.000

January 20, 2012

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1.0 Introduction

In 2009, the Gulf of Maine population of Atlantic salmon was listed as an endangered species under the Endangered Species Act (ESA). The Lockwood Project located on the Kennebec River is within the designated critical habitat for the species. Consequently, continued operation of the hydropower project requires the Licensee[1] (The Merimil Limited Partnership (MLP)) to prepare a habitat conservation plan (HCP) and secure an incidental take permit (ITP). In order to issue an ITP, the HCP must outline measures to be undertaken by the Licensee to avoid, minimize and mitigate Project impacts, so as to assure that there is “no jeopardy" to the species as a result of continued operation of the Project. A first step in considering appropriate performance standards and measures to be included in the HCP is a common understanding of the effect of the Project on Atlantic salmon and its habitat. The purpose of this white paper is to evaluate current Project effects and examine whole station survival on downstream migrating Atlantic salmon smolts and kelts as well as upstream migrating Atlantic salmon. The whole station survival of downstream migrating Atlantic salmon smolts was modeled based on available environmental, biological and physical data related to or similar to the Lockwood Project. The construction and output of that modeling process are discussed in Sections 3, 4 and 5 of this paper. Upstream salmon passage at the Lockwood Project is discussed in Section 6 of this report. In addition, the whole station survival of downstream migrating Atlantic salmon kelts was modeled based on available environmental, biological and physical data related to or similar to the Lockwood Project. The construction and output of that modeling process are discussed in Sections 6 and 7 of this report. Additional considerations such as predation are discussed in Section 8.

This white paper has been revised from the original draft (provided during April, 2011) based on comments received from agencies and other members of the HCP Technical Advisory Committee (TAC). A summary of comments and a description of how comments were addressed in both the August, 2011 and this version (January 2012) of the white paper is provided in Appendix C.

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[1] The Licensee for the Lockwood Project is the Merimil Limited Partnership.

2.0 Background

2.1 Project Facilities and Operation

The Lockwood Project, owned by the Merimil Limited Partnership is located at river mile 63, and is the first dam on the mainstem of the Kennebec River. The Lockwood Project includes an 81.5-acre impoundment, an 875 ft long and 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 (Figure 1). 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. The west spillway extends about 650 ft from the small island in a southwesterly direction to the forebay canal headworks, which extend to the west bank of the river. Each spillway is equipped with 15 in wooden flashboards.

The headworks and intake structures are integral to the dam and the powerhouses, respectively. The forebay intake section contains eleven headgates 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 having a total installed capacity of 6.8 MW.and a combined flow of approximately 5,660 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 in clear spacing in front of Units 1-6 and 3.5 in 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.

The Lockwood Project includes an existing ice and debris surface sluice located between Units 6 and 7. This sluice is 6-feet-wide by 30-inches-deep, and it passes flows in the range of 60 to 70 cfs. Flows from this sluice discharge directly into the Project tailrace, which is approximately 15 feet-deep. The Lockwood Project also has another existing debris surface sluice located above the head works structure and is 7.5-feet-wide by 16-inches-deep. Flows through this sluice range from 35 to 40 cfs and discharge over the face of the dam into a shallow pool connected to the river. Downstream anadromous fish passage (presently in study and modification phase) is provided through a recently installed 7.0 ft wide by 9.0 ft deep surface sluice gate located on the river side of the forebay canal in conjunction with a 300 ft long by 10 ft deep floating guidance boom leading to the new sluice gate. The new gate can pass flows up to 340 cfs. There are also two deep canal drain gates located underneath the new surface sluice gate.

The Lockwood Project is operated in a run-of-river mode. The normal minimum head pond elevation is approximately 51.66 ft msl (six inches below the top of the spillway flashboards) when the flashboards are in place, and approximately 49.91 ft msl (1 ft below the spillway crest) when flashboards are being replaced. 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 3 (three feet long by eight 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. When the flashboards are being replaced, there are no minimum flows into the bypassed reach.

2.2 Target Species: Atlantic salmon

Numerous reviews detailing the life history of Atlantic salmon exist (NRC 2004, Fay et al. 2006, NMFS 2009) and their life cycle are summarized here. Adult Atlantic salmon begin to return to freshwater rivers during the spring. Redds are constructed and fertilized eggs are buried during the late fall. Following the fall spawn, approximately 20% of spent adult salmon (kelts) move back downstream and into the ocean but the majority move back downstream and into the ocean the following spring (Baum 1997). Eggs remain in the gravel until hatching during the early spring. Following a three to six week period, the young salmon emerge from the gravel as fry and begin to actively seek food. As fry begin to feed they develop cryptic vertical stripes and are then known as parr. Atlantic salmon remain in the parr stage for one to three years and remain resident to the freshwater river during that period. Following that period, each parr undergoes a series of physiological and morphological changes known as smoltification. It is at that time that these fish move downstream through the freshwater river system and into the ocean. This downstream migration takes place during the spring season (April-June) with the majority of Maine smolts entering the ocean during May (NFMS 2009). A review of downstream migration timing data from the Penobscot and Narraguagus Rivers indicates that approximately 2% of smolts depart during April, 77% during May and 21% during June (GNP 1997, USUSUC 2005). Those individuals remain in the ocean for a period of 1-2 years prior to returning as adults and continuing the cycle.

2.3 Fish Passage Operations at the Lockwood Project

Upstream passage at the Lockwood Project is provided by a fish lift installed in 2006 which is equipped with a manual trap, sort and transfer facility. The fish lift is operated annually from May 1 - October 31. Upstream migrants are attracted to the lift with 150 cfs attraction flow and water velocities of four to six ft/s at the lift entrance. Downstream smolt and kelt passage at Lockwood occurs via unregulated spillage and through a recently installed 7.0 ft wide by 9.0 ft deep surface sluice gate located on the river side of the forebay canal in conjunction with a 300 ft long by 10 ft deep floating guidance boom leading to the sluice gate. The new gate can pass flows up to 340 cfs. During the spring smolt migration season (April 1 – June 15) and the fall kelt migration season (Oct 15 - Dec 15) the sluice passes 340 cfs pending further study and modification.

Within the Kennebec River, returning adult salmon are collected at the Lockwood fish lift and are trucked upstream around the Lockwood, Hydro Kennebec (owned and operated by Brookfield), Shawmut, and Weston Projects and are released into the Sandy River. It is assumed that these fish spawn in the Sandy River (approximately 12 river miles upstream from Weston, 28 miles upstream from Shawmut and 31 miles upstream from Lockwood). Radio-tagged sea run Atlantic salmon transported to the Sandy River during 2007 and 2008 showed a high degree of fidelity to that river with 89% (8 of 9) of tagged fish remaining in the Sandy River through the fall spawning season during both 2007 and 2008 (MDMR 2008, MDMR 2009). The Sandy River has the greatest biological value for both spawning and rearing habitat within the occupied range of the Merrymeeting Bay Salmon Habitat Recovery Unit (NMFS 2009). Given the combination of geographical distance between quality habitat in the Sandy River and the downstream projects and territorial nature of both the fry and parr life stages to that quality rearing habitat (Danie et al. 1984) it is unlikely that either life stage would be significantly impacted by the existing hydroelectric projects on the Kennebec. The focus of this assessment is the potential Project impacts to downstream migrating Atlantic salmon smolts (Sections 3, 4, and 5) as well as an initial consideration to the impacts on kelts and upstream migrating Atlantic salmon (Section 6).

3.0 Methods: Downstream Migrating Smolt Survival

Downstream migrating Atlantic salmon smolts encountering the Lockwood Project must either pass the Lockwood Project over the spillway via the flashboard slots or over the boards or concrete crest, or enter the forebay canal and pass downstream via either the fish bypass system, or one of the seven Project turbines. These three potential routes of passage were considered and incorporated into the model of whole station survival at the Lockwood Project (Figure 2). Information from the primary literature, reports and literature reviews on fish passage through turbines and non-turbine exit routes was assembled for examination and analysis for application to the Lockwood Project. Necessary components for assessing the impact of safe fish passage at the Lockwood Project included: smolt run timing, prevailing river flows, proportion diverted to Project spillways and the associated survival rate, proportion diverted into the Project forebay canal, proportion guided into the bypass system and the associated survival, proportion transported through the turbines and the associated survival through two turbine types (1 Kaplan, and 6 Francis Units). Kaplan turbines are a type of propeller turbine with adjustable blades which can be rotated to allow the turbine to operate at high efficiency over a range of flows and heads. Francis turbines contain a runner which has water passages through it formed by curved vanes or blades. Water passage through the runner and over the curved surfaces causes the runner to rotate and drive the generation process.

3.1 Smolt Downstream Bypass Efficiency

Downstream bypass efficiency studies for passage of Atlantic salmon smolts have been conducted at the Lockwood Project during 2007 (Normandeau 2008) and 2011 (Normandeau 2011). The 2011 field testing assessed the effectiveness of a new downstream fish bypass facility and guidance boom using radio telemetry techniques. For the purposes of estimating the downstream bypass efficiency component of whole station survival for smolts, results from the 2011 efficiency study were used.

3.2 Spillway and Downstream Bypass Passage Smolt Survival Assessment

Due to the lack of site-specific field-test information, estimates for passage survival of Atlantic salmon smolts through the Lockwood spillway and downstream bypass were developed based on existing empirical studies conducted at other hydroelectric projects with similar characteristics. The principal causes of injury and mortality for fish passed through either a spillway or bypass sluice are shear forces, turbulence, rapid deceleration, terminal velocity, impact against the base of the spillway, scraping against the rough concrete face of the spillway and rapid pressure changes (Heisey et al. 1996). Empirical studies related to spillway and bypass survival were pooled into a single data set. Existing studies described in the peer-reviewed primary literature and gray literature reports were collected and reviewed for potential application to the Lockwood Project. Professional judgment was used to sort through the existing studies and select those appropriate for and similar to Lockwood. Selection criteria used for this assessment included physical characteristics of the spillways/sluices at those projects, fish species tested, and geographical location.

Acceptability criteria for spillway and bypass survival studies were as follows:

- Completeness of the reported data on the important spill characteristics known to affect fish survival, information on the tested species, and other relevant information such as environmental conditions.

- Ensure control group survival >75% and sample size >25. The use of a control group allows for the isolation of effects due to the experimental treatment from those associated with the experimental procedure (e.g., handling stress or scale loss injury due to netting). Low control group survival may mask treatment effects or indicate that the experimental design and/or implementation were flawed to an extent that the results may not be reliable. Adequate sample size is important to achieve reasonable precision levels and to reduce the importance of each individual fish in a given test. For example, if 100 fish are used in a treatment group, each fish represents 1% of the sample. However, if 10 fish are used, each fish represents 10% of the sample. As control group survival decreases or the recapture rate of treatment and control fish decreases, the sample size must increase to achieve a particular level of precision.

3.3 Turbine Passage Smolt Survival Assessment

Due to the lack of site-specific information, estimates of turbine passage survival of Atlantic salmon smolts at Lockwood were developed using a combination of existing empirical studies and modeled calculations. Existing studies described in the peer-reviewed primary literature, gray literature reports, review documents and databases were collected and reviewed for potential application to the Lockwood Project. Professional judgment was used to sort through the existing studies and select those appropriate for Lockwood estimates. Selection criteria used for this assessment included physical characteristics of the projects, characteristics of the turbines at those projects, fish species tested, and geographical location. In addition to existing empirical data from similar hydroelectric projects, established models for determination of blade strike probabilities for fish passing through different turbine types were constructed for Units 1 through 7 at Lockwood.

An examination of the results of recent studies indicate that turbine passage survival is largely a function of fish size relative to size of the water passageway (as indexed by runner diameter), clearance between structural components (*e.g.*, spacing between runner blades or buckets, wicket gates, and turbine housing), flow, angle of flow, and the number of buckets/blades, though other non-mechanical factors (*e.g.*, hydraulic) may also contribute to fish injury/mortality. Thus, species *per se* is not as important as fish size (Heisey et al. 1996; Franke et al. 1997) in safe passage through turbines.

3.3.1 Empirical Estimates of Smolt Turbine Passage Survival

Acceptance criteria were established prior to the review of existing empirical data for turbine survival studies. Following determination of suitability, the studies were put into two databases, one for Kaplan or propeller turbines and another for Francis turbines. Acceptability criteria were as follows:

- Completeness of the reported data on the important turbine characteristics known to affect fish survival and information on the tested species, fish size, and other relevant information such as station discharge or environmental conditions.
- Ensure control group survival >75% and sample size >25. The use of a control group allows for the isolation of effects due to the experimental treatment from those associated with the experimental procedure (e.g., handling stress or scale loss injury due to netting). Low control group survival may mask treatment effects and indicates that the experimental design and/or implementation were flawed to an extent that the results may not be reliable. Adequate sample size is important to achieve reasonable precision levels and to reduce the importance of each individual fish in a given test. For example, if 100 fish are used in a treatment group, each fish represents 1% of the sample. However, if 10 fish are used, each fish represents 10% of the sample. As control group survival decreases

or the recapture rate of treatment and control fish decreases, the sample size must increase to achieve a particular level of precision.

3.3.2 Modeled Estimates of Smolt Turbine Passage Survival

Franke et al. (1997) defined the three primary risks to outmigrating fish passing through the turbine environment as 1) mechanical mechanisms, 2) fluid mechanisms, and 3) pressure mechanisms. Mechanical mechanisms were primarily defined as forces on fish body resulting from direct contact with turbine structural components (e.g. rotating runner blades, wicket gates, stay vanes, discharge ring, draft tube, passage through gaps between the blades and hub or at the distal end of blades or other structures placed into the water passageway). The probability of that contact is dependent on distance between blades, number of blades and fish body length. Additional sources of mechanical injury may include gap grinding, abrasion, wall strike and mechanical chop. Fluid mechanisms were defined as shear-turbulence (the effect on fish of encountering hydraulic forces due to rapidly changing water velocities) and cavitation (injury resulting from forces on fish body due to vapor pockets imploding near fish tissue). Impacts to fish from pressure resulted from the inability of fish to adjust from the regions of high pressure immediately upstream of turbines to regions of low pressure immediately downstream of turbines. Results from most studies indicate that mechanical related injuries are the dominant source of mortality for fish in the turbine environment at low head (< 30 m or 100 ft) projects (Franke et al. 1997). Blade strike is considered the primary mechanism of mortality when fish pass through turbines (Eicher Associates Inc. 1987; Cada 2001). Franke et al. (1997) noted that pressure related injuries appear to be of minor secondary importance when working at low head (< 30 m or 100 ft) hydroelectric projects. In addition, Franke et al. (1997) noted that tolerance to pressure reduction is greater for physostomous fish species, such as salmonids. Physostomous fish species are defined by having a pneumatic duct connecting the air bladder to the esophagus so that gasses from the air bladder can quickly dissipate through the mouth to accommodate changing pressures. Franke et al. (1997) noted that although evidence of injuries due to fluid shear forces does exist, relative to other injury types, they are not a dominant source of mortality during turbine passage.

Given that mechanical related injuries comprise the dominant source of mortality for fish passing through low head (< 30 m or 100 ft) hydroelectric projects, blade strike probabilities and turbine passage survival at Units 1 through 7 of the Lockwood Project was estimated for outmigrating Atlantic salmon smolts using the Advanced Hydro Turbine model developed by Franke et al. (1997). The Franke et al. (1997) blade strike model was developed as part of the U.S. Department of Energy program to develop more "fish friendly" turbines and is a modified form of the equation originally proposed by VonRaben (Bell 1981). Franke et al. (1997) refined the VonRaben model to consider tangential projection of the fish length and calculation of flow angles based on overall operating head and discharge parameters because most turbine passage mortality is likely caused by fish striking a blade or other component of the turbine unit. The Franke blade strike model predicts the probabilities of leading edge strikes (a possible mechanical injury source). Those strikes could result from contact between a fish body and a blade, a gap between blade and an adjacent structure, stay vane leading edge, wicket gate leading edge, or leading edge to any support pieces in the intake or draft tube.

The probability (*P*) of direct contact between a fish and a leading edge depends on a number of factors including the number of turbine blades (or buckets; N), fish length (L), runner blade speed (rpm), turbine type, runner diameter (D), and total discharge. Additionally, a correlation function (λ) is added to the equations to account for several factors (Franke et al. 1997). Among these are that an individual fish may not lie entirely in the plane of revolution due either to internal forces within the turbine or the physical movement of the individual fish. Additionally, a length-related fraction could be applied to account for the fact that an impact on a sensitive portion of the fish body (i.e. the head) may be more damaging than an impact to a less sensitive portion (i.e. the tail) of the fish (Franke et al. 1997). The use of the correlation factor also extends the applicability for the blade strike equations to all injury mechanisms related to the variable NL/D (number of blades*body length / runner diameter). These include both mechanical (leading edge strikes and gap grinding) and fluid mechanisms (Franke et al. 1997). As used in this analysis, the equation assumes that any strike results in immediate mortality whether the fish actually died, was injured, or not. The probability of survival predicted by this model will provide a useful perspective for fish sizes where site-specific data is not available.

Turbine passage survival was calculated for a range of fish body lengths (5-9 inches) considered to be representative of outmigrating salmon smolts in Maine rivers (NRC 2004; Fay et al. 2006). The blade strike probability for the Lockwood Kaplan unit (Unit 7) was calculated using Equation 1:

$$P = \lambda \frac{N \cdot L}{D} \cdot \left[\frac{\cos \alpha\alpha}{8\, Q_{\omega d}} + \frac{\sin \alpha_{\alpha}}{\pi \frac{r}{R}} \right]$$

(Equation 1)

where Equation 2 was used to calculate the value of α_α:

$$\tan \alpha_{\alpha} = \frac{\pi \bullet E_{\omega d} \cdot \eta}{2 \cdot Q_{\omega d} \cdot \frac{r}{R}}$$

(Equation 2)

The blade strike probabilities for Lockwood Francis units (Units 1-6) were calculated using Equation 3

$$P = \lambda \frac{N \cdot L}{D} \cdot \left[\frac{\frac{\sin \alpha_t \cdot \frac{B}{D_1}}{2\, Q_{\omega d}} + \cos \alpha_t}{\pi} \right]$$

(Equation 3)

where Equation 4 was used to calculate the value of α_t:

$$\tan(90 - \alpha_t) = \frac{2\pi E_{\omega d} \cdot \eta}{Q_{\omega d}} \cdot \frac{B}{D_1} + \frac{\pi \cdot 0.707^2}{2Q_{\omega d}} \frac{B}{D_1} \left(\frac{D_2}{D_1}\right)^2 - 4 \cdot 0.707 \cdot \tan \beta \frac{B}{D_1} \frac{D_1}{D_2}$$

(Equation 4)

and Equation 5 was used to calculate the value of tan β.

$$\tan \beta = \frac{0.707 \frac{\pi}{8}}{\xi \cdot Q_{\omega d} opt {\frac{D_1}{D_2}}^3}$$

(Equation 5)

Input parameters for Equations 1 through 5 were defined as:

B = Runner height at inlet

D = Diameter of runner

D_1 = Diameter of runner at the inlet

D_2 = Diameter of runner at the discharge

g = Acceleration due to gravity

H = Turbine head

L = Length of fish

N = Number of turbine blades or buckets

P = Predicted strike probability

Q = Turbine discharge

Q_{opt} = Turbine discharge at best efficiency

r = Fish entry point (along blade)

R = Radius

RPM = Revolutions per minute

α_α = Angle to axial of absolute flow upstream of runner (for Kaplan and Propeller units)

α_t = Angle to tangential of absolute flow upstream of runner (for Francis units)

β = Relative flow angle at runner discharge

ξ = Ratio between Q with no exit swirl and Q_{opt} (typical value = 1.1)

λ = Strike mortality correlation factor

η = Turbine efficiency

ω = Rotational speed (calculated as $\omega = RPM \cdot \frac{2\pi}{60}$)

$E_{\omega d}$ = Energy coefficient (calculated as $E_{\omega \mathbf{d}} = \frac{gH}{(\boldsymbol{\omega}\mathbf{d})^2}$)

$Q_{\omega d}$ = Discharge coefficient (calculated as $Q_{\omega \mathbf{d}} = \frac{Q}{\boldsymbol{\omega}\mathbf{D}^3}$)

Calculated blade strike probabilities (P) generated by leading edge strike equations for Kaplan and Francis turbines were converted into a percent survival (S) using equation 7.

$$S = 100 - P \qquad \text{(Equation 6)}$$

4.0 Results: Downstream Migrating Smolt Survival

4.1 Smolt Run Timing

In order to model whole station survival for Atlantic salmon smolts passing the Lockwood Project, it is necessary to know the timing and seasonal distribution of smolts moving downstream. Seasonal distribution data for smolt downstream migration on the Kennebec River is unavailable. As a result, distribution data collected from the smolt downstream migration on other Maine rivers was used as a surrogate. Seasonal run timing data was collected from seven different sampling years and two Maine rivers. Smolt passage was assessed during the months of April, May and June during 1988, 1989, 1990, 1993, 1994, and 1995 at the Mattaceunk Project (Weldon Dam) on the Penobscot River (Table 1; GNP 1997). During those six sampling years, a total of 16,114 Atlantic salmon smolts were collected. The average seasonal distribution for smolts during those six years was 0.09% during April (range = 0-0.46%), 71.94 during May (range = 38.0-93.84%) and 27.96 during June (range = 6.13-62.0%) (Table 2). Additional sampling was conducted and data was available related to smolt outmigration in the Penobscot River during 2004 (USASAC 2005). Total catch of Atlantic salmon smolts within Penobscot River rotary screw traps during spring 2004 is presented in Figure 6 (Note – this figure is reprinted from USASAC 2005). Based on visual assessment of Penobscot River data in Figure 6, it was estimated that approximately 10% of the Atlantic salmon smolt run took place during April, approximately 88% of the run took place during May and the remaining approximately 2% of the run took place during June. Rotary screw trap data from the Narraguagus River was also collected during 2004 (USASAC 2005). Based on visual assessment of Narraguagus River data in Figure 6, it was estimated that approximately 4% of the Atlantic salmon smolt run took place during April, approximately 96% of the run took place during May and 0% took place during June.

For the purposes of estimating whole station survival for downstream migrating Atlantic salmon smolts moving past the Lockwood Project it was assumed the average smolt distribution from the seven years of available data on seasonal smolt distribution from the Penobscot and Narraguagus Rivers would account for annual variation and be representative of patterns observed within the Kennebec River. Patterns in mean daily discharge for the three rivers were examined for the years 2006-2010 and similar trends in the timing of spring run-off events were observed. Although not readily available, it is likely that spring water temperatures are also similar among the three rivers. Similarity in spring water temperatures and run-off timing for the three rivers supports the extrapolation of smolt run timing from those systems for application to the Kennebec River. As a result, the model presented here is based on a seasonal distribution of Atlantic salmon smolts of 1.8% during April, 77.0% during May and 21.2% during June (Table 2)[2]. Variations in this seasonal distribution and their impacts to whole station survival are examined in Section 5.1 of this report.

4.1.1 Additional Considerations Related to Smolt Run Timing

There are additional ecological and anthropogenic factors that may influence smolt run timing in the Kennebec River on an annual basis. Potential sources of variation to the seasonal distribution of Atlantic salmon smolts used in the model presented in this report could include smolt origin (hatchery-reared vs.

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[2] Following the 26 April 2011 Technical Committee Meeting, a fifteen year data set from the Narraguagus River (1996-2010) was acquired and provided the first (arrival), median and last dates for outmigrating Atlantic salmon smolts (J. Kocik, personal communication). However, since there was no associated abundance information for those years, the monthly proportioning of the smolt outmigration used in this model remains unchanged.

wild) as well as differences in river temperature between upstream smolt rearing areas and the downstream hydroelectric Projects.

Smolt Origin:

Differences in the timing and seasonal distribution for smolts moving downstream may vary depending on the origin of the individuals (hatchery-reared vs. wild). Holbrook (2007) observed hatchery-reared smolts released during April (2005 and 2006) to exhibit downstream migratory behavior earlier than wild smolts within the Penobscot River. It was theorized that premature smolting of hatchery-reared individuals may potentially cause them to miss the natural environmental "window of opportunity" for successful outmigration. This "window of opportunity" (McCormick et al. 1998) is defined by impacts to smolt survival based on a number of physiological and ecological factors. The impact of potential differences in the timing and seasonal distribution of hatchery-reared and wild smolts is complicated by the long history of hatchery supplementation for the species (Holbrook 2007). Collections of outmigrating smolts during the studies used in this white paper assessment (and the resulting models for the NextEra Projects) did not distinguish between hatchery-reared or wild individuals.

Source Water Temperatures:

It has been suggested that rising spring water temperatures may be the key environmental trigger for initiation of outmigration of Atlantic salmon smolts from freshwater systems with the peak of migration occurring at water temperatures of approximately 10°C (Ruggles 1980). Currently, Kennebec River smolts originate in the upper reaches of the Sandy River. Water temperature data recorded by MDMR at three locations (upper Orbeton spawning shoals, Route 4 Bridge, and Old Sandy River dam site) in the Sandy River during 2007 was examined in an attempt to provide support for the seasonal distribution of smolts used in this report (G. Wippelhauser, MDMR, personal communication). Daily average water temperatures (based on 24-hour records) were calculated for the period 23 April – 27 May 2007 at the most upstream (upper Orbeton spawning shoals) and most downstream (Old Sandy River dam site) water temperature sampling sites. Those two sampling sites are separated by approximately 60 miles of river. During 2007, Sandy River water temperatures first hit 10°C in the upper reaches of the river on 24 May. Given the literature-reported peak of smolt migration (10°C; Ruggles 1980) and the temporal occurrence of that peak temperature within the upper reaches of the Sandy River during 2007 , the seasonal distribution of Atlantic salmon smolts at the NextEra Projects of 1.8% during April, 77.0% during May and 21.2% during June seems reasonable. Given the lack of smolt outmigration data from the Sandy and Kennebec Rivers, the models for smolt outmigration presented in this report will rely on the data acquired from other Maine Rivers and described in Section 4.1.

4.2 Kennebec River Flows

Flow duration curves were obtained for the Kennebec River at the Lockwood Project during the months of April, May and June (D. Dow, NOAA, personal communication)[3]. Lockwood Project flow duration curves were based on the flow record for the period 1979 through 2010. A description of the methodology used in the development of these curves can be found in Appendix B of this report. For the purposes of modeling project survival of Atlantic salmon smolts migrating past the Lockwood Project, the median monthly flow condition (i.e. the value with 50% flow exceedence) was used. It is likely that the use of the 50% flow exceedence value will provide a conservative estimate of the percentage of smolts

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[3] The 1979-2010 flow duration curves provided by Don Dow (NOAA) replace the 1978-1998 curves (Merimil 2002) that were used in the April 2011 draft of this paper.

passing via spill (as well as a conservative estimate of whole station survival). Once environmental cues thought to initiate the smolt outmigration period (such as water temperature) are triggered and the smolt migration is underway, it is likely that during years with seasonal pulses of flow greater than the 50% flow exceedence value will pass a greater number of smolts via spill. The median flow condition at the Lockwood Project during April was approximately 13,000 cfs (Figure 3), during May was approximately 9,000 cfs (Figure 4) and during June was approximately 5,500 cfs (Figure 5). Impacts to the model of whole station smolt survival during years of high flow (10 and 25% flow exceedence) and low flow (75 and 90% flow exceedence) are examined in Section 5.1 of this report.

4.3 Smolt Downstream Route Determination

River discharge during the spring migration period will dictate the proportion of Atlantic salmon smolts passed downstream of the Lockwood Project though the spillway (and conversely, through the forebay canal). Determination of the spill effectiveness, defined as the proportion of smolts passed through spill relative to the total number passing the project, is the first step in assessing whole station survival (Figure 2). Spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (i.e., spilling 50% of total river flow results in 50% of smolts passing via the spillway). Although a number of site specific factors may impact spill effectiveness (i.e. project configuration and operations, forebay bathymetry, fish behavior, etc) the 1:1 spill effectiveness assumption has been validated at other hydroelectric projects (Normandeau 2010) and serves as a good initial value for this model.

Verification of the 1:1 assumption was provided through site-specific radio-telemetry studies intended to evaluate Atlantic salmon smolt downstream passage (Normandeau 2008; Normandeau 2011). During the 2007 study, a group of 18 Atlantic salmon smolts were monitored as they passed the Lockwood Project during a period of spill (Kennebec River flows = 11,900 cfs at time of release). Results from that study showed that the disposition of those 18 smolts was as follows: 67% passed over the spillway (or the surface sluice adjacent to the headworks structure) and 33% entered the forebay canal. Based on a Lockwood Project generation of 5,600 cfs and the assumed 1:1 ratio, about 47% of the smolts would have been expected to enter the forebay canal. Although the sample size of field tested smolts is small (and as a result, a single fish carries significant weight), the predicted percentage (47%; 8 of the 18 total smolts) of smolts entering the forebay canal compares favorably to the 33% (6 of the 18 total smolts) observed during the 2007 field season. Similarly, totals of 30 and 32 Atlantic salmon smolts were released upstream of the Lockwood Project during spring 2011 periods of spill (13,603 cfs and 16,731 cfs at time of releases). Results of smolts released at 13,603 cfs were as follows: 43% passed over the spillway (or the surface sluice adjacent to the headworks structure) and 57% entered the forebay canal. Based on a Lockwood Project generation of 5,600 cfs and the assumed 1:1 ratio, about 41% of the smolts would have been expected to enter the forebay canal. The predicted percentage (41%; 12 of the 30 total smolts) of smolts entering the forebay canal is slightly lower than the observed number of smolts (17 of the 30 total smolts) during that test release. In contrast, the results for smolts released at 16,731 cfs were as follows: 100% passed over the spillway (or the surface sluice adjacent to the headworks structure) and 0% entered the forebay canal. Based on a Lockwood Project generation of 5,600 cfs and the assumed 1:1 ratio, about 34% of the smolts would have been expected to enter the forebay canal. The predicted percentage (34%; 11 of the 32 total smolts) of smolts entering the forebay canal is much greater than the observed number of smolts (0 of the 32 total smolts) during that test release.

An overall spill effectiveness for the period April through June of 30.1% was used for the assessment of whole station survival at Lockwood. This value was calculated using a Project capacity of 5,600 cfs, the monthly distribution of Atlantic salmon smolt outmigration for the nearby Penobscot and Narraguagus Rivers (Section 4.1), monthly median Kennebec River flow conditions (Section 4.2) and the assumption of 1:1 spill effectiveness. Table 3 provides a summary of that calculation as well as the monthly values used for the assessment of Lockwood Project spill effectiveness.

4.4 Smolt Downstream Bypass Efficiency

Efficiency of the Lockwood downstream bypass was assessed during spring 2011 (Normandeau 2011). Prior to that study, MLP installed a new downstream fish bypass guidance facility. The new facility consisted of a 300 ft long by 10 ft deep floating guidance boom leading to a 7.0 ft wide by 9.0 ft deep sluice located on the left-hand side of the canal. The floating portion of the boom consisted of "Slick Boom" brand floats connected to a 4.0 ft deep solid membrane with an attached 6.0 ft deep section of 5/16 in dynema netting. Modifications were made to the boom during June 2010 to increase buoyancy, strength and add new screening. The original floats were replaced with "Tuff Boom" brand flotation with attached 4.0 ft deep, 5/16 in metal punch plate panels and 6.0 ft deep, 5/16 in dynema netting attached to the punch plate.

Evaluation of the effectiveness of the new downstream bypass and guidance device at the Lockwood Project for passing Atlantic salmon smolts was conducted during spring 2011 using radio-telemetry (Normandeau 2011). For all radio-tagged Atlantic salmon smolts released into or entering the powerhouse canal, approximately 18.8% passed via the downstream bypass with the remainder (81.2%) passing via the turbine units. During the 2011 study, bypass efficiency varied with changes in the bypass setting (4% vs. 6% of powerhouse flow). A total of 14.3% of radio-tagged salmon smolts passed the Lockwood Project through the downstream bypass when it was set at 4% of powerhouse flow whereas 20.9% of radio-tagged salmon smolts passed through the downstream bypass when it was set at 6% of powerhouse flow. It should also be noted that a percentage of individuals within the Lockwood forebay canal were within close proximity to the downstream bypass prior to turbine passage. Overall, 38.5% of radio-tagged smolts passing Lockwood via the turbine units were initially detected in the vicinity of the downstream bypass. When examined by setting, 11.1% (2 of 18) of smolts present in the canal with the bypass set at 4% and 52.9% (18 of 34) of smolts present in the canal with the bypass set at 6% were detected in the vicinity of the downstream bypass prior to turbine passage.

4.5 Smolt Spillway and Downstream Bypass Passage Survival Assessment

The Lockwood Project spillway sections dam 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. The west spillway extends about 650 ft from the small island in a southwesterly direction to the forebay canal headworks, which extend to the west bank of the river. Each spillway has 15 in high flashboards. In addition, there are three orifices in the flashboards (3 ft wide by 8 in high) placed annually at locations along the spillway.

As the principal causes of injury and mortality for fish passed through either a spillway or bypass sluice are similar (Heisey et al. 1996) empirical studies related to spillway and bypass survival were pooled into a single data set. Injury/scale loss rates for Atlantic salmon smolt test and control fish released through sluices and bypasses at five different hydroelectric projects are presented in Table 4. Initial (1-hr) injury rates were available at all five projects and for test fish varied widely from 0% to 59% (average 18.4%) while those for control fish ranged from 0% to 4%. When initial (1-hr) test fish injuries from each of the five locations were pooled (Table 5), bruising/hemorrhaging had the greatest frequency of occurrence, being noted on 47.7% of individual smolts with injuries (10.9% of all individuals examined). Minor scale loss (<25% of body), major scale loss (>25% scale loss) and lacerations/tears were noted on 42.1%, 22.4%, and 8.4%, respectively of the individual smolts with injuries (9.6%, 5.1%, and 1.9%, respectively, of all individuals examined). Delayed (48-hr) injury rates were available at three of the five projects and for both test and control fish varied from 0% to 18% (average 6.0%). When delayed (48-hr) test fish injuries from each of the three locations were pooled (Table 5), minor scale loss (<25% of body) had the greatest frequency of occurrence, being noted on 85.7% of individual smolts with injuries (6.1% of all individuals examined). Bruising/hemorrhaging was noted on 14.3% of the individual smolts with injuries (1.0% of all individuals examined). Note that multiple injury types could be assigned to a single individual during each of the studies included in Tables 4 and 5.

Table 6 presents the measured initial (1-hr) and delayed (48-hr) survival for Atlantic salmon smolts passed through sluices and bypasses at five different hydroelectric projects. Selection of studies was limited to only those using the Hi-Z balloon tag method so that survival estimates were based solely on direct impacts from passage through the spill and not from indirect effects such as predation. Survival data collected from efficiency or fish movement studies do not represent actual Project survival and as a result, were not used in this analysis. Immediate survival (1-hr) estimates for Atlantic salmon smolts following passage through sluiceways and bypasses ranged from 93.3 to 100.0%, resulting in a mean overall spill survival of 97.1%. Delayed survival (48-hr) estimates for Atlantic salmon smolts following passage through sluiceways and bypasses ranged from 91.1 to 100.0%, resulting in a mean overall spill survival of 96.3%.

Although the study design (Normandeau 2008) was not intended to assess Project survival, support for the spillway and bypass smolt survival rates derived from Hi-Z balloon tag studies is provided by observations of a limited number (N=18) of radio-tagged Atlantic salmon smolts which passed the Lockwood Project via the spillway or surface sluice during 2007. Based on post-passage movements, none of those individuals were determined to have suffered mortality during passage. Additionally, a review of 17 different spillway and sluice Hi-Z balloon tag studies conducted by Franke et al. (1997) reported an average immediate survival (1-hr) of 97.2%. That review included studies conducted for Atlantic salmon, Chinook salmon, American shad and blueback herring.

4.6 Smolt Entrainment Rates and Turbine Passage Survival Assessment

The Lockwood powerhouse contains a total of seven generating units (six vertical Francis and one horizontal Kaplan) and has a total Project generating capacity of 6.915 MW. The maximum capacity (cfs) for each unit is presented in Table 7 and ranges from 666-721 cfs for the six vertical Francis units and is 1,689 cfs for the horizontal Kaplan unit. Total unit flow for the Project is approximately 5,600 cfs. Normal operating head for the Lockwood Project is 21 ft. The trash racks screening the intakes are 2 in spacing in front of Units 1-6 and 3.5 in spacing in front of Unit 7. Additional turbine characteristics for Lockwood Units 1 through 7 are provided in Table 7.

4.6.1 Turbine Entrainment Rates

Additional information collected during a spring 2007 study intended to evaluate the effectiveness of the previous downstream bypass at the Lockwood Project provided some data relative to turbine passage for radio-tagged Atlantic salmon smolts (Normandeau 2008). During that study, a total of 37 smolts moved downstream through the Project turbines and passage distribution for those migrants was 5.4% through Unit 1, 13.5% through Unit 2, 2.7% through Unit 3, 5.4% through Unit 4, 2.7% through Unit 5, 2.7%

through Unit 6 and 67.6% through Unit 7. Overall, 33.4% of salmon smolts that did not pass on spillage were entrained through the Francis units (Units 1-6) whereas 67.6% were entrained through the Kaplan unit (Unit 7).

4.6.2 Empirical Estimates of Turbine Passage Survival

Although existing information for turbine passage survival for Kaplan, propeller and Francis turbines is extensive (e.g. Franke et al. 1997, EPRI 1997), studies specific to the passage of Atlantic salmon are not as plentiful. Injury/scale loss rates for Atlantic salmon smolt test and control fish having passed through Kaplan, propeller or Francis turbines at eleven different hydroelectric projects are presented in Table 8. Smolts recaptured during Normandeau turbine tag studies were assessed for scale loss and injuries following their initial recapture. Individuals were then held for a 48-hr period after which any incidence of latent mortality was recorded. Initial (1-hr) injury rates for test fish varied widely from 0% to 30.8% (Kaplan average = 7.5%; Francis average = 23.8%) while those for control fish ranged from 0% to 2%. When initial (1-hr) test fish injuries from each of the studies involving Kaplan units were pooled (Table 9), mechanical related injuries such as severed body/back bone, bruised head/body, and operculum/gill damage had the highest frequency of occurrence, being noted on 28.9%, 20.6%, and 15.5% of individual smolts with injuries (2.1%, 1.5%, and 1.1%, respectively, of all individuals examined). Smolts displaying a loss of equilibrium (i.e. dazed) had a 25.8% frequency of occurrence in smolts injured passing through Kaplan units (1.8% of all individuals examined following Kaplan passage).

When initial (1-hr) test fish injuries from each of the studies involving Francis units were pooled (Table 9), incidences of severed body/back bone and minor scale loss (<25%) had the highest frequency of occurrence, being noted on 31.3%, and 18.8% of individual smolts with injuries (7.9%, and 4.8%, respectively, of all individuals examined) having passed through a Francis unit. Smolts displaying a loss of equilibrium (i.e. dazed) had a 43.8% frequency of occurrence in smolts injured passing through Francis units (11.1% of all individuals examined following Francis passage). Note that multiple injury types could be assigned to a single individual during each of the studies included in Tables 8 and 9.

Tables 10 and 11 present the initial (1-hr) and delayed (48-hr) survival rates and basic Project characteristics for turbine passage survival studies conducted to evaluate turbine survival for Atlantic salmon smolts passing though Francis units (Table 10) and Kaplan/propeller units (Table 11). Selection of studies was limited to only those using the Hi-Z balloon tag method so that estimates were based solely on direct impacts from passage through a turbine unit. Survival data collected from efficiency or fish movement studies do not represent actual Project survival and as a result, were not used in this analysis. Additional study-specific information related to each study presented in Tables 10 and 11 is presented in Appendix A of this report.

Francis:

Previously conducted studies evaluating the survival of Atlantic salmon smolts passed through Francis turbines are limited. Results for two different studies conducted at two different hydroelectric projects are presented in Table 10. Initial survival (1-hr) estimates for Atlantic salmon smolt survival from individual tests (N=2) for Francis units ranged from 85.0 to 85.1%, resulting in a mean overall survival of 85.1%. Delayed survival (~48-hr) estimates for Atlantic salmon smolts from individual tests (N=2) following passage through Francis units ranged from 85.0 to 85.1%, resulting in a mean overall delayed survival of 85.1%.

Kaplan:

A greater number of passage survival studies conducted on Atlantic salmon smolts passing through Kaplan and propeller turbines exist than are available for Francis units. Results for eleven different studies conducted at eleven different hydroelectric projects are presented in Table 11. Initial survival (1-hr) estimates of Atlantic salmon smolt survival from individual tests (N=15) for Kaplan/propeller units ranged from 88.0 to 100.0%, resulting in a mean overall survival of 94.7%. Delayed survival (~48-hr) estimates for Atlantic salmon smolts from individual tests (N=15) following passage through Kaplan units ranged from 87.5 to 100.0%, resulting in a mean overall delayed survival of 92.8%.

4.6.3 Modeled Estimates of Turbine Passage Survival

Survival estimates for turbine passage were generated for the single Kaplan and six Francis units in operation at Lockwood. Estimates were calculated for five body lengths considered representative of the range of total length for outmigrating Atlantic salmon smolts (5, 6, 7, 8, and 9 inches). Two correlation factors (λ) were used in this analysis (0.1 and 0.2). Franke et al. (1997) recommended the value for the correlation factor be within the range of 0.1 to 0.2 based on a review of empirical results associated with a substantial number of salmonid survival studies. Survival estimates for Lockwood units 1-7 were modeled using the maximum turbine discharge (cfs) and the associated efficiency. The maximum turbine discharges were selected for use in the model under the assumption that the Project would be in full operation during the spring period of high seasonal river flow.

Francis:

Model runs for five body lengths and two correlation factors resulted in a total of 10 survival estimates which are likely to bracket the actual survival for salmon smolts passing through Francis units 1-6 at the Lockwood Project. Predicted survival values for salmon smolts passing through the Lockwood Francis units ranged from a high value of 91.6% for a five inch smolt to a low value of 68.8% for a nine inch smolt (Table 12). The range of survival estimates were similar for Francis Units 1-6 and the predicted survival probability increased as smolt body length decreased. The average survival of salmon smolts passing through the Francis units at Lockwood was determined by averaging the 10 modeled survival estimates for each unit. Those values ranged from a high of 82.5% at Unit 1 to a low of 81.8% at Unit 5 with an overall calculated mean survival of 82.0% for all Lockwood Francis units combined.

Kaplan:

Model runs for five body lengths, two correlation factors and three *r* values resulted in a total of 30 survival estimates which likely bracket the actual survival for salmon smolts passing through the Kaplan unit at Lockwood (Unit 7). The three *r* values represent the point along the runner radius that the fish enters the turbine. Values for *r* used in this assessment were 0.1, 0.5, and 0.9% of the runner radius.

Predicted survival values for salmon smolts passing through the Kaplan unit (Unit 7) at Lockwood ranged from a high of 97.9% for a five inch smolt to a low of 73.0% for a nine inch smolt (Table 13). Predicted survival probabilities increased as smolt body length and entry point proximity to the turbine hub decreased. The average survival of salmon smolts passing through the Kaplan unit at Lockwood was determined by averaging the 30 modeled survival estimates for each combination of fish length, entry point and λ. The calculated mean survival for the Lockwood Kaplan unit was 91.6%.

4.6.4 Comparison of Modeled and Empirical Passage Survival

Francis:

Initial (1-hr) and delayed (48-hr) survival estimates for Francis turbines obtained from empirical data collected at other hydroelectric projects were compared with the predictive models developed specifically for the Lockwood Project Units 1-6. As expected, the average modeled survival rate for Lockwood Francis units (82.0%) was most similar to empirical data collected from other smaller-sized Francis units (as indicated by runner diameter) than empirical data collected from larger Francis units. Turbines characterized by narrower water passage areas (as defined by small runner diameter and/or more runner blades) relative to fish size pose greater risks associated with mechanical damage to a fish (Franke et al. 1997).

Kaplan:

Initial (1-hr) and delayed (48-hr) survival estimates for Kaplan turbines obtained from empirical data collected at other hydroelectric projects were compared with the predictive model developed specifically for the Lockwood Project Unit 7. As expected, the average modeled survival rate for the Lockwood Kaplan unit (91.6%) was within the range (87.5-100.0%) of delayed empirical survival estimates for Kaplan turbines at other hydroelectric projects.

5.0 Estimated Project Impact on Outmigrating Atlantic salmon Smolts

5.1 Modeled Estimate of Whole Station Survival for Smolts

Whole station survival for the Lockwood Project was estimated by integrating Kennebec River flows, Project operating flows, the proportion of smolts diverted towards the spillway and forebay canal, spillway survival rate (as estimated from empirical data), turbine passage survival rates (as estimated through a combination of empirical and modeled data), site specific fish bypass guidance efficiency (Normandeau 2008), and fish bypass passage survival rate (as estimated from empirical data). Four models intended to estimate whole station survival of smolts passing the Lockwood Project were constructed using the available empirical and modeled survival estimates for both spill and turbine passage. The four individual models were:

1) Initial Survival Rate Model (Model A): Spill survival based on 1-hr empirical survival data and Kaplan and Francis turbine survival based on 1-hr empirical survival data
2) Delayed Survival Rate Model (Model B): Spill survival based on 48-hr empirical survival data and Kaplan and Francis turbine survival based on 48-hr empirical survival data
3) Delayed/Calculated Survival Rate Model (Model C): Spill survival based on 48-hr empirical survival data and Kaplan and Francis turbine survival based Franke estimates
4) Initial Injury Rate Model (Model D): survival based on 1-hr empirical injury data and Kaplan and Francis turbine survival based on 1-hr empirical injury data

5.1.1 Whole Station Smolt Survival Modeled Using Initial Survival Rates

The Model A whole station smolt survival estimate was generated using initial (1-hr) survival rates for spill and turbine passed fish obtained from empirical data collected at other hydroelectric projects. The following values for each of the necessary model parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in this calculation of whole station survival for salmon smolts at Lockwood Project:

- Kennebec River Flow – monthly medians of 13,000 cfs (April), 9,000 cfs (May) and 5,500 cfs (June);
- Project operating flow – 5,600 cfs (Merimil 2002);
- Proportion of salmonid smolts diverted – utilized a ratio of 1:1 fish to river flow and was corroborated by the recent radio-tagging conducted at Lockwood (Normandeau 2008; Normandeau 2011);
- Project spillway survival – 97.1% (based on review of initial (1-hr) empirical survival data from other hydroelectric projects);
- Fish bypass guidance efficiency – 18.8% for Atlantic salmon smolts (Normandeau 2011);
- Entrainment rate through turbines – used site specific turbine entrainment rates (Normandeau 2008) ;
- Kaplan turbine passage survival – 94.7% (based on review of initial (1-hr) empirical survival data from other hydroelectric projects);

- Francis turbine passage survival – 85.1% (based on review of initial (1-hr) empirical survival data from other hydroelectric projects);
- Fish bypass system survival – 97.1% (based on review of initial (1-hr) empirical survival data from other hydroelectric projects).

The integration of the above values is illustrated in Figure 7 for a hypothetical case of 1,000 Atlantic salmon smolts approaching the Lockwood Project during the spring migration period (April-June). The Model A whole station survival estimate for Atlantic salmon smolts passing the Lockwood Project generated using initial (1-hr) empirical data for spillway and turbine survival estimates is 94%[4].

5.1.1.1 Impacts to Estimated Smolt Survival Associated with Bypass Efficiency Assumption

The Initial Survival Rate Model (Model A) for Lockwood can be easily manipulated to provide insight into potential impacts to whole station survival based on modifying the various input parameters. Model A was generated using a fish bypass guidance efficiency rate of 18.8% which was the average value obtained during field studies conducted at Lockwood with the bypass set at 4% and 6% of powerhouse flow (Normandeau 2011). When only trials with the bypass facility set at 4% of powerhouse flow are considered, the bypass efficiency rate at Lockwood was determined to be 14.3% (Normandeau 2011) and the whole station survival estimate (Model A) for Atlantic salmon smolts remained at 94%. When only trials with the bypass facility set at 6% of powerhouse flow are considered, the bypass efficiency rate at Lockwood was determined to be 20.9% (Normandeau 2011) and the whole station survival estimate (Model A) for Atlantic salmon smolts remained at 94%. Increased effectiveness of the downstream bypass would reduce the impact of turbine passage on outmigrating smolts and should increase whole station survival. Table 14 provides whole station survival estimates for a range of theoretical bypass efficiency rates. Theoretical bypass effectiveness rates between 25 and 100% were modeled and produced a range of whole station survival estimates for outmigrating Atlantic salmon smolts between 94% and 97%.

5.1.1.2 Impacts to Estimated Smolt Survival Associated with Seasonal Distribution Assumption

In cases with no site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (e.g., spilling 50% of total river flow results in 50% of smolts passing via the spillway). A basic implication of the deviation from the 1:1 assumption is that if a proportionally smaller percentage of smolts relative to the river flow enter the Project forebay then the calculated station-related smolt survival would be higher. Under these conditions, a greater percentage of smolts would pass the project via spill and would avoid impacts associated with turbine passage. Alternatively, if a proportionally higher percentage of smolts are entering the station forebay than the calculated station related smolt survival would be lower. Under these conditions, a lower percentage of smolts would pass the project via spill and a greater number would be entrained through the Project turbines.

The sensitivity of the Initial Survival Rate Model (Model A) associated with deviation from the assumed 1:1 ratio of fish to flow at the Lockwood Project is presented in Table 15. A range of spill effectiveness rates for Atlantic salmon smolts from 10% (0.3:1) to 90% (3:1) were evaluated. For conditions where a proportionately lower percentage of smolts relative to river flow entered the forebay canal (i.e. spill effectiveness rates of 50, 60, 70, 80, and 90%), the estimates for whole station survival were greater than

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[4] Whole station survival estimates are reported to the nearest whole percentage so as to not overstate the accuracy of these models. This was done following comments made at the Technical Advisory Committee meeting held on 7 September 2011.

that observed under the assumption of 1:1 spill effectiveness and ranged from 95% to 97%. For conditions where a proportionately higher or nearly equally percentage of smolts relative to river flow entered the forebay canal (i.e. spill effectiveness rates of 10, 20, 30, and 40%), the estimates for whole station survival were lower than or equal to that observed under the assumption of 1:1 spill effectiveness.

5.1.1.3 Impacts to Estimated Smolt Survival Associated with Seasonal Flow Assumption

The Initial Survival Rate Model (Model A) for Lockwood was constructed using the assumption of median Kennebec River flows (i.e. 50% exceedence) during the months of April, May and June. Two "low flow" conditions (75 and 90% exceedence) and two "high flow" conditions (10 and 25% exceedence) were also examined. Estimated monthly Kennebec River flows for the months of April, May and June under the 10, 25, 75, and 90% exceedence conditions are presented in Table 16. Table 17 presents the modeled whole station survival estimates for downstream migrating Atlantic salmon smolts under the additional low and high flow conditions. Under the low flow conditions (i.e. those exceeded 75 and 90 % of the time) the estimated whole station survival for salmon smolts at the Lockwood Project decreased to 93%. Under the high flow conditions (i.e. those exceeded only 10 or 25% of the time) the estimated whole station survival for salmon smolts at the Lockwood Project increased to 96% and 95%, respectively.

5.1.2 Whole Station Smolt Survival Modeled Using Delayed Survival Rates

The Model B whole station smolt survival estimate was generated using delayed (48-hr) survival rates for spill and turbine passed fish obtained from empirical data collected at other hydroelectric projects. The following values for each of the necessary model parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in this calculation of whole station survival for salmon smolts at Lockwood Project:

- Kennebec River Flow – monthly medians of 13,000 cfs (April), 9,000 cfs (May) and 5,500 cfs (June);
- Project operating flow – 5,600 cfs (Merimil 2002);
- Proportion of salmonid smolts diverted – utilized a ratio of 1:1 fish to river flow and was corroborated by the recent radio-tagging conducted at Lockwood (Normandeau 2008; Normandeau 2011);
- Project spillway survival – 96.3% (based on review of delayed (48-hr) empirical survival data from other hydroelectric projects);
- Fish bypass guidance efficiency – 18.8% for Atlantic salmon smolts (Normandeau 2011);
- Entrainment rate through turbines – used site specific turbine entrainment rates (Normandeau 2008) ;
- Kaplan turbine passage survival – 92.8% (based on review of delayed (48-hr) empirical survival data from other hydroelectric projects);
- Francis turbine passage survival – 85.1% (based on review of delayed (48-hr) empirical survival data from other hydroelectric projects);
- Fish bypass system survival – 96.3% (based on review of delayed (48-hr) empirical survival data from other hydroelectric projects).

The integration of the above values is illustrated in Figure 8 for a hypothetical case of 1,000 Atlantic salmon smolts approaching the Lockwood Project during the spring migration period (April-June). The

Model B whole station survival estimate for Atlantic salmon smolts passing the Lockwood Project generated using delayed (48-hr) empirical data for spillway and turbine survival estimates is 93%.

5.1.2.1 Impacts to Estimated Smolt Survival Associated with Bypass Efficiency Assumption

The Delayed Survival Model (Model B) for Lockwood can be manipulated to provide insight into potential impacts to whole station survival based on modifying the various input parameters. Model B was generated using a fish bypass guidance efficiency rate of 18.8% which was the average value obtained during field studies conducted at Lockwood with the bypass set at 4% and 6% of powerhouse flow (Normandeau 2011). When only trials with the bypass facility set at 4% of powerhouse flow are considered, the bypass efficiency rate at Lockwood was determined to be 14.3% (Normandeau 2011) and the whole station survival estimate (Model B) for Atlantic salmon smolts remained at 93%. When only trials with the bypass facility set at 6% of powerhouse flow are considered, the bypass efficiency rate at Lockwood was determined to be 20.9% (Normandeau 2011) and the whole station survival estimate (Model B) for Atlantic salmon smolts remained at 93%. Increased effectiveness of the downstream bypass would reduce the impact of turbine passage on outmigrating smolts and should increase whole station survival. Table 18 provides whole station survival estimates for a range of theoretical bypass efficiency rates. Theoretical bypass effectiveness rates between 25 and 100% were modeled and produced a range of whole station survival estimates for outmigrating Atlantic salmon smolts between 93% and 96%.

5.1.2.2 Impacts to Estimated Smolt Survival Associated with Seasonal Distribution Assumption

In cases with no site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (e.g., spilling 50% of total river flow results in 50% of smolts passing via the spillway). A basic implication of the deviation from the 1:1 assumption is that if a proportionally smaller percentage of smolts relative to the river flow enter the Project forebay then the calculated station-related smolt survival would be higher. Under these conditions, a greater percentage of smolts would pass the project via spill and would avoid impacts associated with turbine passage. Alternatively, if a proportionally higher percentage of smolts are entering the station forebay than the calculated station related smolt survival would be lower. Under these conditions, a lower percentage of smolts would pass the project via spill and a greater number would be entrained through the Project turbines.

The sensitivity of the Delayed Survival Model (Model B) associated with deviation from the assumed 1:1 ratio of fish to flow at the Lockwood Project is presented in Table 19. A range of spill effectiveness rates for Atlantic salmon smolts from 10% (0.3:1) to 90% (3:1) were evaluated. For conditions where a proportionately lower percentage of smolts relative to river flow entered the forebay canal (i.e. spill effectiveness rates of 50, 60, 70, 80, and 90%), the estimates for whole station survival were greater than that observed under the assumption of 1:1 spill effectiveness and ranged from 94% to 96%. For conditions where a proportionately higher or nearly equal percentage of smolts relative to river flow entered the forebay canal (i.e. spill effectiveness rates of 10, 20, 30, and 40%), the estimates for whole station survival were lower than or equal to that observed under the assumption of 1:1 spill effectiveness.

5.1.2.3 Impacts to Estimated Smolt Survival Associated with Seasonal Flow Assumption

The Delayed Survival Model (Model B) for Lockwood was constructed using the assumption of median Kennebec River flows (i.e. 50% exceedence) during the months of April, May and June. Two “low flow” conditions (75 and 90% exceedence) and two “high flow” conditions (10 and 25% exceedence) were also examined. Estimated monthly Kennebec River flows for the months of April, May and June under the 10, 25, 75, and 90% exceedence conditions are presented in Table 16. Table 20 presents the modeled whole station survival estimates for downstream migrating Atlantic salmon smolts under the additional low and high flow conditions. Under the low flow conditions (i.e. those exceeded 75 and 90 % of the time) the estimated whole station survival for salmon smolts at the Lockwood Project decreased to 92% and 91%, respectively. Under the high flow conditions (i.e. those exceeded only 10 or 25% of the time) the estimated whole station survival for salmon smolts at the Lockwood Project increased to 94% and 94%, respectively.

5.1.3 Whole Station Smolt Survival Modeled Using Delayed/Calculated Survival Rates

The Model C whole station smolt survival estimate was generated using delayed (48-hr) survival rates for spill obtained from empirical data collected at other hydroelectric projects in conjunction with modeled estimates of turbine passed fish obtained using the Franke (Franke et al. 1997) formula. The following values for each of the necessary model parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in this calculation of whole station survival for salmon smolts at Lockwood Project:

- Kennebec River Flow – monthly medians of 13,000 cfs (April), 9,000 cfs (May) and 5,500 cfs (June);
- Project operating flow – 5,600 cfs (Merimil 2002);
- Proportion of salmonid smolts diverted – utilized a ratio of 1:1 fish to river flow and was corroborated by the recent radio-tagging conducted at Lockwood (Normandeau 2008; Normandeau 2011);
- Project spillway survival – 96.3% (based on review of delayed (48-hr) empirical survival data from other hydroelectric projects);
- Fish bypass guidance efficiency – 18.8% for Atlantic salmon smolts (Normandeau 2011);
- Entrainment rate through turbines – used site specific turbine entrainment rates (Normandeau 2008) ;
- Kaplan turbine passage survival – 91.6% (based on modeled values generated using site-specific turbine parameters);
- Francis turbine passage survival – 82.0% (based on modeled values generated using site-specific turbine parameters);
- Fish bypass system survival – 96.3% (based on review of delayed (48-hr) empirical survival data from other hydroelectric projects).

The integration of the above values is illustrated in Figure 9 for a hypothetical case of 1,000 Atlantic salmon smolts approaching the Lockwood Project during the spring migration period (April-June). The Model C whole station survival estimate for Atlantic salmon smolts passing the Lockwood Project generated using delayed (48-hr) empirical data for spillway survival and site-specific modeled data for turbine survival estimates is 92%.

5.1.3.1 Impacts to Estimated Smolt Survival Associated with Bypass Efficiency Assumption

The Delayed/Calculated Survival Model (Model C) for Lockwood can be manipulated to provide insight into potential impacts to whole station survival based on modifying the various input parameters. Model C was generated using a fish bypass guidance efficiency rate of 18.8% which was the average value obtained during field studies conducted at Lockwood in 2011 with the bypass set at 4% and 6% of powerhouse flow (Normandeau 2011). When only trials with the bypass facility set at 4% of powerhouse flow are considered, the bypass efficiency rate at Lockwood was determined to be 14.3% (Normandeau

2011) and the whole station survival estimate (Model C) for Atlantic salmon smolts remained at 92%. When only trials with the bypass facility set at 6% of powerhouse flow are considered, the bypass efficiency rate at Lockwood was determined to be 20.9% (Normandeau 2011) and the whole station survival estimate (Model C) for Atlantic salmon smolts remained at 92%. Increased effectiveness of the downstream bypass would reduce the impact of turbine passage on outmigrating smolts and should increase whole station survival. Table 21 provides whole station survival estimates for a range of theoretical bypass efficiency rates. Theoretical bypass effectiveness rates between 25 and 100% were modeled and produced a range of whole station survival estimates for outmigrating Atlantic salmon smolts between 92% and 96%.

5.1.3.2 Impacts to Estimated Smolt Survival Associated with Seasonal Distribution Assumption

In cases with no site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (e.g., spilling 50% of total river flow results in 50% of smolts passing via the spillway). A basic implication of the deviation from the 1:1 assumption is that if a proportionally smaller percentage of smolts relative to the river flow enter the Project forebay then the calculated station-related smolt survival would be higher. Under these conditions, a greater percentage of smolts would pass the project via spill and would avoid impacts associated with turbine passage. Alternatively, if a proportionally higher percentage of smolts are entering the station forebay than the calculated station related smolt survival would be lower. Under these conditions, a lower percentage of smolts would pass the project via spill and a greater number would be entrained through the Project turbines.

The sensitivity of the Delayed/Calculated Survival Model (Model C) associated with deviation from the assumed 1:1 ratio of fish to flow at the Lockwood Project is presented in Table 22. A range of spill effectiveness rates for Atlantic salmon smolts from 10% (0.3:1) to 90% (3:1) were evaluated. For conditions where a proportionately lower percentage of smolts relative to river flow entered the forebay canal (i.e. spill effectiveness rates of 50, 60, 70, 80, and 90%), the estimates for whole station survival were greater than that observed under the assumption of 1:1 spill effectiveness and ranged from 93% to 96%. For conditions where a proportionately higher or nearly equal percentage of smolts relative to river flow entered the forebay canal (i.e. spill effectiveness rates of 10, 20, 30 and 40%), the estimates for whole station survival were lower than or equal to that observed under the assumption of 1:1 spill effectiveness.

5.1.3.3 Impacts to Estimated Smolt Survival Associated with Seasonal Flow Assumption

The Delayed/Calculated Survival Model (Model C) for Lockwood was constructed using the assumption of median Kennebec River flows (i.e. 50% exceedence) during the months of April, May and June. Two “low flow” conditions (75 and 90% exceedence) and two “high flow” conditions (10 and 25% exceedence) were also examined. Estimated monthly Kennebec River flows for the months of April, May and June under the 10, 25, 75, and 90% exceedence conditions are presented in Table 16. Table 23 presents the modeled whole station survival estimates for downstream migrating Atlantic salmon smolts under the additional low and high flow conditions. Under the low flow conditions (i.e. those exceeded 75 and 90 % of the time) the estimated whole station survival for salmon smolts at the Lockwood Project decreased to 90%. Under the high flow conditions (i.e. those exceeded only 10 or 25% of the time) the estimated whole station survival for salmon smolts at the Lockwood Project increased to 94%.

5.1.4 Whole Station Smolt Survival Modeled Using Initial Injury Rates

The Model D whole station smolt survival estimate was generated using initial (1-hr) injury rates for spill and turbine passed fish obtained from empirical data collected at other hydroelectric projects.

Comparisons of initial injury assessment and delayed survival rates for Atlantic salmon smolts subjected to mark-recapture spill and turbine passage studies suggest that not all injuries sustained by smolts during dam passage will result in mortality. However, for the purposes of this analysis, it was assumed that any fish subjected to an injury (regardless of the magnitude of that injury) suffered mortality. Model D was intended to provide a "worst case" scenario for Atlantic salmon smolts passing the Lockwood Project. The following values for each of the necessary model parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in this calculation of whole station survival for salmon smolts at Lockwood Project:

- Kennebec River Flow – monthly medians of 13,000 cfs (April), 9,000 cfs (May) and 5,500 cfs (June);
- Project operating flow – 5,600 cfs (Merimil 2002);
- Proportion of salmonid smolts diverted – utilized a ratio of 1:1 fish to river flow and was corroborated by the recent radio-tagging conducted at Lockwood (Normandeau 2008; Normandeau 2011);
- Project spillway survival – 81.6% (based on review of initial (1-hr) empirical injury data from other hydroelectric projects used as a surrogate for survival);
- Fish bypass guidance efficiency – 18.8% for Atlantic salmon smolts (Normandeau 2011);
- Entrainment rate through turbines – used site specific turbine entrainment rates (Normandeau 2008) ;
- Kaplan turbine passage survival – 92.5% (based on review of initial (1-hr) empirical injury data from other hydroelectric projects used as a surrogate for survival);
- Francis turbine passage survival – 76.2% (based on review of initial (1-hr) empirical injury data from other hydroelectric projects used as a surrogate for survival);
- Fish bypass system survival – 81.6% (based on review of initial (1-hr) empirical injury data from other hydroelectric projects used as a surrogate for survival).

The integration of the above values is illustrated in Figure 10 for a hypothetical case of 1,000 Atlantic salmon smolts approaching the Lockwood Project during the spring migration period (April-June). The Model D whole station survival estimate for Atlantic salmon smolts passing the Lockwood Project generated using initial (1-hr) empirical injury data as a surrogate for spillway and turbine survival estimates is 85%.

5.1.4.1 Impacts to Estimated Smolt Survival Associated with Bypass Efficiency Assumption

The Initial Injury Rate Model (Model D) for Lockwood can be manipulated to provide insight into potential impacts to whole station survival based on modifying the various input parameters. Model D was generated using a fish bypass guidance efficiency rate of 18.8% which was the average value obtained during field studies conducted at Lockwood with the bypass set at 4% and 6% of powerhouse flow (Normandeau 2011). When only trials with the bypass facility set at 4% of powerhouse flow are considered, the bypass efficiency rate at Lockwood was determined to be 14.3% (Normandeau 2011) and the whole station survival estimate (Model D) for Atlantic salmon smolts remained at 85%. When only trials with the bypass facility set at 6% of powerhouse flow are considered, the bypass efficiency rate at Lockwood was determined to be 20.9% (Normandeau 2011) and the whole station survival estimate (Model D) for Atlantic salmon smolts remained at 85%. Increased effectiveness of the downstream bypass would reduce the impact of turbine passage on outmigrating smolts and should increase whole station survival. Table 24 provides whole station survival estimates for a range of theoretical bypass efficiency rates. Theoretical bypass effectiveness rates between 25 and 100% were modeled and produced a range of whole station survival estimates for outmigrating Atlantic salmon smolts between 85% and 82%.

5.1.4.2 Impacts to Estimated Smolt Survival Associated with Seasonal Distribution Assumption

In cases with no site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (e.g., spilling 50% of total river flow results in 50% of smolts passing via the spillway). A basic implication of the deviation from the 1:1 assumption is that if a proportionally smaller percentage of smolts relative to the river flow enter the Project forebay then the calculated station-related smolt survival would be higher. Under these conditions, a greater percentage of smolts would pass the project via spill and would avoid impacts associated with turbine passage. Alternatively, if a proportionally higher percentage of smolts are entering the station forebay than the calculated station related smolt survival would be lower. Under these conditions, a lower percentage of smolts would pass the project via spill and a greater number would be entrained through the Project turbines.

The sensitivity of the Initial Injury Rate Model (Model D) associated with deviation from the assumed 1:1 ratio of fish to flow at the Lockwood Project is presented in Table 25. A range of spill effectiveness rates for Atlantic salmon smolts from 10% (0.3:1) to 90% (3:1) were evaluated. For conditions where a proportionately lower percentage of smolts relative to river flow entered the forebay canal (i.e. spill effectiveness rates of 40, 50, 60, 70, 80, and 90%), the estimates for whole station survival were lower than that observed under the assumption of 1:1 spill effectiveness and ranged from 84% to 82%. For conditions where a proportionately higher percentage of smolts relative to river flow entered the forebay canal (i.e. spill effectiveness rates of 10% and 20%), the estimates for whole station survival were greater than that observed under the assumption of 1:1 spill effectiveness and were 86% and 85%, respectively.

5.1.4.3 Impacts to Estimated Smolt Survival Associated with Seasonal Flow Assumption

The Initial Injury Rate Model (Model D) for Lockwood was constructed using the assumption of median Kennebec River flows (i.e. 50% exceedence) during the months of April, May and June. Two “low flow” conditions (75 and 90% exceedence) and two “high flow” conditions (10 and 25% exceedence) were also examined. Estimated monthly Kennebec River flows for the months of April, May and June under the 10, 25, 75, and 90% exceedence conditions are presented in Table 16. Table 26 presents the modeled whole station survival estimates for downstream migrating Atlantic salmon smolts under the additional low and high flow conditions. Under the low flow conditions (i.e. those exceeded 75 and 90 % of the time) the estimated whole station survival for salmon smolts at the Lockwood Project increased to 86%. Under the high flow conditions (i.e. those exceeded only 10 or 25% of the time) the estimated whole station survival for salmon smolts at the Lockwood Project decreased to 83% and 84%, respectively.

5.2 Summary of Modeled Estimate of Whole Station Survival for Smolts

Four models of whole station survival of Atlantic salmon smolts at the Lockwood Project were constructed using available empirical and modeled survival rates for passage via spill and through turbine units. The primary estimates of whole station survival generated by those four models ranged from 94% to 85% with modifications during the various sensitivity analyses expanding those bounds to 97% and 82%. Use of initial (1-hr) empirical spill and turbine survival data (Model A, the Initial Survival Rate Model) from other hydroelectric projects yielded the highest estimate of whole station smolt survival. Model D, the Initial Injury Rate Model (using 1-hr empirical spill and turbine injury rates as a surrogate for survival) produced the lowest estimate of whole station smolt survival. Model D was constructed under the assumption that any fish subjected to an injury (regardless of the magnitude of that injury) suffered mortality. It should be noted that comparisons of initial injury assessment and delayed survival rates for Atlantic salmon smolts subjected to mark-recapture spill and turbine passage studies suggest that not all injuries sustained by smolts during dam passage will result in mortality. In addition, the sensitivity analyses for Model D showed an increase in whole station survival as a greater proportion of smolts were passed via turbine units. This was due to the relatively low survival rate (81.6%) when empirical injury data collected at other hydroelectric projects for spill passed salmon smolts was used as a surrogate for survival. The majority of injuries observed for Atlantic salmon smolts passed via spill (Table 5) were minor scale loss and bruising/hemorrhaging. Although some studies have suggested that descaling of smolts may reduce performance and decrease survival during migration (Gadomski et al. 1994; Zydlewski et al. 2010), another study has suggested that the required time (in freshwater) for a smolt to recover from a loss of scales that would be lethal in saltwater is within one day (Bouck and Smith 1979). While injuries to smolts passed via spill and turbines will lead to mortality for a percentage of individuals, it is likely that Model D, the Initial Injury Rate model (using 1-hr injury rates as a surrogate for survival), underestimates whole station smolt survival at Lockwood. Model C, the Delayed/Calculated Survival Rate Model provides the most conservative and reliable estimate of whole station smolt survival at Lockwood (92%).

The existing smolt survival models (A, B, C, and D) do not incorporate the potential impacts of migratory delay into whole station smolt survival estimates. Residency times for radio-tagged Atlantic salmon smolts released directly into the forebay canal and upstream of the Lockwood Project were determined by radio-telemetry during spring 2011 (Normandeau 2011). The median residency time for smolts released directly into the forebay canal was six minutes (range 3 minutes to 2 days, 2 hours, 12 minutes). The median residency time for smolts released upstream of the Lockwood Project was two minutes (range < 1 minute to 1 day, 22 hours, 17 minutes).

6.0 Atlantic Salmon Adults and Kelts

6.1 Adult Upstream Migration

6.1.1 Kennebec River Returns

Within the Kennebec River, returning adult salmon are collected at the Lockwood fish lift and are trucked upstream around the Lockwood, Hydro Kennebec, Shawmut, and Weston Projects and are released into the Sandy River. Collection totals for the previous six years (2006-2011) at Lockwood have ranged from a low of five individuals during 2010 to a high of 64 individuals during 2011 (Table 27). The average adult fork length for years 2006-2011 has ranged between 65.0-73.5 cm and the majority of individuals were aged at 1 or 2 years at sea.

6.1.2 Upstream Migration Delays

Delays to the upstream migration of Atlantic salmon have been observed below hydroelectric facilities. Fay et al. (2006) provided a review of available literature (Dube 1988; Shepard 1989; Shepard and Hall 1991; Shepard 1995) related to the observed passage delays at a number of hydroelectric projects on the Penobscot River. Results from these radio-telemetry studies indicate that the duration of delay varies widely among year and hydroelectric facility. Yearly pooled median passage times for adult Atlantic salmon at Veazie ranged from 4.7 to 33.2 days over five years of study. Yearly pooled median passage times for adult Atlantic salmon at Great Works ranged from 1.4 to 2.7 days over four years of study. Yearly pooled median passage times for adult Atlantic salmon at Milford Dam ranged from 1.0 to 5.3 days over five years of study. A recent (2005/2006) radio-telemetry assessment of upstream passage for Atlantic salmon adults at Penobscot River projects reported individual passage times (defined as interval between first tailrace detection and first upstream detection) for a limited number of fish at Veazie, Great Works and Milford Dams (Holbrook et al. 2009). Individual passage times (2005) for adult salmon approaching Veazie from Penobscot Bay were 2.0 and 3.3 days (for 2 of 4 individuals detected in tailrace) and for salmon approaching Great Works were 1.9, 13.1, and 25.4 days (for 3 of 6 individuals detected in tailrace). Individual passage times for all adult salmon having passed Great Works were 0.1, 2.9, and 3.7 days at Milford. Individual passage times (2006) for adult salmon reapproaching Veazie (following passage over the dam) were 2.1, 6.8 and 58.4 days (for 3 of 7 individuals detected in tailrace) and for salmon approaching Great Works were 8.6, 8.7, and 12.5 days (for 3 of 25 individuals detected in tailrace).

At this point, absent any site-specific field-test data, it is reasonable to assume that adult salmon approaching the Lockwood Project on their upstream migration may be subject to delays similar in duration as to what has been observed for radio-tagged individuals on the Penobscot River.

6.2 Kelt Downstream Migration

Following the fall season spawning period, Atlantic salmon kelts either outmigrate during the fall or remain in the freshwater portion of the river before outmigrating during the following spring. Baum (1997) indicated that following the fall spawn, approximately 20% of kelts move back downstream with the remainder (80%) moving downstream and the following spring. Quantitative data obtained from studies regarding timing, duration and survival of Atlantic salmon kelts during their downstream migration in the Kennebec River and through the Lockwood Project are either unavailable or limited. Results from an initial attempt at assessing passage routes for kelts through the Lockwood Project during

2007 were suspect due to the use of inappropriately sized hatchery-reared fish (Normandeau and FPL 2008). Kelts obtained from the hatchery for use during that study were smaller than had been anticipated and relative size of implanted radio-tags may have been a factor.

Although sample size and information related to passage routes are limited, successful downstream passage through four hydroelectric projects on the lower Kennebec River was observed for a single kelt radio tagged as part of a study on the Sandy River (MDMR 2009). A total of 18 sea-run Atlantic salmon were captured at the Lockwood Project, radio tagged and trucked to the Sandy River during the spring seasons of 2007 and 2008 (MDMR 2008, MDMR 2009). The majority (8 of 9) of those fish were determined to have remained in the Sandy River through the spawning season during both years. A single individual released in the Sandy River during early June 2008 successfully passed downstream of the Weston Project and was located in the mainstem of the Kennebec River during August and September of 2008. That same individual was next detected downstream of Lockwood during January 2009. Detection of that fish below Lockwood demonstrates that it successfully passed downstream past the Weston, Shawmut, and Lockwood projects as well as Hydro Kennebec (owned and operated by Brookfield Power).

6.3 Modeled Downstream Migrating Kelt Survival

Limited data for Atlantic salmon kelts make it difficult to assess the specific effects of the Lockwood Project on kelt survival. Observations on the Penobscot and other river systems in the Northeast suggest that kelts tend to linger in spawning areas and in parts of the freshwater river system, including hydropower reservoirs and facilities. Similar to the behavior recorded on the Penobscot River, anecdotal observations by Normandeau personnel working on the Merrimack River, NH have noted adult salmon to remain within the forebay canal of the Garvins Falls Project and individuals are often visible within the upper portion of the water column at that site. Kelts are not thought to sound frequently and that notion is supported through the reduction in turbine passage at Weldon following the installation of tightly spaced 1 in trashracks over the upper 16 feet of the intakes. In addition, adult salmon are strong swimmers and have the ability to avoid turbine intakes. Observed burst speeds for adult salmon range between 14.1 to 19.7 ft/s with a maximum sustained swim speed of 3.4 f/s (Beamish 1978). These behaviors suggest that salmon could be successful at locating and using surface bypasses. Similar to the whole station survival estimate generated for outmigrating Atlantic salmon smolts in Sections 4.0 and 5.0 of this report, this section will attempt to predict kelt survival at the Lockwood Project. Where passage related data is unavailable for the kelt life stage, it will be assumed that outmigration behaviors are similar to those of the smolt life stage.

6.3.1 Kelt Run Timing

In order to model whole station survival for Atlantic salmon kelts passing the Lockwood Project, it is necessary to know the timing and seasonal distribution of their downstream migration. Seasonal distribution data for kelt downstream migration specific to the Kennebec River is unavailable. Baum (1997) indicated that following the fall spawn, approximately 20% of kelts move back downstream and into the ocean but the majority move back downstream and into the ocean the following spring. Based on observations during MDMR redd surveys, outmigration of kelts immediately following the fall spawn occurs during the latter half of October, November, and the first half of December (N. Dube, MDMR, personal communication). For the purposes of estimating whole station kelt survival at Lockwood, it was assumed that the percentage of the total kelt outmigration occurring during the fall (20%) would be partitioned among the known salmon outmigration months of October (5%), November (10%) and

December (5%). Likewise, the percentage of the total kelt outmigration occurring during the spring (80%) would be divided between the known salmon kelt outmigration months of April (40%) and May (40%). Variations in this seasonal distribution and their impacts to whole station survival are examined in Section 7.1.1.2 of this report.

6.3.2 Kennebec River Flows

Flow duration curves were obtained for the Kennebec River at the Lockwood Project during the months of April, May, October, November and December (D. Dow, NOAA, personal communication). Lockwood Project flow duration curves were based on the flow record for the period 1979 through 2010. A description of the methodology used in the development of these curves can be found in Appendix B of this report. For the purposes of modeling project survival of Atlantic salmon kelts migrating past the Lockwood Project, the median monthly flow condition (i.e. the value with 50% flow exceedence) was used. Median flow conditions at the Lockwood Project used to estimate whole station survival for outmigrating kelts were the same as those used for smolts during the spring months of April and May (Section 4.2). The median monthly condition for April was approximately 13,000 cfs (Figure 3), during May was approximately 9,000 cfs (Figure 4), during October was approximately 4,500 cfs (Figure 11), during November was approximately 6,000 cfs (Figure 12), and during December was approximately 5,750 cfs (Figure 13). Impacts to the model of whole station kelt survival during years of high flow (10 and 25% flow exceedence) and low flow (75 and 90% flow exceedence) are examined in Section 7.1.1.3 of this report.

6.3.3 Kelt Downstream Route Determination

Similar to the assumption for outmigrating smolts, it was assumed that river discharge during the months of October, November, December, April and May will dictate the proportion of Atlantic salmon kelts passed downstream of the Lockwood Project though the spillway (and conversely, through the forebay canal). This is likely a conservative estimate given the strong swimming ability of adult salmon and their behavioral reluctance to sound. Determination of the spill effectiveness, defined as the proportion of kelts passed through spill relative to the total number passing the project, is the first step in assessing whole station survival. As was done for smolts, it was assumed that the Project spillway has a 1:1 ratio of percent total fish to percent total river flow passed (i.e., spilling 50% of total river flow results in 50% of kelts passing via the spillway). An overall spill effectiveness for the outmigration months of October, November, December, April and May of 38.7% was used for the assessment of whole station kelt survival at Lockwood. This value was calculated using a Project capacity of 5,600 cfs, the monthly distribution of Atlantic salmon kelt outmigration (Section 6.3.1), monthly median Kennebec River flow conditions (Section 6.3.2) and the assumption of 1:1 spill effectiveness. Table 28 provides a summary of that calculation as well as the monthly values used for the assessment of Lockwood Project spill effectiveness for kelts.

6.3.4 Kelt Downstream Bypass Efficiency

Given the lack of downstream bypass efficiency studies for Atlantic salmon kelts at the NextEra Projects on the Kennebec River the guidance efficiency rate used for the smolt model (Section 4.4) was used as a surrogate value for estimation of whole station survival for kelts. That efficiency rate was obtained for Atlantic salmon smolts during spring 2011 using radio-telemetry (Normandeau 2011). It was assumed that for Atlantic salmon kelts entering the powerhouse canal, approximately 18.8% were passed via the surface sluice with the remainder (81.2%) passing via the turbine units. Variations in bypass efficiency and their impacts to whole station survival are examined in Section 7.1.1.1 of this report.

6.3.5 Kelt Spillway and Downstream Bypass Passage Survival Assessment

The Lockwood Project spillway sections dam 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. The west spillway extends about 650 ft from the small island in a southwesterly direction to the forebay canal headworks, which extend to the west bank of the river. Each spillway has 15 in high flashboards. In addition, there are three orifices in the flashboards (3 ft wide by 8 in high) placed annually at locations along the spillway.

Based on the lack survival studies conducted for Atlantic salmon kelts at the NextEra and other hydroelectric projects, it was assumed that survival for Atlantic salmon kelts passing the Project via the downstream bypass or spillway was 96.3%. That value was based on a review of empirical studies conducted for Atlantic salmon smolts passed through sluices and bypasses at five different hydroelectric projects (See Section 4.5). Delayed survival (48-hr) estimates for Atlantic salmon smolts following passage through sluiceways and bypasses ranged from 91.1 to 100.0%, resulting in a mean overall spill survival of 96.3%.

6.3.6 Kelt Entrainment Rates and Turbine Passage Survival

The Lockwood powerhouse contains a total of seven generating units (six vertical Francis and one horizontal Kaplan) and has a total Project generating capacity of 6.915 MW. The maximum capacity (cfs) for each unit is presented in Table 7 and ranges from 666-721 cfs for the six vertical Francis units and is 1,689 cfs for the horizontal Kaplan unit. Total unit flow for the Project is approximately 5,600 cfs. Normal operating head for the Lockwood Project is 21 ft. The trash racks screening the intakes are 2 in spacing in front of Units 1-6 and 3.5 in spacing in front of Unit 7. Additional turbine characteristics for Lockwood Units 1 through 7 are provided in Table 7.

Turbine Entrainment Rates

Empirical data related to the route selection of Atlantic salmon kelts using the Lockwood turbine units to move downstream of the project does not exist. As a result, it was assumed (for modeling purposes) that the distribution of kelt passage through the Lockwood turbine units would be equal to the distribution of outflow through those units at maximum discharge (Table 7). Therefore, the theoretical entrainment rates for Atlantic salmon kelts passing Lockwood via the turbine units used for estimating whole station survival was 29.1% through the Kaplan unit and 70.9% through the Francis units.

Ten records of adult Atlantic salmon total lengths (762 – 821mm) and maximum body widths (79-100mm) were obtained from sea-run returns to the Deerfield River during spring 2011 (B. Hanson, Normandeau, personal communication). Total lengths from that data set were converted to fork lengths using the equation FL = 0.9173TL (Carlander 1969) where FL = fork length and TL = total length. The linear relationship for the log-transformed (ln) fork length and body width was determined to be ln(width) = 1.3113(lnFL) – 4.1717. Although the relationship was weak ($r^2 = 0.155$), it was used to predict body widths for theoretical salmon fork lengths to determine the longest fork length that would fit through the 2 in trash rack spacing in front of Units 1-6 and 3.5 in trash rack spacing in front of Unit 7. Based on that relationship, it was determined that adult Atlantic salmon with a fork length of greater than 19.3 inches would have achieved a body width greater than the 2in trash rack spacing at Lockwood Units 1-6 and adult Atlantic salmon with a fork length of greater than 29.4 inches would have achieved a body width greater than the 3.5in trash rack spacing at Lockwood Unit 7.

Fork length data was obtained for sea-run Atlantic salmon returns collected within the Kennebec and Sebasticook Rivers during the years 2006-2010 (P. Christman, MDMR, personal communication) as well as at the Veazie fishway trap on the Penobscot River for the years 1978-2009 (J. Murphy, NMFS, personal communication). Fork lengths recorded for returning Atlantic salmon (86 individuals) to the Kennebec drainage had a mean fork length of 27.3 in (range 19.7-34.3 in). Fork lengths recorded for 25,721 individual Atlantic salmon to the Penobscot River ranged from 15.7-40.9 in (mean 27.5in).

The length-frequency distribution for sea run returns to the Penobscot River was used as a surrogate for outmigrating kelts on the Kennebec due to the robust nature of the data set. It was assumed that fork lengths of kelts approaching both Francis and Kaplan units at Lockwood would be of a similar length-frequency distribution to that of the Penobscot River data set. For Atlantic salmon kelts approaching the Kaplan unit, 70.9% of individuals were predicted to pass through the 3.5in trash racks and be subjected to turbine passage. The remaining 29.1% would be excluded from turbine passage at both Unit types and were assumed to pass via bypass spill. For Atlantic salmon kelts approaching the Francis units, 0.8% of individuals were predicted to pass through the 2in trash racks and be subjected to turbine passage. Due to the lack of information regarding the movement of kelts in the Lockwood forebay canal, it was assumed that all kelts expected to pass via the Francis units but prevented from doing so by their predicted body widths relative to the 2in trash racks would next attempt passage via the Kaplan units. When the length-frequency distribution for sea run returns to the Penobscot River was truncated to remove the 0.8% of individuals capable of passing through 2in trash racks, it was estimated that 70.7% of those individuals had a predicted body width capable of passing through the 3.5in trash racks and being subjected to Kaplan turbine passage. The remainder of those individuals would be excluded from turbine passage at both Unit types and were assumed to pass via bypass spill. Impacts to the model of whole station kelt survival related to the assumption that all kelts screened from passage through the Francis units would next attempt downstream passage through the Kaplan unit are examined in Section 7.1.1.4 of this report.

Turbine Passage Survival

Kelt survival estimates for turbine passage were generated for the single Kaplan and six Francis units in operation at Lockwood using the same equations (Franke et al. 1997) as used for smolts and detailed in Section 3.3.2 of this report. Estimates for Atlantic salmon kelts passing through the Francis units were calculated for five body lengths considered representative of individuals capable of passing through 2in trash racks (16, 17, 18, 19, and 20 inches). Estimates for Atlantic salmon kelts passing through the Kaplan unit were calculated for five body lengths considered representative of individuals capable of passing through 3.5in trash racks (16, 20, 23, 27, and 30 inches). Two correlation factors (λ) were used in this analysis (0.1 and 0.2). Survival estimates for Lockwood units 1-7 were modeled using the maximum turbine discharge (cfs) and the associated efficiency.

Francis:

Model runs for five body lengths and two correlation factors resulted in a total of 10 survival estimates which are likely to bracket the actual survival for Atlantic salmon kelts passing through Francis units 1-6 at the Lockwood Project. Predicted survival values for salmon kelts capable of passing through the 2in trash racks screening the Lockwood Francis units ranged from a high value of 73.3% for a 16 inch kelt to a low value of 30.7% for a 20 inch kelt (Table 29). The range of survival estimates were similar for Francis Units 1-6 and the predicted survival probability increased as kelt body length decreased. The average survival of salmon kelts passing through the Francis units at Lockwood was determined by averaging the 10 modeled survival estimates for each unit. Those values ranged from a high of 54.9% at

Unit 1 to a low of 53.2% at Unit 5 with an overall calculated mean survival of 53.8% for Atlantic salmon kelts passing through the Lockwood Francis units.

Kaplan:

Model runs for five body lengths, two correlation factors and three *r* values resulted in a total of 30 survival estimates which likely bracket the actual survival for Atlantic salmon kelts passing through the Kaplan unit at Lockwood (Unit 7). The three *r* values represent the point along the runner radius that the fish enters the turbine. Values for *r* used in this assessment were 0.1, 0.5, and 0.9% of the runner radius.

Predicted survival values for salmon kelts capable of passing through the 3.5 in trash racks screening the Lockwood Kaplan unit (Unit 7) ranged from a high of 93.2% for a 16 inch kelt to a low of 10.1% for a 30 inch kelt (Table 30). Predicted survival probabilities increased as kelt body length and entry point proximity to the turbine hub decreased. The average survival of salmon kelts passing through the Kaplan unit at Lockwood was determined by averaging the 30 modeled survival estimates for each combination of fish length, entry point and λ. The calculated mean survival for Atlantic salmon kelts passing through the Lockwood Kaplan unit was 72.1%.

7.0 Estimated Project Impact on Outmigrating Atlantic Salmon Kelts

7.1 Modeled Estimate of Whole Station Survival for Kelts

Whole station survival for outmigrating kelts at the Lockwood Project was estimated by integrating Kennebec River flows, Project operating flows, the proportion of kelts diverted towards the spillway and forebay canal, spillway survival rate (as estimated from empirical data for smolts), screening effectiveness of turbine trash racks, turbine passage survival rates (as estimated by modeled data), site specific fish bypass guidance efficiency (Normandeau 2008), and fish bypass passage survival rate (as estimated from empirical data for smolts). The following values for each of the above parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in the calculations of whole station survival for salmon kelts at Lockwood Project:

7.1.1 Modeled Estimate of Whole Station Survival for Kelts

Whole station kelt survival was modeled using delayed (48-hr) smolt survival rates for spill obtained from empirical data collected at other hydroelectric projects and model derived estimates for turbine passed fish. The following values for each of the necessary model parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in this calculation of whole station survival for salmon kelts at Lockwood Project:

- Kennebec River Flow – monthly medians of 13,000 cfs (April), 9,000 cfs (May), 4,500 cfs (October), 5,600 cfs (November), and 5,750 cfs (December);
- Project operating flow – 5,600 cfs (Merimil 2002);
- Proportion of kelts diverted – utilized a ratio of 1:1 fish to river flow and was corroborated by the recent smolt radio-tagging conducted at Lockwood (Normandeau 2008; Normandeau 2011);
- Project spillway survival – 96.3% (based on review of delayed (48-hr) empirical survival data for smolts from other hydroelectric projects);
- Fish bypass guidance efficiency – 18.8% for Atlantic salmon smolts (Normandeau 2011);
- Entrainment rate through turbines – based on distribution of Unit outflow at maximum discharge ;
- Proportion of kelts screened from passage through turbines – based on Penobscot River length-frequency data and derived FL-width relationship
- Kaplan turbine passage survival – 72.1% (based on modeled values generated using site-specific turbine parameters);
- Francis turbine passage survival – 53.8% (based on modeled values generated using site-specific turbine parameters);
- Fish bypass system survival – 96.3% (based on review of delayed (48-hr) empirical survival data for smolts from other hydroelectric projects).

The integration of the above values is illustrated in Figure 14 for a hypothetical case of 100 Atlantic salmon kelts approaching the Lockwood Project during the outmigration period (April-May, October-December). The whole station survival estimate for Atlantic salmon kelts passing the Lockwood Project generated using delayed (48-hr) empirical data for spillway and modeled turbine survival estimates is 88%.

7.1.1.1 Impacts to Estimated Kelt Survival Associated with Bypass Efficiency Assumption

The model for estimating whole station survival for outmigrating kelts at Lockwood can be manipulated to provide insight into potential impacts based on modifying the various input parameters. The whole station survival estimate for kelts was generated using a fish bypass guidance efficiency rate of 18.8% which was the average value obtained during field studies conducted using smolts at Lockwood with the bypass set at 4% and 6% of powerhouse flow (Normandeau 2011). Increased effectiveness of the downstream bypass would reduce the impact of turbine passage on outmigrating kelts and should increase whole station survival. Table 31 provides whole station kelt survival estimates for a range of theoretical bypass efficiency rates. Theoretical bypass effectiveness rates between 25 and 100% were modeled and produced a range of whole station survival estimates for outmigrating Atlantic salmon kelts between 88% and 96%.

7.1.1.2 Impacts to Estimated Kelt Survival Associated with Seasonal Distribution Assumption

In cases with no site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (e.g., spilling 50% of total river flow results in 50% of fish passing via the spillway). A basic implication of the deviation from the 1:1 assumption is that if a proportionally smaller percentage of kelts relative to the river flow enter the Project forebay then the calculated station-related kelt survival would be higher. Under these conditions, a greater percentage of kelts would pass the project via spill and would avoid impacts associated with turbine passage. Alternatively, if a proportionally higher percentage of kelts are entering the station forebay than the calculated station related kelt survival would be lower. Under these conditions, a lower percentage of kelts would pass the project via spill and a greater number would be entrained through the Project turbines.

Potential impacts to the model estimating whole station kelt survival associated with deviation from the assumed 1:1 ratio of fish to flow at the Lockwood Project are presented in Table 32. A range of spill effectiveness rates for Atlantic salmon kelts from 10% (0.4:1) to 90% (3.5:1) were evaluated. For conditions where a proportionately lower percentage of kelts relative to river flow entered the forebay canal (i.e. spill effectiveness rates of 50, 70, and 90%), the estimates for whole station survival were greater than that observed under the assumption of 1:1 spill effectiveness and ranged from 89% to 95%. For conditions where a proportionately higher percentage of kelts relative to river flow entered the forebay canal (i.e. spill effectiveness rates of 10 and 30%), the estimates for whole station survival were lower (84% and 86%, respectively) than that observed under the assumption of 1:1 spill effectiveness.

7.1.1.3 Impacts to Estimated Kelt Survival Associated with Seasonal Flow Assumption

The model for estimating whole station survival for outmigrating kelts at Lockwood was constructed using the assumption of median Kennebec River flows (i.e. 50% exceedence) during the months of April, May, October, November, and December. Two “low flow” conditions (75 and 90% exceedence) and two “high flow” conditions (10 and 25% exceedence) were also examined. Estimated monthly Kennebec River flows for the months of April, May, October, November, and December under the 10, 25, 75, and 90% exceedence conditions are presented in Table 33. Table 34 presents the modeled whole station survival estimates for downstream migrating Atlantic salmon kelts under the additional low and high flow conditions. Under the low flow conditions (i.e. those exceeded 75 and 90 % of the time) the estimated whole station survival for salmon kelts at the Lockwood Project decreased to 85% and 83%, respectively.

Under the high flow conditions (i.e. those exceeded only 10 or 25% of the time) the estimated whole station survival for salmon kelts at the Lockwood Project increased to 93% and 91%, respectively.

7.1.1.4 Impacts to Estimated Kelt Survival Associated Forebay Behavioral Assumption

For the purposes of modeling whole station kelt survival, it was assumed that the proportion of kelts effectively screened from passing downstream by the 2 in trash racks in front of the Francis units would all make a second downstream passage attempt through the Kaplan unit. Those kelts whose body width (>3.5 in) prevented them from passing through the Kaplan trash racks would then be subjected to passage via bypass spill. This assumption presents the worst case scenario for the kelts predicted to be passed via Francis units but prevented from doing so by the 2 in trash rack spacing. The conservative nature of the behavioral assumption made here is supported by observations of radio-tagged kelts at the Weldon Project on the Penobscot River which were reluctant or unable to migrate through trashracks even though they demonstrated a strong tendency to move downstream (GNP 1987; GNP 1988; GNP 1989). Table 35 presents the modeled whole station kelt survival estimates for a range of behavioral responses for kelts excluded from Francis turbine passage by the 2 in trash racks. Behavioral responses of 0, 10, 30, 50, 70, and 90% of kelts excluded from Francis turbines by the 2 in trash racks opting to pass via bypass spill (rather than Kaplan) were modeled. Should all kelts excluded from Francis turbine passage by the 2 in trash racks pass via bypass spill, the whole station survival estimate for kelts would increase to 94%.

7.2 Summary of Modeled Estimate of Whole Station Survival for Kelts

A single model of whole station survival of Atlantic salmon kelts at the Lockwood Project was constructed using available empirical and modeled survival rates for passage via spill and through turbine units. Where data was unavailable for the kelt lifestage, empirical data from smolt studies was used as a surrogate. The model constructed for whole station survival of Atlantic salmon kelts at the Lockwood Project generated a survival estimate of 88% with modifications during the various sensitivity analyses expanding those bounds to 83%- 96%. A percentage of kelts will over winter in freshwater and resume feeding following the fall spawn (Danie et al. 1984). Although mortality is high upon reentry to saltwater, a percentage of kelts which successfully migrate to ocean feeding grounds may become repeat spawners (Danie et al. 1984). Baum (1997) states that repeat spawners can reach weights approaching 30 pounds and contain an average of approximately 11,300 eggs. For comparison, a first time returning two sea-winter salmon will contain an average of approximately 7,500 eggs. In the National Research Council’s book “Atlantic Salmon in Maine” (NRC 2007) it was stated that most Atlantic salmon are semelparous, spawning once and then dying. It was estimated that 1%-6% of anadromous Atlantic salmon are iteroparous and will survive to make a second spawning run the following year. Baum (1997) notes that data collected during the 1960’s and 1970’s suggested that 5-10% of the salmon run in Maine rivers was composed of repeat spawners. Baum (1997) indicates that value has declined in recent years to less than 1% due primarily to commercial fisheries during the 1960’s to early 1990’s. During the five year period (1992-1996) wild salmon repeat spawners in the Magaguadavic River (New Brunswick) were noted to represent an overall percentage of 6% (Carr et al. 1997). Within the Miramichi River, considered to have the largest run of Atlantic salmon in eastern North America, the proportion of repeat spawners within the annual run has ranged from a low of approximately 2% to a high of approximately 53% during the forty year period of 1970-2010 (Chaput and Douglas 2010). The proportion of repeat spawners within the Miramichi River was greater than 10% during 34 of the 40 years, greater than 20% during 22 of the 40 years, greater than 30% during 16 of the 40 years, greater than 40% during 6 of the 40 years and greater than 50% during 2 of the 40 years.

8.0 Predation

8.1 Smolt Predation

The smolt survival models presented in Section 5.0 of this report represent mortality associated directly with smolt/Project interactions and does not account for indirect mortality (such as predation). Atlantic salmon smolts are a potential food source for a number of fish (i.e. striped bass, black bass, northern pike) avian (i.e. cormorants, seagulls, ospreys) and mammalian predators (i.e. harbor seals) which may frequent the Kennebec River below the Lockwood Project. However, direct quantification of predation rates for Atlantic salmon smolts in the Kennebec River is not available.

Due to the lack of predation rate data for outmigrating salmon smolts in the Kennebec River, a rate was estimated based on that used for Habitat Conservation Plans for the Rocky Reach hydroelectric project on the mid-Columbia River, Washington. Combined predation (upstream and downstream) for that project was estimated at 2.0% of smolts and was derived from site-specific empirical data as well as observations at other Columbia River hydroelectric projects (S. Hayes, personal communication). In the Columbia River, predation on juvenile salmonids by piscivorous fishes has been investigated in detail (Rieman et al 1991; Zimmerman 1999) and has resulted in an extensive management program to control smolt loss to predation by northern pikeminnow (Beamesderfer et al. 1996; Friesen and Ward 1999). It is suspected that striped bass may represent a predatory impact to outmigrating Atlantic salmon smolts within the Kennebec River. Blackwell and Juanes (1998) noted 48% of striped bass with prey items in their stomachs contained Atlantic salmon smolts during a spring study below the Essex Dam on the Merrimack River. As striped bass densities would be expected to be lower towards the northern portion of their range, it is not expected that predation by that species would be as high in the Kennebec River. Anecdotal observations from fishway personnel indicated that striped bass arrive at the Lockwood tailwater during late May and early June which is during the latter part of the smolt outmigration.

Given the absence of site-specific data, an estimate of 1.0% loss was used to represent predation that may occur in the tailwater area. This was based on the absence of a major controlling predator, such as the northern pikeminnow on the Columbia River, for the duration of the outmigration season in the Kennebec River. Based on observations from the Merrimack River, striped bass most likely do represent a predation threat once they reach the Lockwood tailwater during the latter part of the spring.

In addition to predation in the hydroelectric project tailwaters, outmigrating Atlantic salmon smolts are also subjected to predation within the impounded river portions located upstream of hydroelectric projects (Ruggles 1980; Blackwell et al. 1997; Jepsen et al. 1998). Although not intended to directly assess predation rates, the release of radio-tagged smolts into impounded portions of the Kennebec River upstream of the Lockwood and Hydro-Kennebec (owned and operated by Brookfield Power) Projects can be used in an attempt to estimate impoundment predation. During May and June, 2011, a total of 98 radio-tagged smolts were released into the impoundment approximately 0.6 miles upstream of the Hydro-Kennebec Project. Of those smolts, only 3 individuals (3.1%) did not pass the Project and may have been predated. Similarly, a total of 60 radio-tagged smolts were released into the impoundment approximately 0.5 miles upstream of the Lockwood Project. Of those smolts, only 1 individual (1.6%) did not pass the Project and may have been predated. A total of 22 radio-tagged smolts were released into the impoundment approximately 0.5 miles upstream of the Lockwood Project during the 2007 (Normandeau 2008) bypass efficiency evaluation. During that study, no individuals released in the impoundment above Lockwood were reported to have not passed the Project. It should be noted that these telemetry studies were not intended to directly assess natural predation rates and other factors such as tag retention, desmoltification, or behavioral differences associated with having been hatchery-reared may factor into the lack of downstream movement observed for some smolts. Based on the limited rates of loss for radio-tagged smolts in Kennebec River impoundments (3.1%, 1.6%, and 0.0%) a mean average rate of 1.6% was estimated for predation on Atlantic salmon smolts that may occur in the impoundment.

8.2 Adult Predation

Sea-run returning adult Atlantic salmon potentially delayed by the presence of the Lockwood Project may be exposed to predation risks. Atlantic salmon adults are a potential food source for a limited number of fish (i.e. northern pike) and mammalian predators (i.e. harbor seals) which may frequent the Kennebec River below the Lockwood Project. The frequency of seal bites on returning Penobscot River salmon increased from less that 0.5% to greater than 3.0% between the early 1980's and mid 1990's (NRC 2004). However, there are no data available to estimate the number of adult salmon captured and consumed by seals (NRC 2004). Additionally, mortality associated with catch and release angling injuries or poaching may also impact adult salmon in the Project tailwater. At this point, absent any data, it is unreasonable to assign a predation rate to adult salmon in the Lockwood tailrace.

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FIGURES

Figure 1. Design plan and physical layout of the Lockwood Project. (Lets redue this to clean up the hand written stuff and font)

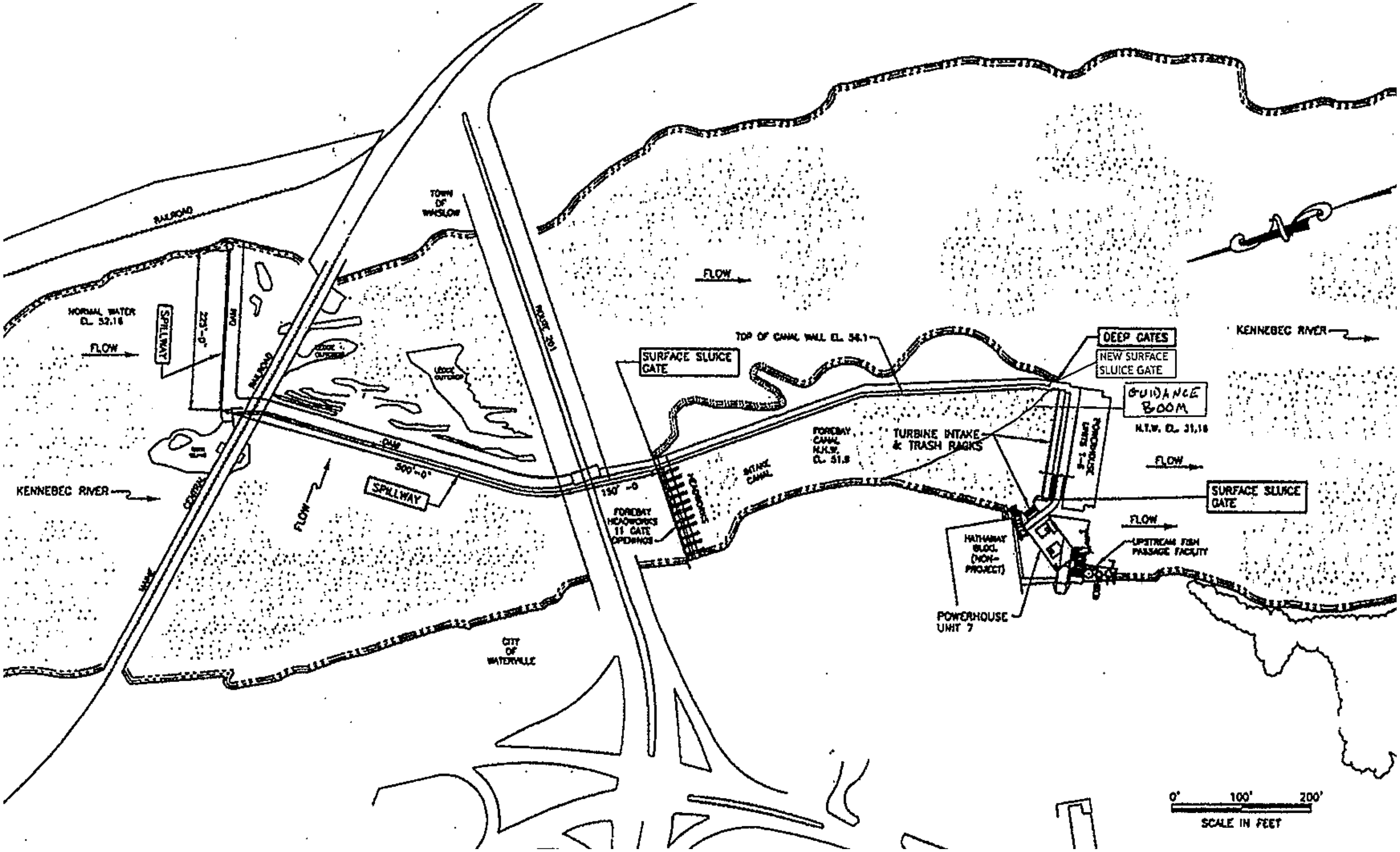


Figure 2. Potential downstream passage routes at the Lockwood Project.

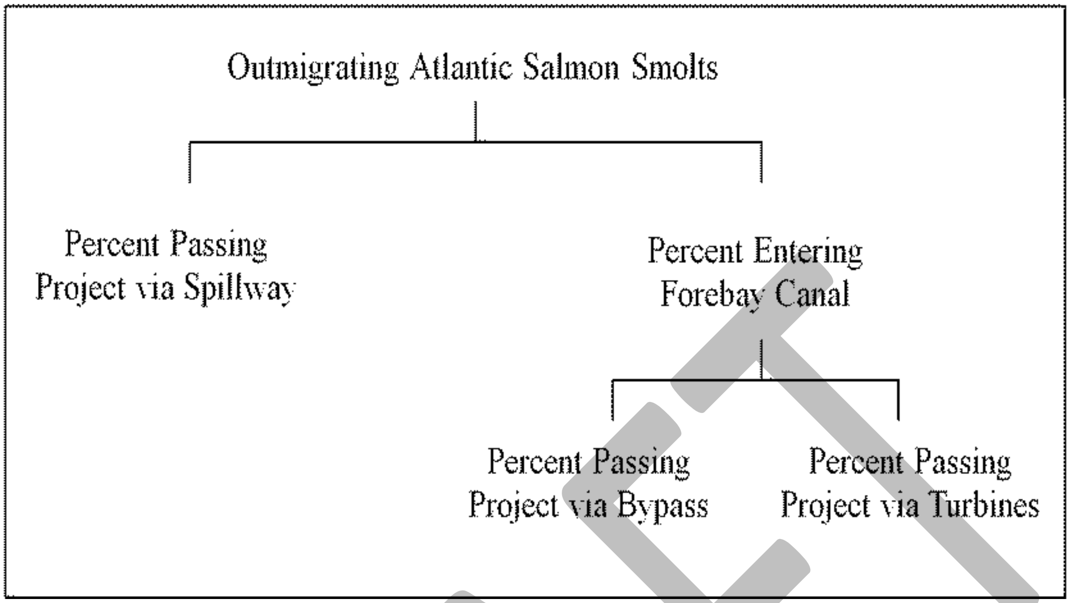


Figure 3. Kennebec River (Lockwood Project) flow duration curve for April.

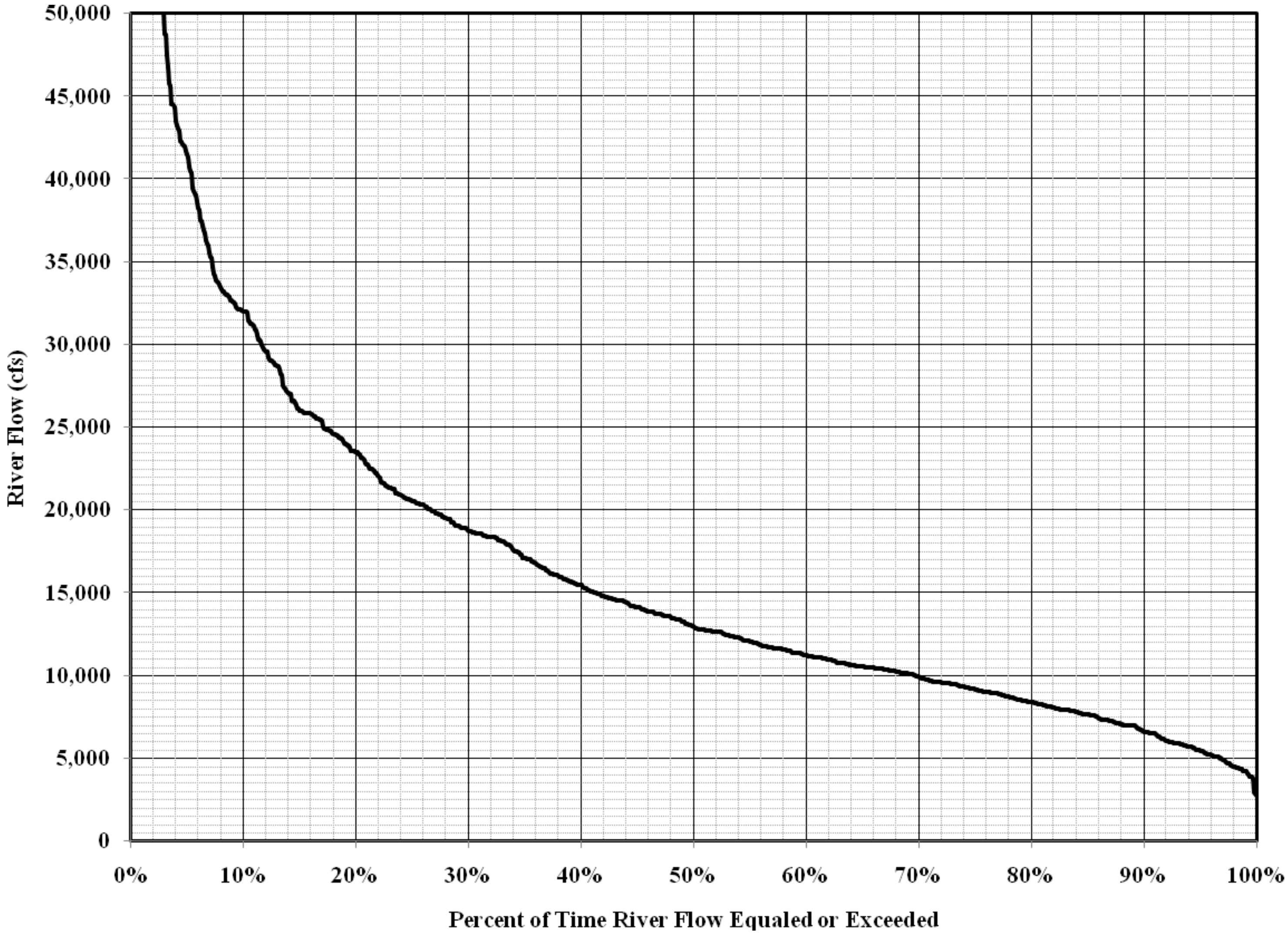


Figure 4. Kennebec River (Lockwood Project) flow duration curve for May.

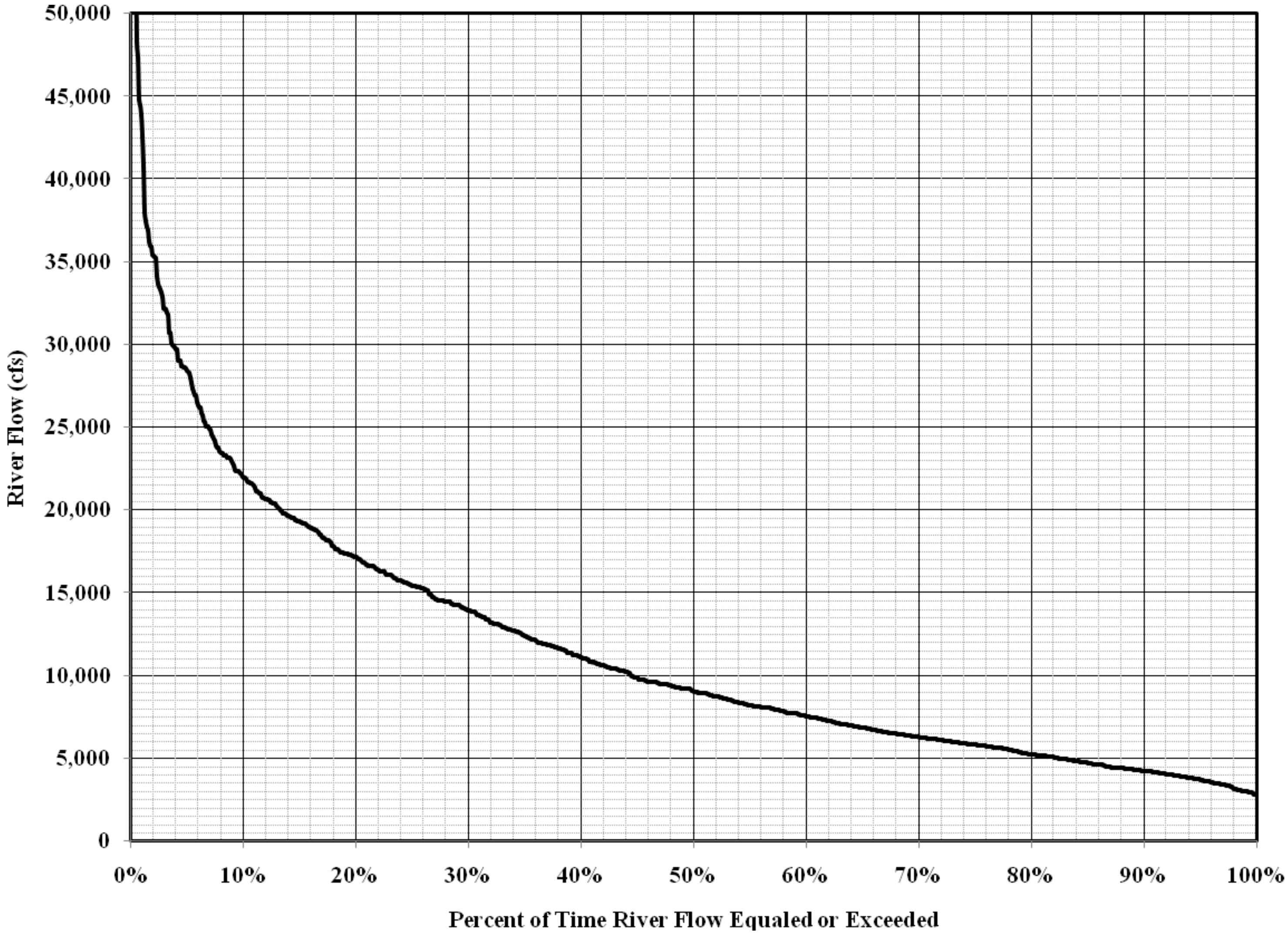


Figure 5. Kennebec River (Lockwood Project) flow duration curve for June.

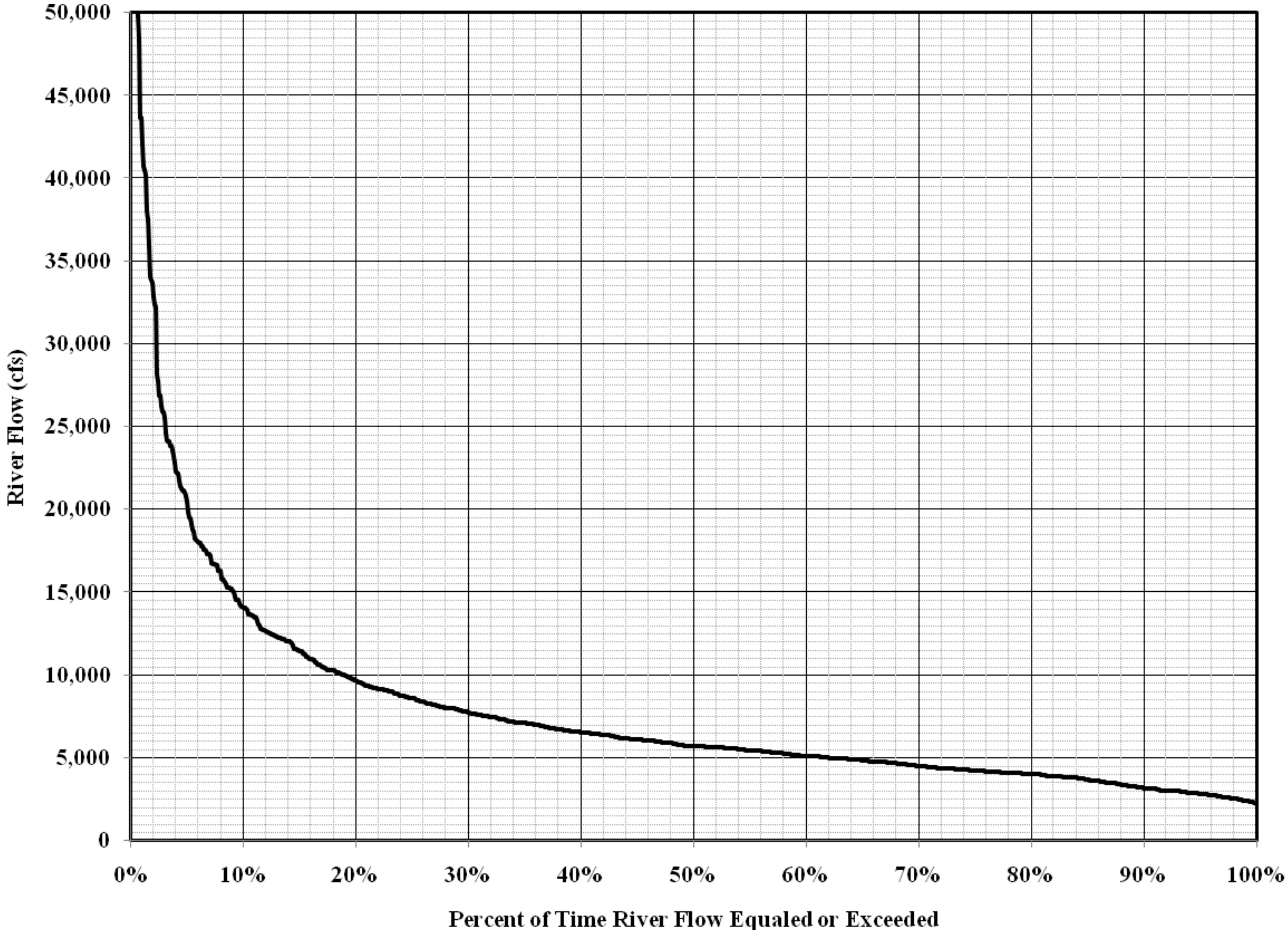


Figure 6. Smolt capture data from 2004 for the Narraguagus, Pleasant and Penobscot Rivers, Maine. Reprinted from USASAC 2005 Annual Report.

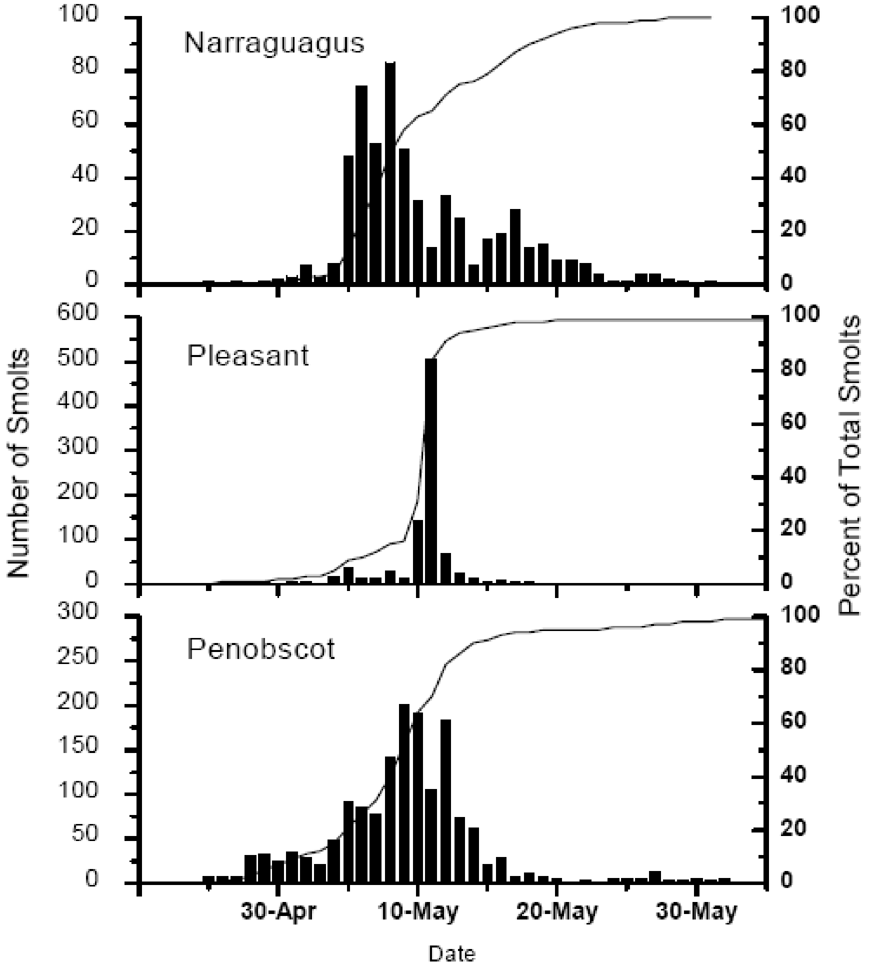


Figure 7. Example of whole station survival estimate for Atlantic salmon smolts calculated using the Initial Survival Rate Model (Model A) at the Lockwood Project, Kennebec River.

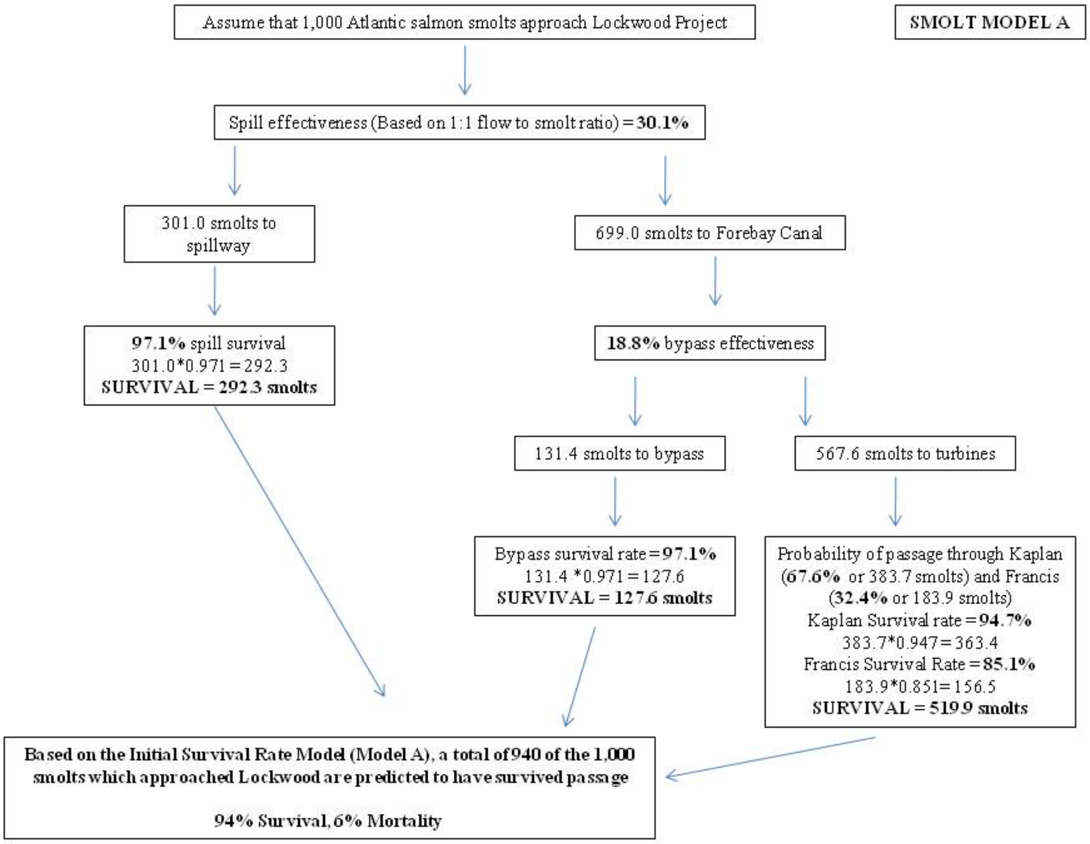


Figure 8. Example of whole station survival estimate for Atlantic salmon smolts calculated using the Delayed Survival Rate Model (Model B) at the Lockwood Project, Kennebec River.

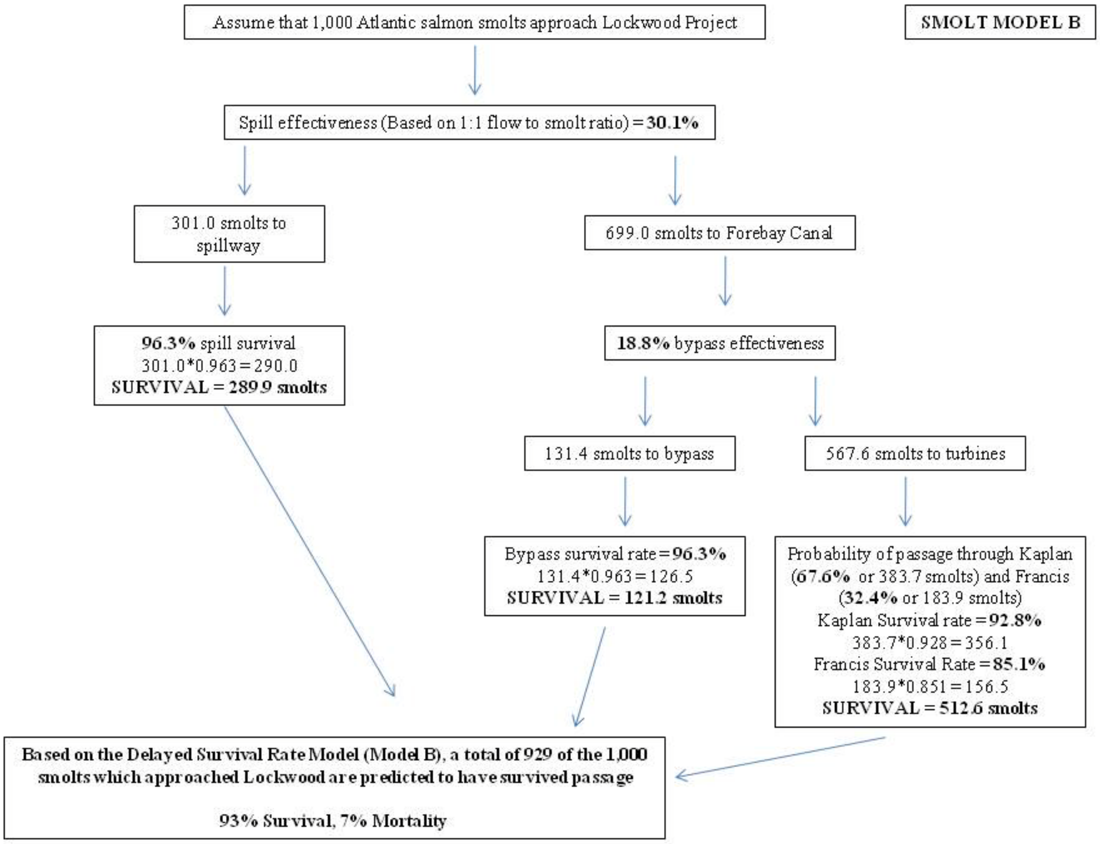
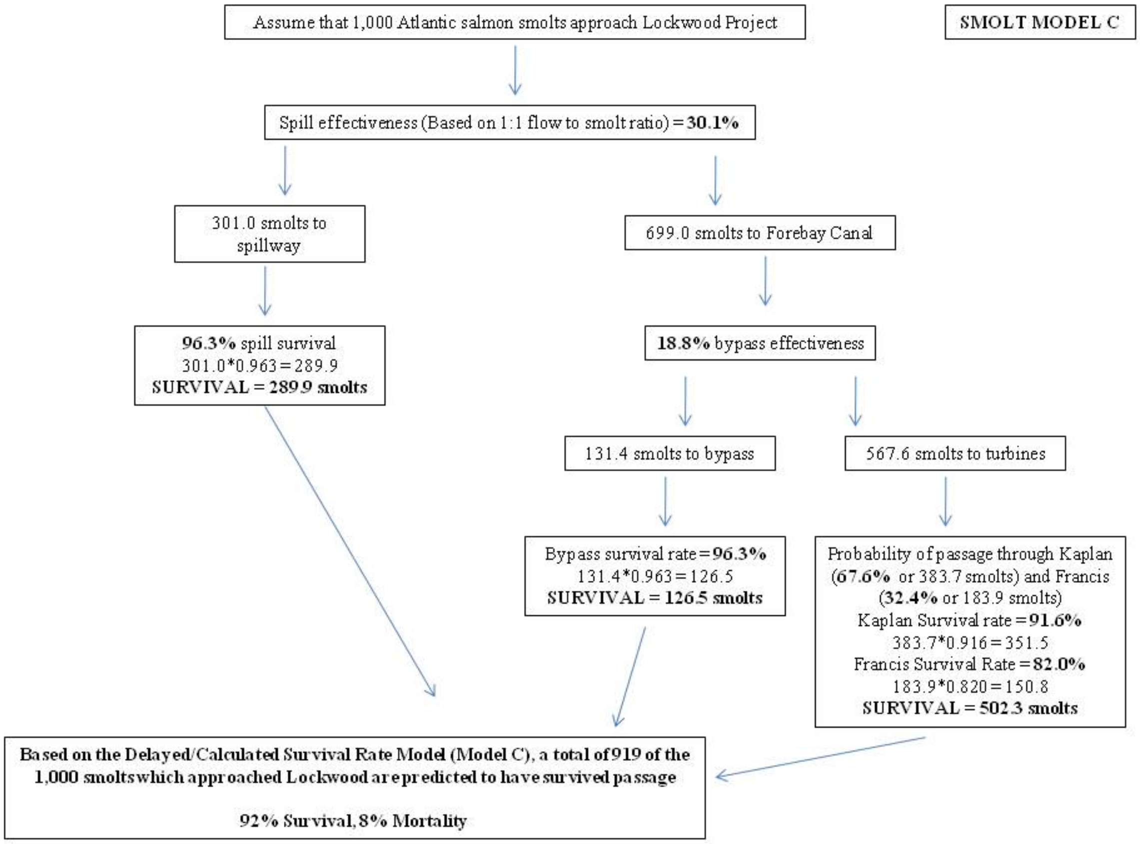


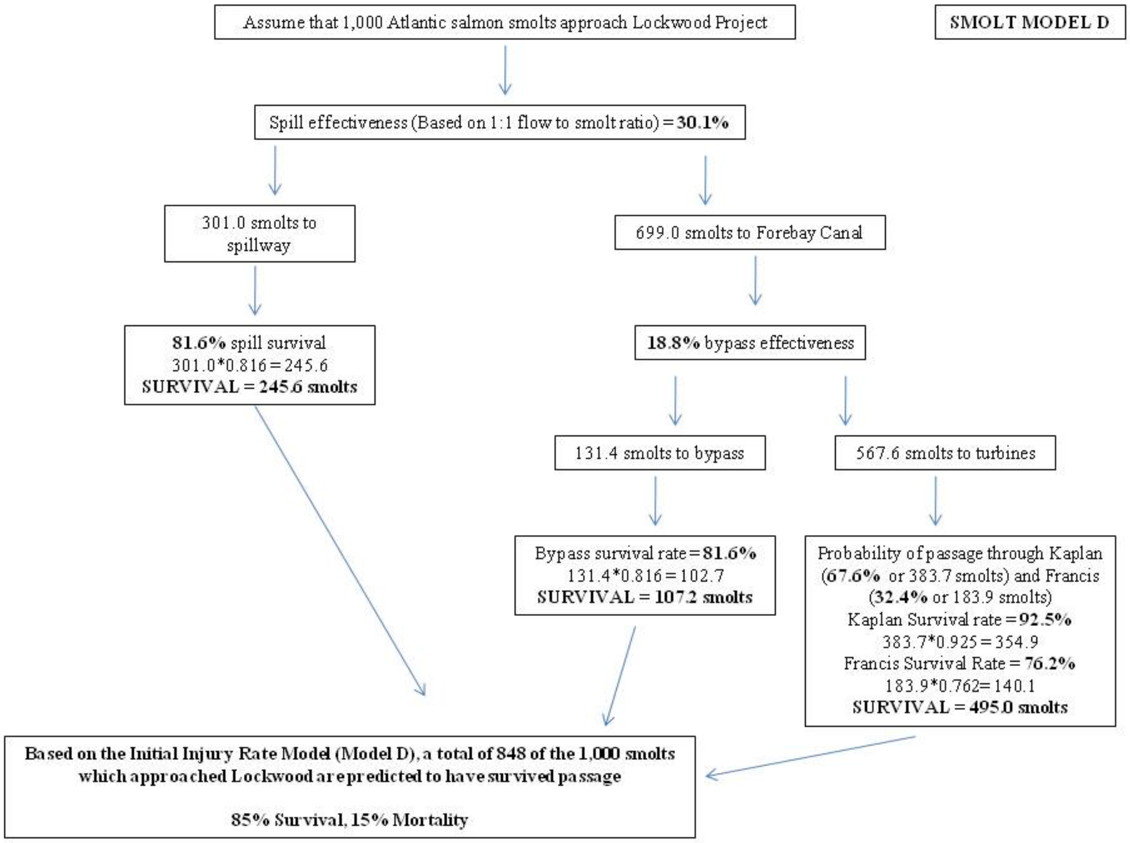
Figure 9. Example of whole station survival estimate for Atlantic salmon smolts calculated using the Delayed/Calculated Survival Rate Model (Model C) at the Lockwood Project, Kennebec River.



Based on the Delayed/Calculated Survival Rate Model (Model C), a total of 919 of the 1,000 smolts which approached Lockwood are predicted to have survived passage

92% Survival, 8% Mortality

Figure 10. Example of whole station survival estimate for Atlantic salmon smolts calculated using the Initial Injury Rate Model (Model D) at the Lockwood Project, Kennebec River.



Assume that 1,000 Atlantic salmon smolts approach Lockwood Project

SMOLT MODEL D

Spill effectiveness (Based on 1:1 flow to smolt ratio) = **30.1%**

301.0 smolts to spillway

699.0 smolts to Forebay Canal

81.6% spill survival
301.0*0.816 = 245.6
SURVIVAL = 245.6 smolts

18.8% bypass effectiveness

131.4 smolts to bypass

567.6 smolts to turbines

Bypass survival rate = **81.6%**
131.4*0.816 = 102.7
SURVIVAL = 107.2 smolts

Probability of passage through Kaplan (**67.6%** or 383.7 smolts) and Francis (**32.4%** or 183.9 smolts)
Kaplan Survival rate = **92.5%**
383.7*0.925 = 354.9
Francis Survival Rate = **76.2%**
183.9*0.762= 140.1
SURVIVAL = 495.0 smolts

Based on the Initial Injury Rate Model (Model D), a total of 848 of the 1,000 smolts which approached Lockwood are predicted to have survived passage

85% Survival, 15% Mortality

Figure 11. Kennebec River (Lockwood Project) flow duration curve for October.

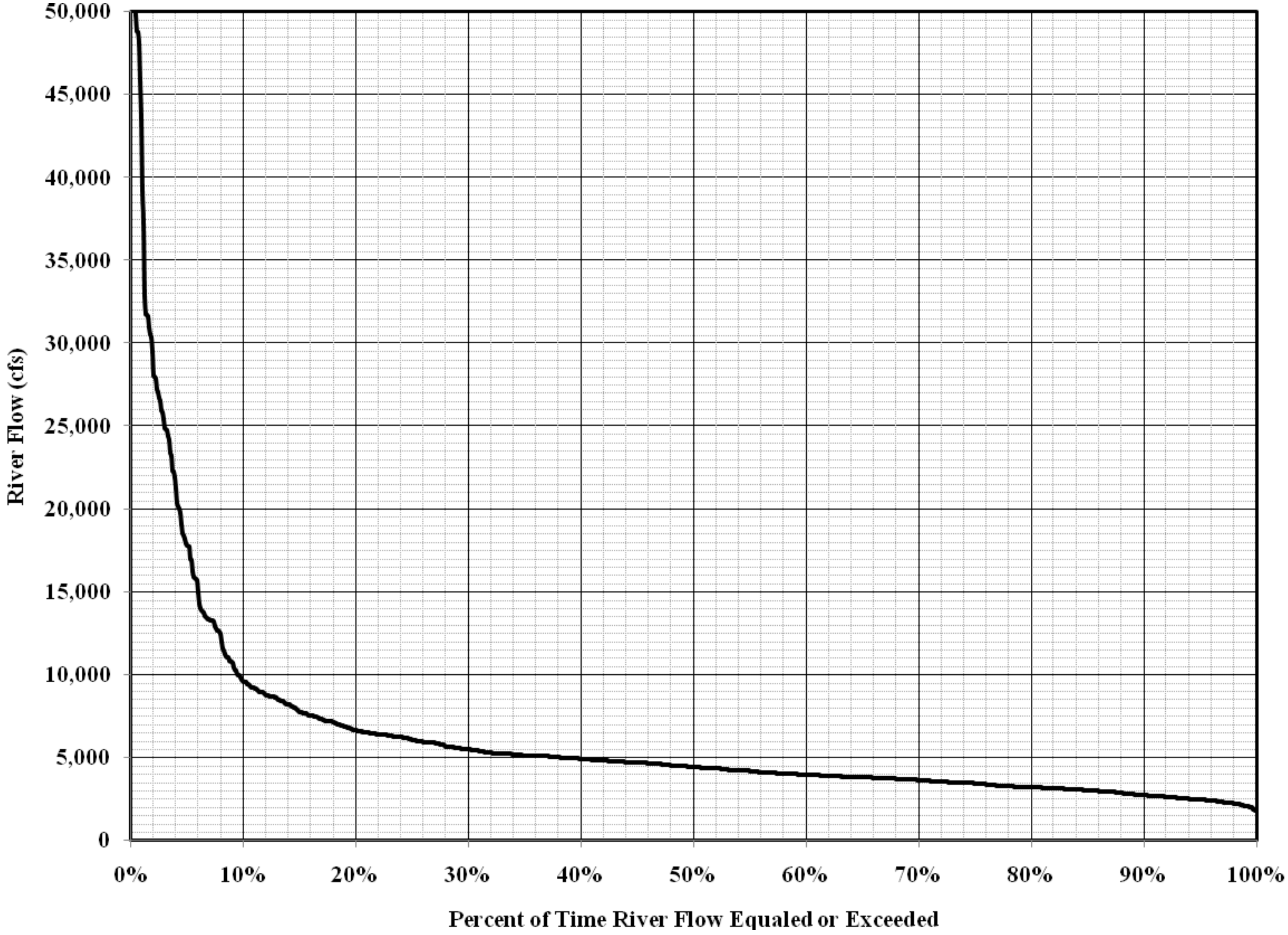


Figure 12. Kennebec River (Lockwood Project) flow duration curve for November.

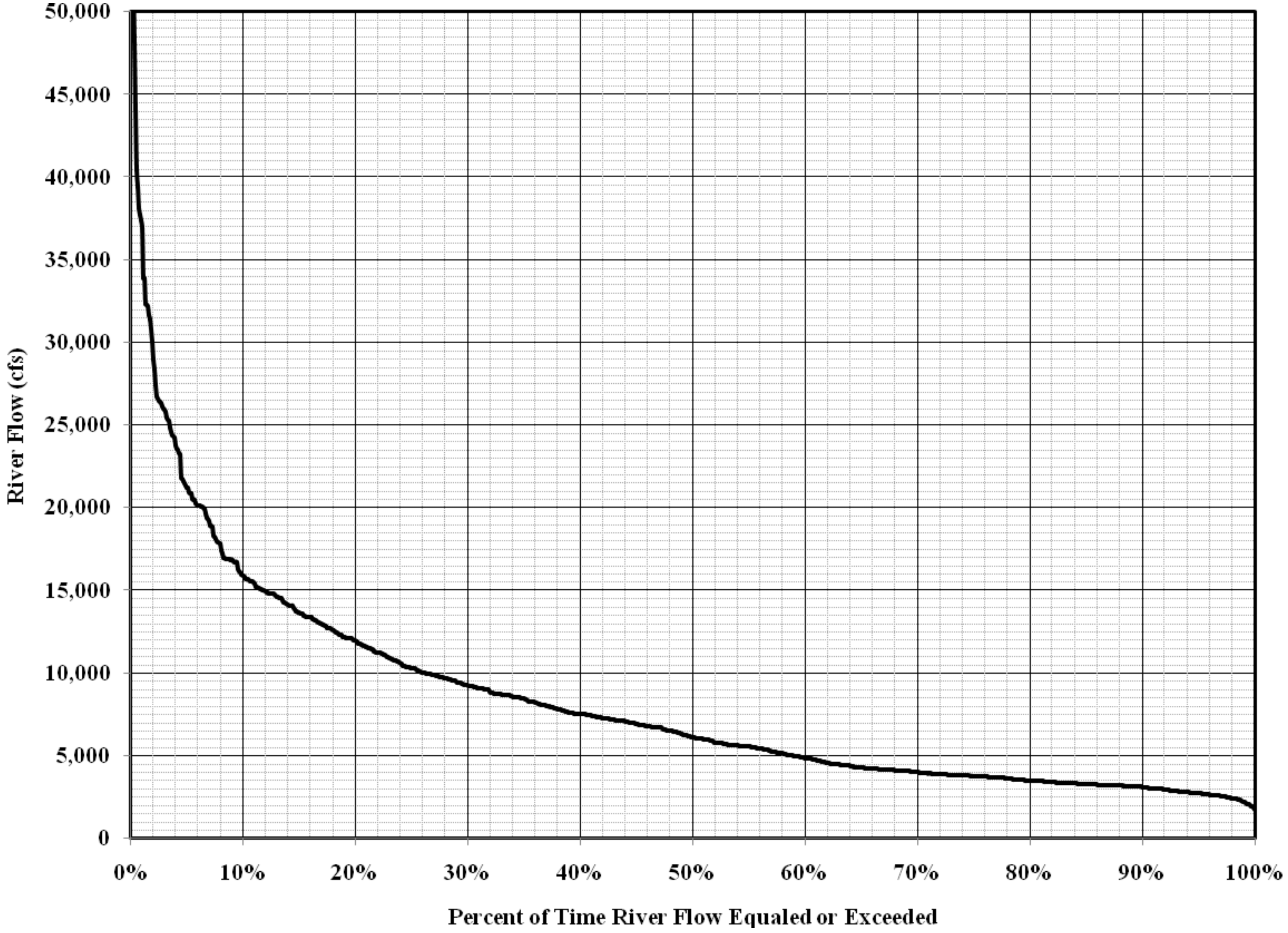


Figure 13. Kennebec River (Lockwood Project) flow duration curve for December.

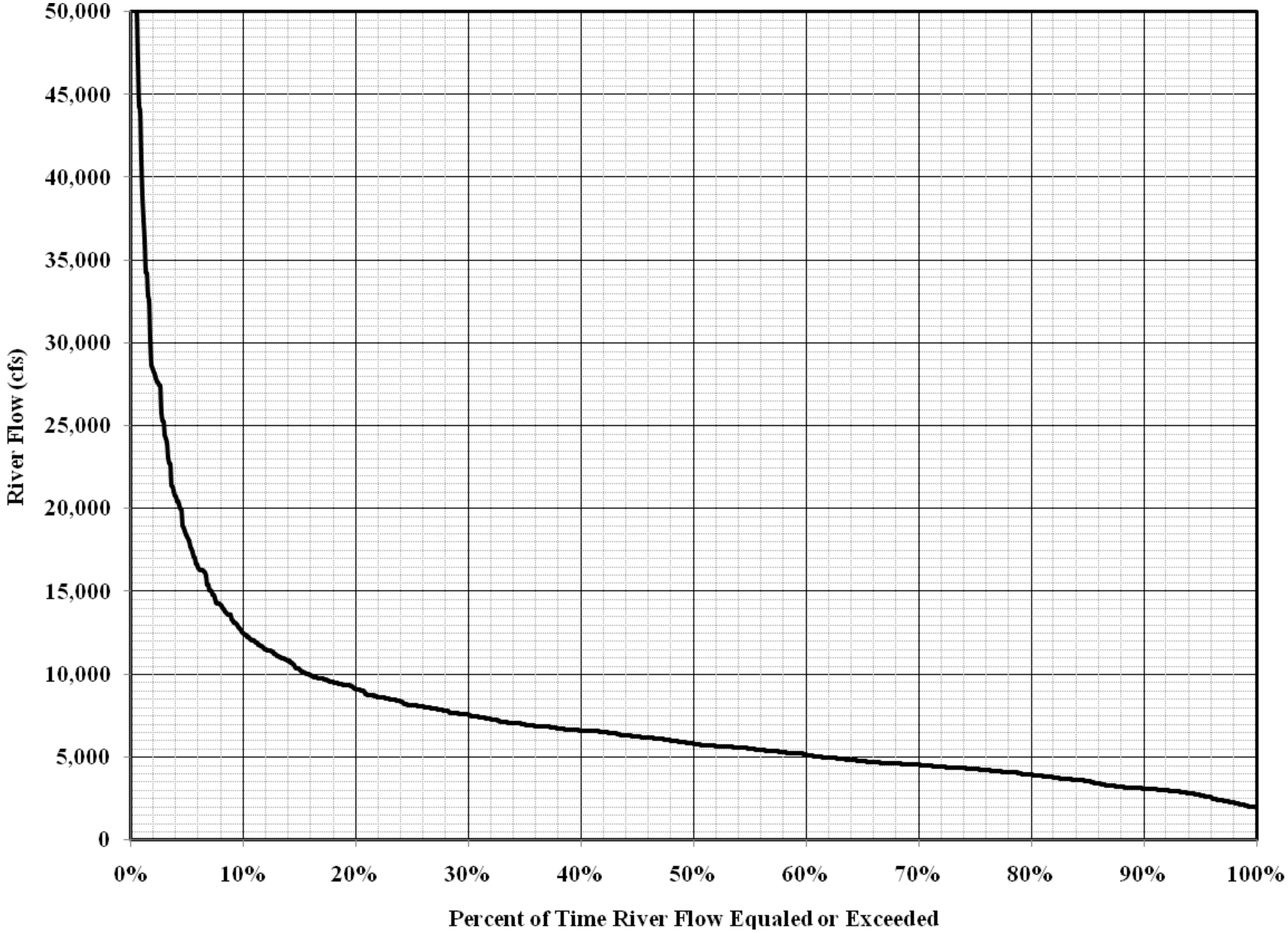
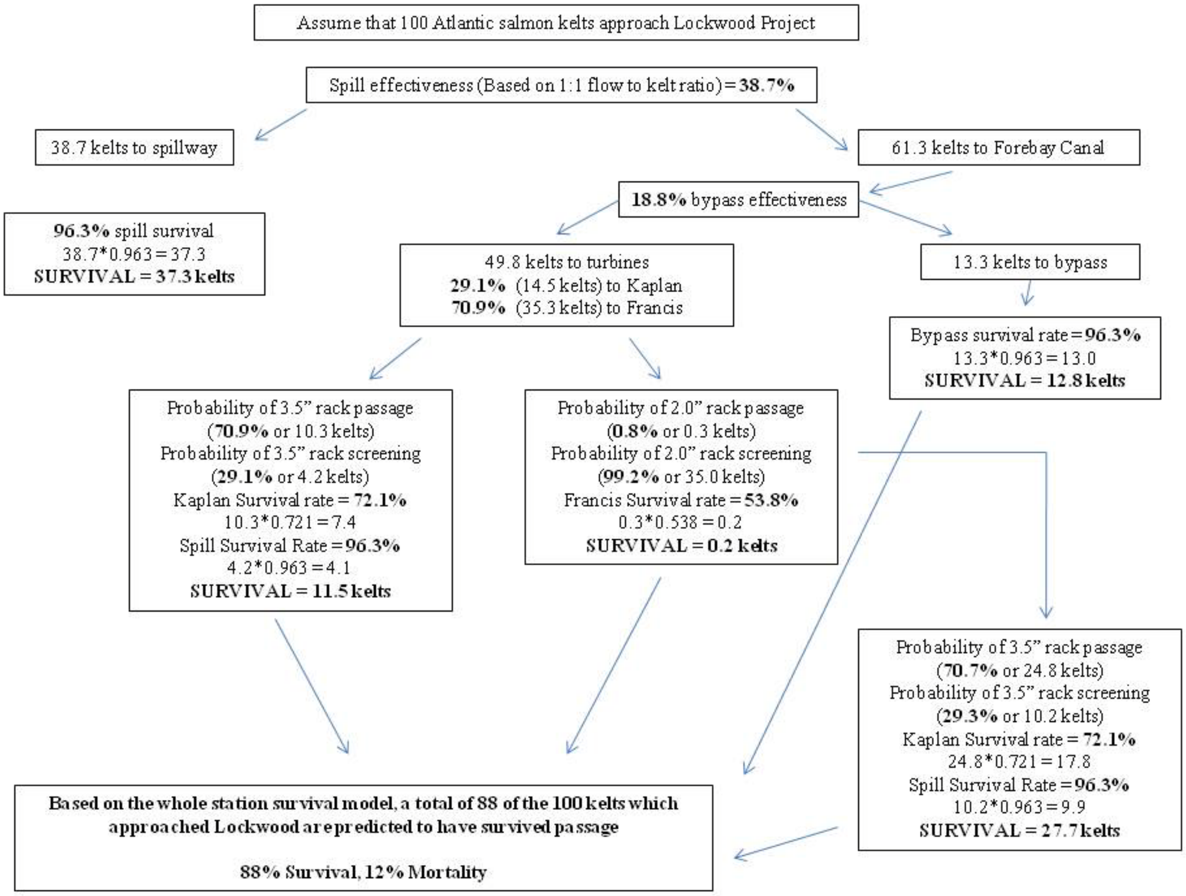


Figure 14. Example calculation of kelt survival associated with downstream passage past the Lockwood Project, Kennebec River.



TABLES

Table 1. Number of individuals collected and seasonal timing of downstream migration of Atlantic salmon smolts at the Mattaceunk Project (Weldon Dam) on the Penobscot River. Note: NS = no sample; data is reprinted from GNP 1997.

3-Days Starting	Sample Year					
	1995	1994	1993	1990	1989	1988
1-Apr	NS	0	0	0	NS	0
4-Apr	NS	0	0	0	NS	0
7-Apr	NS	0	0	0	NS	0
10-Apr	NS	0	0	0	NS	0
13-Apr	NS	0	0	0	NS	0
16-Apr	NS	0	0	0	0	0
19-Apr	NS	0	0	0	0	1
22-Apr	NS	0	0	0	0	0
25-Apr	0	0	1	1	0	0
28-Apr	1	0	0	1	0	0
1-May	3	0	0	2	0	0
4-May	15	3	13	1	3	0
7-May	33	1	46	27	9	15
10-May	130	6	189	27	19	43
13-May	238	9	133	33	11	214
16-May	975	7	179	79	38	113
19-May	2,123	32	290	76	267	152
22-May	298	309	699	40	671	262
25-May	264	37	873	25	233	202
28-May	211	620	642	33	294	529
31-May	172	517	81	14	171	208
3-Jun	108	673	30	44	357	106
6-Jun	51	256	38	15	192	16
9-Jun	21	126	16	3	109	12
12-Jun	16	61	25	4	559	21
15-Jun	15	31	5	7	89	9
18-Jun	8	5	3	4	68	NS
21-Jun	9	0	2	1	33	NS
24-Jun	NS	1	0	NS	NS	NS
27-Jun	NS	0	0	NS	NS	NS
30-Jun	NS	1	0	NS	NS	NS

Table 2. Seasonal distributions for smolt downstream migration used for assessment of whole station survival at the Lockwood Project.

River System	Year	Proportion			Reference
		April	May	June	
Penobscot	1988	0.1	80.4	19.5	GNP 1997
Penobscot	1989	0.0	49.5	50.5	GNP 1997
Penobscot	1990	0.5	78.5	21.1	GNP 1997
Penobscot	1993	0.0	93.8	6.1	GNP 1997
Penobscot	1994	0.0	38.0	62.0	GNP 1997
Penobscot	1995	0.0	91.5	8.5	GNP 1997
Penobscot	2004	10.0	88.0	2.0	USASAC 2005
Narraguagus	2004	4.0	96.0	0.0	USASAC 2006
Average		**1.8**	**77.0**	**21.2**	

Table 3. Estimated percentage of smolts entering the Lockwood Project forebay canal or passing via spillway.

Month	Discharge (cfs)			Percent of River Discharge		Smolt Run Distribution[4]	Project Smolt Distribution[5]	
	River Discharge[1]	Lockwood [2]	Calculated Spill [3]	Spill	Forebay Canal		Spill	Forebay Canal
April	13,000	5,600	7,400	56.9%	43.1%	1.8%	1.0%	0.8%
May	9,000	5,600	3,400	37.8%	62.2%	77.0%	29.1%	47.9%
June	5,500	5,500	0	0.0%	100.0%	21.2%	0.0%	21.2%
TOTAL	-	-	-	-	-	-	**30.1%**	**69.9%**

1 - Monthly median condition as obtained from Project flow duration curves (50% exceedence)

2 - Project capacity or river inflow

3 - Equal to River discharge - Project capacity

4 - Monthly distribution of Atlantic salmon smolt run for the Penobscot River (GNP 1997; USASAC2005) and Narraguagus River (USASAC 2005)

5 - Based on 1:1 assumption of spill effectiveness

Table 4. Initial (1-hr) and delayed (48-hr) injury/scale loss rates for Atlantic salmon smolts passed through spillways and sluices at various hydroelectric projects. All tests conducted using the Hi-Z Turb'N Tag.

			Initial (1hr) Rates		Delayed (48hr) Rates		
Site Name	**Passage Route**	**Normal head (ft)**	**Test Fish Injury Rates (%)**	**Control Fish Injury Rates (%)**	**Test Fish Injury Rates (%)**	**Control Fish Injury Rates (%)**	**Reference**
Garvins Falls, NH	Bypass	30	0.0	0.0	0.0	0.0	Normandeau 2005
Amoskeag, NH	Bypass	46	3.0	0.0	0.0	0.0	Normandeau 2006a
Bellows Falls, VT	Sluice	59	2.0	0.0	18.0	18.0	RMC 1991
Wilder, VT	Sluice	52	59.0	0.6	-	-	RMC 1992
Wilder, VT	Sluice	52	36.0	0.6	-	-	RMC 1992
Wilder, VT	Sluice	52	26.0	0.6	-	-	RMC 1992
Vernon, VT	Sluice	27	2.9	4.0			Normandeau 1995

Table 5. **Summary of injury types and frequency of occurrence (among injured and all smolts examined) for Atlantic salmon smolts passed through spillways and sluices at various hydroelectric projects. All tests conducted using the Hi-Z Turb'N Tag.**

				Injury Type			
Interval	**Site Name**	**# of Individuals Examined**	**# of Individuals with Injuries**	**Minor scale loss, <25%**	**Major scale loss, >25%**	**Laceration(s), tear(s)**	**Hemorrhaging, bruised**
Initial (1hr)	Garvins Falls, NH	30	0	0	0	0	0
	Amoskeag, NH	30	1	0	0	0	1
	Bellows Falls, VT	95	3	1	0	0	2
	Wilder, VT	100	59	22	20	7	24
	Wilder, VT	44	16	9	0	2	10
	Wilder, VT	99	26	11	4	0	14
	Vernon, VT	70	2	2	0	0	0
	All Projects	468	107	45	24	9	51
	Percent Occurrence for Smolts with Injuries			**42.1%**	**22.4%**	**8.4%**	**47.7%**
	Percent Occurrence for All Smolts Examined			**9.6%**	**5.1%**	**1.9%**	**10.9%**
Delayed (48 hr)	Garvins Falls, NH	30	0	0	0	0	0
	Amoskeag, NH	30	0	0	0	0	0
	Bellows Falls, VT	38	7	6	0	0	1
	All Projects	98	7	6	0	0	1
	Percent Occurrence for Smolts with Injuries			**85.7%**	**0.0%**	**0.0%**	**14.3%**
	Percent Occurrence for All Smolts Examined			**6.1%**	**0.0%**	**0.0%**	**1.0%**

Table 6. **Survival and associated test parameters for Atlantic salmon smolts passed through spillways and sluices at various hydroelectric projects. All tests conducted using the Hi-Z Turb'N Tag.**

Site Name	Normal head (ft)	Test Discharge (cfs)	Water Temperature (°C)	Test Fish Size (mm)			Control Fish Size (mm)			No. of Fish Released		Immediate Survival (1-hr)	48-hr Survival	Reference
				Min.	Max.	Avg.	Min.	Max.	Avg.	T	C			
Garvins Falls, NH	30	80	13.0	174	208	190	155	203	185	30	20	100.0	100.0	Normandeau 2005
Amoskeag, NH	46	149	14.0	176	226	207.8	178	229	203.8	30	30	100.0	100.0	Normandeau 2006a
Bellows Falls, VT	59	275-340	10.0-11.5	145	358	-	-	-	-	100	100	96.0	96.0	RMC 1991
Wilder, VT	52	200	8.5-15.5	180	245	212	185	240	211.4	245	145	99.0	97.0	RMC 1992
Wilder, VT	52	300	8.5-15.6	180	245	212	185	240	211.4	245	145	93.3	91.1	RMC 1992
Wilder, VT	52	500	8.5-15.7	180	245	212	185	240	211.4	245	145	98.0	97.0	RMC 1992
Vernon, VT	27	40	16.0-17.5	115	216	156	119	200	149	75	25	93.3	93.3	Normandeau 1995

Table 7. Turbine characteristics for Units 1 through 7 at the Lockwood Project.

Parameter	Lockwood Turbines						
	Unit 1	**Unit 2**	**Unit 3**	**Unit 4**	**Unit 5**	**Unit 6**	**Unit 7**
Turbine Type	Vertical Francis	Vertical Francis	Vertical Francis	Vertical Francis	Vertical Francis	Vertical Francis	Horizontal Kaplan
Number blades/buckets	15	15	15	15	15	15	5
Max turbine discharge (cfs)	721	679	710	666	676	670	1,689
Efficiency at max discharge	0.72	0.77	0.71	0.78	0.79	0.79	0.80
Peak turbine discharge (cfs)*	600	607	597	607	578	599	775
Efficiency at peak discharge	0.85	0.79	0.84	0.85	0.82	0.82	0.89
Runner diameter (ft)	-	-	-	-	-	-	9.2
Runner Diameter at inlet (ft)	4.3	4.3	4.3	4.3	4.3	4.3	-
Runner diameter at discharge (ft)	6.6	6.6	6.6	6.6	6.6	6.6	-
Runner height at inlet (ft)	2.7	2.7	2.7	2.7	2.7	2.7	-
RPM	133	133	133	133	133	133	144
Rated head (ft)	21	21	21	21	21	21	21

*Peak turbine discharge is the maximum efficiency for a particular unit.

Table 8. **Initial (1-hr) injury/scale loss rates for Atlantic salmon smolts passed through Kaplan, propeller and Francis units at various hydroelectric projects. All tests conducted using the Hi-Z Turb'N Tag.**

Site Name	Unit Type	Normal head (ft)	RPM	Unit Flow (cfs)	No. of Blades or Buckets	Runner Diameter (ft)	Test Fish Injury Rates (%)	Control Fish Injury Rates (%)	Reference
Briar Rolfe, NH	Kaplan	35	150	-	5	9.84	7.1	0.0	Normandeau 2004
Bar Mills, ME [1]	Propeller	19.5	120	960 & 1,560	5	11.2	6.3, 12.2	0.0	Normandeau and FPL 2002
Lairg, Scotland	Kaplan	-	167	-	4	8.5	3.2	-	Normandeau and Fishtrack 1998
Cliff, Ireland	Kaplan	32.8	115.3	-	5	14.1	4.0	2.0	Normandeau and Fishtrack 2002
Cathleens Falls, Ireland	Kaplan	93.5	187.5	-	5	12.6	7.0	0.0	Normandeau and Fishtrack 2002
Ardnacrusha, Ireland [1]	Kaplan	93	167	-	5	16.4	10.6, 8.8	0.0	Normandeau and Fishtrack 2004
Wilder, VT-NH	Kaplan	51	112.5	-	5	9.0	4.8	0.0	Normandeau 1994
Vernon, VT [1]	Kaplan	34	144	1,250 & 1,600	5	10.2	9.4, 11.5	0.1	Normandeau 2009
West Buxton, ME	Propeller	26.8	120	1,360 & 1,800	6	11.1	13.7	-	Normandeau 1999
McIndoes, NH [1]	Propeller	26	150	800 & 1,600	4	10.0	0.6, 6.4	1.0	Normandeau 2006b
West Buxton, ME	Francis	26.8	150	611	16	4.0	30.8	-	Normandeau 1999
Vernon, VT	Francis	34	133.3	1,280	14	5.2	16.7	0.0	Normandeau 1996

1 - Tested two different settings

Table 9. Summary of injury types and frequency of occurrence for Atlantic salmon smolts passed through Kaplan, propeller and Francis units at various hydroelectric projects. All tests conducted using the Hi-Z Turb'N Tag.

Unit Type	Site Name	Unit Type	# of Individuals Examined	# of Individuals with Injuries	Injury Type									
					Loss of Equilibrium	**Minor scale loss, <25%**	**Major scale loss, >25%**	**Operculum/gill damage**	**Severed body/ back bone**	**Ruptured/ hemorrhaged eye**	**Bruised head or body**	**Cut/tear on head or body**	**Internal Injuries**	**Other**
Kaplan Units	Briar Rolfe, NH	Kaplan	70	5	2		2		1					
	Bar Mills, ME	Propeller	96	9	1			2	5				1	
	Lairg, Scotland	Kaplan	94	3					1	1		1	1	
	Cliff, Ireland	Kaplan	75	3					3					
	Cathleens Falls, Ireland	Kaplan	71	5				1	4					1
	Ardnacrusha, Ireland	Kaplan	185	18	10			4	4	2				
	Wilder, VT-NH	Kaplan	120	6	1		1		2		2	2		
	Vernon, VT	Kaplan	259	27	4		4	6	3	2	11	1	4	
	West Buxton, ME	Propeller	73	10	4	1					6	3		
	McIndoes, NH	Propeller	310	11	3			2	5	2	1	1		
	All Projects		1353	97	25	1	7	15	28	7	20	8	6	1
	Percent Occurrence for Smolts with Injuries				**25.8%**	**1.0%**	**7.2%**	**15.5%**	**28.9%**	**7.2%**	**20.6%**	**8.2%**	**6.2%**	**1.0%**
	Percent Occurrence for All Smolts Examined				**1.8%**	**0.1%**	**0.5%**	**1.1%**	**2.1%**	**0.5%**	**1.5%**	**0.6%**	**0.4%**	**0.1%**
Francis Units	West Buxton, ME	Francis	39	12	6	2	1		2		2	2		
	Vernon, VT	Francis	24	4	1	1			3					
	All Projects		63	16	7	3	1	0	5	0	2	2	0	0
	Percent Occurrence for Smolts with Injuries				**43.8%**	**18.8%**	**6.3%**	**0.0%**	**31.3%**	**0.0%**	**12.5%**	**12.5%**	**0.0%**	**0.0%**
	Percent Occurrence for All Smolts Examined				**11.1%**	**4.8%**	**1.6%**	**0.0%**	**7.9%**	**0.0%**	**3.2%**	**3.2%**	**0.0%**	**0.0%**

Table 10. **Immediate (1 hr) and delayed (48 hr) survival for Atlantic salmon smolts passed through Francis turbines at various hydroelectric projects. Note: All studies conducted using the Hi-Z Turb'N Tag.**

Site Name	Unit Type	Normal head (ft)	RPM	Unit Flow (cfs)	No. of Blades or Buckets	Runner Diameter (ft)	Immediate Survival (1-hr)	Delayed Survival (48-hr)	Reference
West Buxton, ME	Francis	26.8	150	611	16	4.0	85.0	85.0 [1]	Normandeau 1999
Vernon, VT	Francis	34	133.3	1,280	14	5.2	85.1	85.1	Normandeau 1996

1 - This value represents 24-hr survival

Table 11. Immediate (1 hr) and delayed (48 hr) survival for Atlantic salmon smolts passed through Kaplan/propeller turbines at various hydroelectric projects. Note: All studies conducted using the Hi-Z Turb'N Tag.

Site Name	Unit Type	Normal head (ft)	RPM	Unit Flow (cfs)	No. of Blades or Buckets	Runner Diameter (ft)	Immediate Survival (1-hr)	Delayed Survival (48-hr)	Reference
Briar Rolfe, NH	Kaplan	35	150	-	5	9.84	95.7	95.7	Normandeau 2004
Bar Mills, ME [1]	Propeller	19.5	120	960 & 1,560	5	11.2	88.0 & 94.0	88.0 & 88.0 [2]	Normandeau and FPL 2002
Lairg, Scotland	Kaplan	-	167	-	4	8.5	91.0	91.0	Normandeau and Fishtrack 1998
Cliff, Ireland	Kaplan	32.8	115.3	-	5	14.1	92.3	92.2	Normandeau and Fishtrack 2002
Cathleens Falls, Ireland	Kaplan	93.5	187.5	-	5	12.6	89.3	88.0	Normandeau and Fishtrack 2002
Ardnacrusha, Ireland [1]	Kaplan	93	167	-	5	16.4	96.3 & 95.2	96.3 & 87.5	Normandeau and Fishtrack 2004
Wilder, VT-NH	Kaplan	51	112.5	-	5	9.0	96.0	94.3	Normandeau 1994
Vernon, VT [1]	Kaplan	34	120	1,250 & 1,600	5	10.2	94.7 & 98.5	92.3 & 89.3	Normandeau 2009
West Buxton, ME [1]	Propeller	26.8	120	1,360 & 1,800	6	11.1	100.0 & 94.0	100.0 & 94.0 [3]	Normandeau 1999
McIndoes, NH [1]	Propeller	26	150	800 & 1,600	4	10.0	100.0 & 96.1	100.0 & 94.8	Normandeau 2006b

1 - Tested two different settings

2 - These values represent 24 hour survival

3 - These values represent 72 hour survival

Table 12. Predicted survival rates for salmon smolts passed through Francis Units 1-6 at the Lockwood Project under maximum turbine operating conditions.

Unit	Turbine Type	Maximum Discharge (cfs)	Efficiency at Max. Discharge (%)	Correlation Factor	Predicted Survival (%) by Smolt Length (in)						Unit Average
					5	6	7	8	9	Range	
1	Vertical Francis	721	0.72	0.1	91.6	90.0	88.3	86.6	85.0	85.0 - 90.0	82.5
				0.2	83.3	80.0	76.6	73.3	69.9	69.9 - 80.0	
2	Vertical Francis	679	0.77	0.1	91.4	89.7	88.0	86.3	84.5	84.5 - 91.4	82.0
				0.2	82.8	79.4	75.9	72.5	69.1	69.1 - 82.8	
3	Vertical Francis	710	0.71	0.1	91.6	89.9	88.2	86.5	84.8	84.8 - 91.6	82.3
				0.2	83.1	79.7	76.4	73.0	69.6	69.9 - 83.1	
4	Vertical Francis	666	0.78	0.1	91.4	89.6	87.9	86.2	84.5	84.5 - 91.4	81.9
				0.2	82.7	79.3	75.8	72.4	68.9	68.9 - 82.7	
5	Vertical Francis	676	0.79	0.1	91.3	89.6	87.9	86.1	84.4	84.4 - 91.3	81.8
				0.2	82.7	79.2	75.8	72.3	68.8	68.8 - 82.7	
6	Vertical Francis	670	0.79	0.1	91.4	89.6	87.9	86.2	84.5	84.5 - 91.4	81.9
				0.2	82.7	79.3	75.8	72.4	68.9	68.9 - 82.7	

Table 13. **Predicted survival rates for salmon smolts passed through Kaplan Unit 7 at the Lockwood Project under maximum turbine operating conditions.**

Correlation Factor	Fish Entry Point (ft)	Predicted Survival (%) by Smolt Length (in)						Unit Average
		5	6	7	8	9	Range	
0.1	blade tip	92.5	91.0	89.5	88.0	86.5	86.5 - 92.5	91.6
	mid-blade	97.6	97.1	96.6	96.1	95.6	95.6 - 97.6	
	near hub	97.9	97.5	97.0	96.6	96.2	96.2 - 97.9	
0.2	blade tip	85.0	82.0	79.0	76.0	73.0	73.0 - 85.0	
	mid-blade	95.2	94.2	93.2	92.2	91.3	91.3 - 95.2	
	near hub	95.8	94.9	94.1	93.2	92.4	92.4 - 95.8	

Table 14. Impacts to the whole station smolt survival estimate obtained using the Initial Survival Rate Model (Model A) for theoretical downstream bypass effectiveness rates.

	Evaluated Downstream Bypass Effectiveness Rates									
	0.188	**0.25**	**0.35**	**0.45**	**0.55**	**0.65**	**0.75**	**0.85**	**0.95**	**1.00**
Theoretical Number of Smolts	*1,000*	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway	*0.301*	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
Number of Smolts Passed via Spillway	*301*	301	301	301	301	301	301	301	301	301
Spillway/Bypass Survival Rate	*0.971*	0.971	0.971	0.971	0.971	0.971	0.971	0.971	0.971	0.971
Number Smolts Surviving Spill	*292*	292	292	292	292	292	292	292	292	292
Proportion of Smolts to Forebay Canal	*0.699*	0.699	0.699	0.699	0.699	0.699	0.699	0.699	0.699	0.699
Number of Smolts to Forebay Canal	*699*	699	699	699	699	699	699	699	699	699
Number of Smolts Passed via Bypass	*131*	175	245	315	384	454	524	594	664	699
Number of Smolts Surviving Bypass	*128*	170	238	305	373	441	509	577	645	679
Number of Smolts Passed via Turbines	*568*	524	454	384	315	245	175	105	35	0
Proportion of Smolts Passed via Francis units	*0.324*	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324
Proportion of Smolts Passed via Kaplan unit	*0.676*	0.676	0.676	0.676	0.676	0.676	0.676	0.676	0.676	0.676
Number of Smolts Passed via Francis	*184*	170	147	125	102	79	57	34	11	0
Number of Smolts Passed via Kaplan	*384*	354	307	260	213	165	118	71	24	0
Francis Turbine Survival Rate	*0.851*	0.851	0.851	0.851	0.851	0.851	0.851	0.851	0.851	0.851
Kaplan Turbine Survival Rate	*0.947*	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947
Number Smolts Surviving Francis	*156*	145	125	106	87	67	48	29	10	0
Number Smolts Surviving Kaplan	*363*	336	291	246	201	157	112	67	22	0
TOTAL SMOLT SURVIVAL	***940***	**942**	**946**	**950**	**954**	**958**	**961**	**965**	**969**	**971**
WHOLE STATION ESTIMATE	***94%***	**94%**	**95%**	**95%**	**95%**	**96%**	**96%**	**97%**	**97%**	**97%**

Italics indicates model estimate is based on existing conditions

Table 15. Impacts to the whole station smolt survival estimate obtained using the Initial Survival Rate Model (Model A) for theoretical spill effectiveness rates.

	Evaluated Spill Effectiveness Rates									
	1:1	**0.3:1**	**0.7:1**	**1:1**	**1.3:1**	**1.7:1**	**2:1**	**2.3:1**	**2.7:1**	**3:1**
	0.301	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Proportion of River Flow to Spillway	*0.301*	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
Proportion of River Flow to Forebay Canal	*0.699*	0.699	0.699	0.699	0.699	0.699	0.699	0.699	0.699	0.699
Theoretical Number of Smolts	*1,000*	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Number of Smolts Passed via Spillway	*301*	100	200	300	400	500	600	700	800	900
Spillway/Bypass Survival Rate	*0.971*	0.971	0.971	0.971	0.971	0.971	0.971	0.971	0.971	0.971
Number Smolts Surviving Spill	*292*	97	194	291	388	486	583	680	777	874
Proportion of Smolts to Forebay Canal	*0.699*	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Number of Smolts to Forebay Canal	*699*	900	800	700	600	500	400	300	200	100
Bypass Effectiveness Rate	*0.188*	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188
Number of Smolts Passed via Bypass	*131*	169	150	132	113	94	75	56	38	19
Number of Smolts Surviving Bypass	*128*	164	146	128	110	91	73	55	37	18
Number of Smolts Passed via Turbines	*568*	731	650	568	487	406	325	244	162	81
Proportion of Smolts Passed via Francis units	*0.324*	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324
Proportion of Smolts Passed via Kaplan unit	*0.676*	0.676	0.676	0.676	0.676	0.676	0.676	0.676	0.676	0.676
Number of Smolts Passed via Francis	*184*	237	210	184	158	132	105	79	53	26
Number of Smolts Passed via Kaplan	*384*	494	439	384	329	274	220	165	110	55
Francis Turbine Survival Rate	*0.851*	0.851	0.851	0.851	0.851	0.851	0.851	0.851	0.851	0.851
Kaplan Turbine Survival Rate	*0.947*	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947
Number Smolts Surviving Francis	*156*	201	179	157	134	112	90	67	45	22
Number Smolts Surviving Kaplan	*363*	468	416	364	312	260	208	156	104	52
TOTAL SMOLT SURVIVAL	***940***	**931**	**935**	**940**	**944**	**949**	**953**	**958**	**962**	**967**
WHOLE STATION ESTIMATE	***94%***	**93%**	**94%**	**94%**	**94%**	**95%**	**95%**	**96%**	**96%**	**97%**

Italics indicates model estimate is based 1:1 spill effectiveness ratio

Table 16. Approximate river discharge (cfs) for Kennebec River at Lockwood during April, May and June for low (i.e. 75 and 90% exceedence) and high (10 and 25% exceedence) flow conditions.

Percent of Time Flow is Exceeded	River Discharge (cfs)		
	April	May	June
10	32,000	22,000	14,000
25	20,500	15,500	8,500
50	13,000	9,000	5,500
75	9,000	5,750	4,250
90	6,500	4,250	3,250

Italics indicates values used for primary model

Table 17. Impacts to the whole station smolt survival estimate obtained using the Initial Survival Rate Model (Model A) for theoretical seasonal flow conditions.

	Percent of Time Flow is Exceeded				
	50	**10**	**25**	**75**	**90**
Theoretical Number of Smolts	*1,000*	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway	*0.301*	0.716	0.577	0.026	0.002
Number of Smolts Passed via Spillway	*301*	716	577	26	2
Spillway/Bypass Survival Rate	*0.971*	0.971	0.971	0.971	0.971
Number Smolts Surviving Spill	*292*	695	560	25	2
Proportion of Smolts to Forebay Canal	*0.699*	0.284	0.423	0.974	0.998
Number of Smolts to Forebay Canal	*699*	284	423	974	998
Bypass Effectiveness Rate	*0.188*	0.188	0.188	0.188	0.188
Number of Smolts Passed via Bypass	*131*	53	80	183	188
Number of Smolts Surviving Bypass	*128*	52	77	178	182
Number of Smolts Passed via Turbines	*568*	231	343	791	810
Proportion of Smolts Passed via Francis units	*0.324*	0.324	0.324	0.324	0.324
Proportion of Smolts Passed via Kaplan unit	*0.676*	0.676	0.676	0.676	0.676
Number of Smolts Passed via Francis	*184*	75	111	256	263
Number of Smolts Passed via Kaplan	*384*	156	232	535	548
Francis Turbine Survival Rate	*0.851*	0.851	0.851	0.851	0.851
Kaplan Turbine Survival Rate	*0.947*	0.947	0.947	0.947	0.947
Number Smolts Surviving Francis	*156*	64	95	218	223
Number Smolts Surviving Kaplan	*363*	148	220	506	519
TOTAL SMOLT SURVIVAL	***940***	**958**	**952**	**927**	**926**
WHOLE STATION ESTIMATE	***94%***	**96%**	**95%**	**93%**	**93%**

Italics indicates our existing model

Table 18. Impacts to the whole station smolt survival estimate obtained using the Delayed Survival Rate Model (Model B) for theoretical downstream bypass effectiveness rates.

	Evaluated Downstream Bypass Effectiveness Rates									
	0.188	**0.25**	**0.35**	**0.45**	**0.55**	**0.65**	**0.75**	**0.85**	**0.95**	**1.00**
Theoretical Number of Smolts	*1,000*	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway	*0.301*	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
Number of Smolts Passed via Spillway	*301*	301	301	301	301	301	301	301	301	301
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963	0.963	0.963	0.963	0.963	0.963
Number Smolts Surviving Spill	*290*	290	290	290	290	290	290	290	290	290
Proportion of Smolts to Forebay Canal	*0.699*	0.699	0.699	0.699	0.699	0.699	0.699	0.699	0.699	0.699
Number of Smolts to Forebay Canal	*699*	699	699	699	699	699	699	699	699	699
Number of Smolts Passed via Bypass	*131*	175	245	315	384	454	524	594	664	699
Number of Smolts Surviving Bypass	*127*	168	236	303	370	438	505	572	639	673
Number of Smolts Passed via Turbines	*568*	524	454	384	315	245	175	105	35	0
Proportion of Smolts Passed via Francis units	*0.324*	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324
Proportion of Smolts Passed via Kaplan unit	*0.676*	0.676	0.676	0.676	0.676	0.676	0.676	0.676	0.676	0.676
Number of Smolts Passed via Francis	*184*	170	147	125	102	79	57	34	11	0
Number of Smolts Passed via Kaplan	*384*	354	307	260	213	165	118	71	24	0
Francis Turbine Survival Rate	*0.851*	0.851	0.851	0.851	0.851	0.851	0.851	0.851	0.851	0.851
Kaplan Turbine Survival Rate	*0.928*	0.928	0.928	0.928	0.928	0.928	0.928	0.928	0.928	0.928
Number Smolts Surviving Francis	*156*	145	125	106	87	67	48	29	10	0
Number Smolts Surviving Kaplan	*356*	329	285	241	197	153	110	66	22	0
TOTAL SMOLT SURVIVAL	***929***	**932**	**936**	**940**	**944**	**948**	**953**	**957**	**961**	**963**
WHOLE STATION ESTIMATE	***93%***	**93%**	**94%**	**94%**	**94%**	**95%**	**95%**	**96%**	**96%**	**96%**

Italics indicates model estimate is based on existing conditions

Table 19. Impacts to the whole station smolt survival estimate obtained using the Delayed Survival Rate Model (Model B) for theoretical spill effectiveness rates.

	Evaluated Spill Effectiveness Rates									
	1:1	**0.3:1**	**0.7:1**	**1:1**	**1.3:1**	**1.7:1**	**2:1**	**2.3:1**	**2.7:1**	**3:1**
	0.301	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Proportion of River Flow to Spillway	*0.301*	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
Proportion of River Flow to Forebay Canal	*0.699*	0.699	0.699	0.699	0.699	0.699	0.699	0.699	0.699	0.699
Theoretical Number of Smolts	*1,000*	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Number of Smolts Passed via Spillway	*301*	100	200	300	400	500	600	700	800	900
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963	0.963	0.963	0.963	0.963	0.963
Number Smolts Surviving Spill	*290*	96	193	289	385	482	578	674	770	867
Proportion of Smolts to Forebay Canal	*0.699*	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Number of Smolts to Forebay Canal	*699*	900	800	700	600	500	400	300	200	100
Bypass Effectiveness Rate	*0.188*	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188
Number of Smolts Passed via Bypass	*131*	169	150	132	113	94	75	56	38	19
Number of Smolts Surviving Bypass	*127*	163	145	127	109	91	72	54	36	18
Number of Smolts Passed via Turbines	*568*	731	650	568	487	406	325	244	162	81
Proportion of Smolts Passed via Francis units	*0.324*	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324
Proportion of Smolts Passed via Kaplan unit	*0.676*	0.676	0.676	0.676	0.676	0.676	0.676	0.676	0.676	0.676
Number of Smolts Passed via Francis	*184*	237	210	184	158	132	105	79	53	26
Number of Smolts Passed via Kaplan	*384*	494	439	384	329	274	220	165	110	55
Francis Turbine Survival Rate	*0.851*	0.851	0.851	0.851	0.851	0.851	0.851	0.851	0.851	0.851
Kaplan Turbine Survival Rate	*0.928*	0.928	0.928	0.928	0.928	0.928	0.928	0.928	0.928	0.928
Number Smolts Surviving Francis	*156*	201	179	157	134	112	90	67	45	22
Number Smolts Surviving Kaplan	*356*	458	408	357	306	255	204	153	102	51
TOTAL SMOLT SURVIVAL	***929***	**919**	**924**	**929**	**934**	**939**	**944**	**948**	**953**	**958**
WHOLE STATION ESTIMATE	***93%***	**92%**	**92%**	**93%**	**93%**	**94%**	**94%**	**95%**	**95%**	**96%**

Italics indicates model estimate is based 1:1 spill effectiveness ratio

Table 20. Impacts to the whole station smolt survival estimate obtained using the Delayed Survival Rate Model (Model B) for theoretical seasonal flow conditions.

	Percent of Time Flow is Exceeded				
	50	**10**	**25**	**75**	**90**
Theoretical Number of Smolts	*1,000*	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway	*0.301*	0.716	0.577	0.026	0.002
Number of Smolts Passed via Spillway	*301*	716	577	26	2
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963
Number Smolts Surviving Spill	*290*	690	556	25	2
Proportion of Smolts to Forebay Canal	*0.699*	0.284	0.423	0.974	0.998
Number of Smolts to Forebay Canal	*699*	284	423	974	998
Bypass Effectiveness Rate	*0.188*	0.188	0.188	0.188	0.188
Number of Smolts Passed via Bypass	*131*	53	80	183	188
Number of Smolts Surviving Bypass	*127*	51	77	176	181
Number of Smolts Passed via Turbines	*568*	231	343	791	810
Proportion of Smolts Passed via Francis units	*0.324*	0.324	0.324	0.324	0.324
Proportion of Smolts Passed via Kaplan unit	*0.676*	0.676	0.676	0.676	0.676
Number of Smolts Passed via Francis	*184*	75	111	256	263
Number of Smolts Passed via Kaplan	*384*	156	232	535	548
Francis Turbine Survival Rate	*0.851*	0.851	0.851	0.851	0.851
Kaplan Turbine Survival Rate	*0.928*	0.928	0.928	0.928	0.928
Number Smolts Surviving Francis	*156*	64	95	218	223
Number Smolts Surviving Kaplan	*356*	145	215	496	508
TOTAL SMOLT SURVIVAL	***929***	**949**	**942**	**916**	**914**
WHOLE STATION ESTIMATE	***93%***	**95%**	**94%**	**92%**	**91%**

Italics indicates our existing model

Table 21. **Impacts to the whole station smolt survival estimate obtained using the Delayed/Calculated Survival Rate Model (Model C) for theoretical downstream bypass effectiveness rates.**

	Evaluated Downstream Bypass Effectiveness Rates									
	0.188	**0.25**	**0.35**	**0.45**	**0.55**	**0.65**	**0.75**	**0.85**	**0.95**	**1.00**
Theoretical Number of Smolts	*1,000*	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway	*0.301*	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
Number of Smolts Passed via Spillway	*301*	301	301	301	301	301	301	301	301	301
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963	0.963	0.963	0.963	0.963	0.963
Number Smolts Surviving Spill	*290*	290	290	290	290	290	290	290	290	290
Proportion of Smolts to Forebay Canal	*0.699*	0.699	0.699	0.699	0.699	0.699	0.699	0.699	0.699	0.699
Number of Smolts to Forebay Canal	*699*	699	699	699	699	699	699	699	699	699
Number of Smolts Passed via Bypass	*131*	175	245	315	384	454	524	594	664	699
Number of Smolts Surviving Bypass	*127*	168	236	303	370	438	505	572	639	673
Number of Smolts Passed via Turbines	*568*	524	454	384	315	245	175	105	35	0
Proportion of Smolts Passed via Francis units	*0.324*	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324
Proportion of Smolts Passed via Kaplan unit	*0.676*	0.676	0.676	0.676	0.676	0.676	0.676	0.676	0.676	0.676
Number of Smolts Passed via Francis	*184*	170	147	125	102	79	57	34	11	0
Number of Smolts Passed via Kaplan	*384*	354	307	260	213	165	118	71	24	0
Francis Turbine Survival Rate	*0.82*	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
Kaplan Turbine Survival Rate	*0.916*	0.916	0.916	0.916	0.916	0.916	0.916	0.916	0.916	0.916
Number Smolts Surviving Francis	*151*	139	121	102	84	65	46	28	9	0
Number Smolts Surviving Kaplan	*351*	325	281	238	195	151	108	65	22	0
TOTAL SMOLT SURVIVAL	***919***	**922**	**928**	**933**	**938**	**944**	**949**	**955**	**960**	**963**
WHOLE STATION ESTIMATE	***92%***	**92%**	**93%**	**93%**	**94%**	**94%**	**95%**	**95%**	**96%**	**96%**

Italics indicates model estimate is based on existing conditions

Table 22. Impacts to the whole station smolt survival estimate obtained using the Delayed/Calculated Survival Rate Model (Model C) for theoretical spill effectiveness rates.

	Evaluated Spill Effectiveness Rates									
	1:1	**0.3:1**	**0.7:1**	**1:1**	**1.3:1**	**1.7:1**	**2:1**	**2.3:1**	**2.7:1**	**3:1**
	0.301	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Proportion of River Flow to Spillway	*0.301*	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
Proportion of River Flow to Forebay Canal	*0.699*	0.699	0.699	0.699	0.699	0.699	0.699	0.699	0.699	0.699
Theoretical Number of Smolts	*1,000*	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Number of Smolts Passed via Spillway	*301*	100	200	300	400	500	600	700	800	900
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963	0.963	0.963	0.963	0.963	0.963
Number Smolts Surviving Spill	*290*	96	193	289	385	482	578	674	770	867
Proportion of Smolts to Forebay Canal	*0.699*	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Number of Smolts to Forebay Canal	*699*	900	800	700	600	500	400	300	200	100
Bypass Effectiveness Rate	*0.188*	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188
Number of Smolts Passed via Bypass	*131*	169	150	132	113	94	75	56	38	19
Number of Smolts Surviving Bypass	*127*	163	145	127	109	91	72	54	36	18
Number of Smolts Passed via Turbines	*568*	731	650	568	487	406	325	244	162	81
Proportion of Smolts Passed via Francis units	*0.324*	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324
Proportion of Smolts Passed via Kaplan unit	*0.676*	0.676	0.676	0.676	0.676	0.676	0.676	0.676	0.676	0.676
Number of Smolts Passed via Francis	*184*	237	210	184	158	132	105	79	53	26
Number of Smolts Passed via Kaplan	*384*	494	439	384	329	274	220	165	110	55
Francis Turbine Survival Rate	*0.82*	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
Kaplan Turbine Survival Rate	*0.916*	0.916	0.916	0.916	0.916	0.916	0.916	0.916	0.916	0.916
Number Smolts Surviving Francis	*151*	194	173	151	129	108	86	65	43	22
Number Smolts Surviving Kaplan	*351*	453	402	352	302	251	201	151	101	50
TOTAL SMOLT SURVIVAL	***919***	**906**	**912**	**919**	**925**	**931**	**938**	**944**	**950**	**957**
WHOLE STATION ESTIMATE	***92%***	**91%**	**91%**	**92%**	**92%**	**93%**	**94%**	**94%**	**95%**	**96%**

Italics indicates model estimate is based 1:1 spill effectiveness ratio

Table 23. Impacts to the whole station smolt survival estimate obtained using the Delayed/Calculated Survival Rate Model (Model C) for theoretical seasonal flow conditions.

	Percent of Time Flow is Exceeded				
	50	**10**	**25**	**75**	**90**
Theoretical Number of Smolts	*1,000*	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway	*0.301*	0.716	0.577	0.026	0.002
Number of Smolts Passed via Spillway	*301*	716	577	26	2
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963
Number Smolts Surviving Spill	*290*	690	556	25	2
Proportion of Smolts to Forebay Canal	*0.699*	0.284	0.423	0.974	0.998
Number of Smolts to Forebay Canal	*699*	284	423	974	998
Bypass Effectiveness Rate	*0.188*	0.188	0.188	0.188	0.188
Number of Smolts Passed via Bypass	*131*	53	80	183	188
Number of Smolts Surviving Bypass	*127*	51	77	176	181
Number of Smolts Passed via Turbines	*568*	231	343	791	810
Proportion of Smolts Passed via Francis units	*0.324*	0.324	0.324	0.324	0.324
Proportion of Smolts Passed via Kaplan unit	*0.676*	0.676	0.676	0.676	0.676
Number of Smolts Passed via Francis	*184*	75	111	256	263
Number of Smolts Passed via Kaplan	*384*	156	232	535	548
Francis Turbine Survival Rate	*0.82*	0.82	0.82	0.82	0.82
Kaplan Turbine Survival Rate	*0.916*	0.916	0.916	0.916	0.916
Number Smolts Surviving Francis	*151*	61	91	210	215
Number Smolts Surviving Kaplan	*351*	143	213	490	502
TOTAL SMOLT SURVIVAL	***919***	**945**	**936**	**901**	**900**
WHOLE STATION ESTIMATE	***92%***	**94%**	**94%**	**90%**	**90%**

Italics indicates our existing model

Table 24. Impacts to the whole station smolt survival estimate obtained using the Initial Injury Rate Model (Model D) for theoretical downstream bypass effectiveness rates.

	Evaluated Downstream Bypass Effectiveness Rates									
	0.188	**0.25**	**0.35**	**0.45**	**0.55**	**0.65**	**0.75**	**0.85**	**0.95**	**1.00**
Theoretical Number of Smolts	*1,000*	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway	*0.301*	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
Number of Smolts Passed via Spillway	*301*	301	301	301	301	301	301	301	301	301
Spillway/Bypass Survival Rate	*0.816*	0.816	0.816	0.816	0.816	0.816	0.816	0.816	0.816	0.816
Number Smolts Surviving Spill	*246*	246	246	246	246	246	246	246	246	246
Proportion of Smolts to Forebay Canal	*0.699*	0.699	0.699	0.699	0.699	0.699	0.699	0.699	0.699	0.699
Number of Smolts to Forebay Canal	*699*	699	699	699	699	699	699	699	699	699
Number of Smolts Passed via Bypass	*131*	175	245	315	384	454	524	594	664	699
Number of Smolts Surviving Bypass	*107*	143	200	257	314	371	428	485	542	570
Number of Smolts Passed via Turbines	*568*	524	454	384	315	245	175	105	35	0
Proportion of Smolts Passed via Francis units	*0.324*	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324
Proportion of Smolts Passed via Kaplan unit	*0.676*	0.676	0.676	0.676	0.676	0.676	0.676	0.676	0.676	0.676
Number of Smolts Passed via Francis	*184*	170	147	125	102	79	57	34	11	0
Number of Smolts Passed via Kaplan	*384*	354	307	260	213	165	118	71	24	0
Francis Turbine Survival Rate	*0.762*	0.762	0.762	0.762	0.762	0.762	0.762	0.762	0.762	0.762
Kaplan Turbine Survival Rate	*0.925*	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925
Number Smolts Surviving Francis	*140*	129	112	95	78	60	43	26	9	0
Number Smolts Surviving Kaplan	*355*	328	284	240	197	153	109	66	22	0
TOTAL SMOLT SURVIVAL	***848***	**845**	**842**	**838**	**834**	**830**	**826**	**822**	**818**	**816**
WHOLE STATION ESTIMATE	***85%***	**85%**	**84%**	**84%**	**83%**	**83%**	**83%**	**82%**	**82%**	**82%**

Italics indicates model estimate is based on existing conditions

Table 25. Impacts to the whole station smolt survival estimate obtained using the Initial Injury Rate Model (Model D) for theoretical spill effectiveness rates.

	Evaluated Spill Effectiveness Rates									
	1:1	**0.3:1**	**0.7:1**	**1:1**	**1.3:1**	**1.7:1**	**2:1**	**2.3:1**	**2.7:1**	**3:1**
	0.301	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Proportion of River Flow to Spillway	*0.301*	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
Proportion of River Flow to Forebay Canal	*0.699*	0.699	0.699	0.699	0.699	0.699	0.699	0.699	0.699	0.699
Theoretical Number of Smolts	*1,000*	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Number of Smolts Passed via Spillway	*301*	100	200	300	400	500	600	700	800	900
Spillway/Bypass Survival Rate	*0.816*	0.816	0.816	0.816	0.816	0.816	0.816	0.816	0.816	0.816
Number Smolts Surviving Spill	*246*	82	163	245	326	408	490	571	653	734
Proportion of Smolts to Forebay Canal	*0.699*	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Number of Smolts to Forebay Canal	*699*	900	800	700	600	500	400	300	200	100
Bypass Effectiveness Rate	*0.188*	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188
Number of Smolts Passed via Bypass	*131*	169	150	132	113	94	75	56	38	19
Number of Smolts Surviving Bypass	*107*	138	123	107	92	77	61	46	31	15
Number of Smolts Passed via Turbines	*568*	731	650	568	487	406	325	244	162	81
Proportion of Smolts Passed via Francis units	*0.324*	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324
Proportion of Smolts Passed via Kaplan unit	*0.676*	0.676	0.676	0.676	0.676	0.676	0.676	0.676	0.676	0.676
Number of Smolts Passed via Francis	*184*	237	210	184	158	132	105	79	53	26
Number of Smolts Passed via Kaplan	*384*	494	439	384	329	274	220	165	110	55
Francis Turbine Survival Rate	*0.762*	0.762	0.762	0.762	0.762	0.762	0.762	0.762	0.762	0.762
Kaplan Turbine Survival Rate	*0.925*	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925
Number Smolts Surviving Francis	*140*	180	160	140	120	100	80	60	40	20
Number Smolts Surviving Kaplan	*355*	457	406	355	305	254	203	152	102	51
TOTAL SMOLT SURVIVAL	***848***	**857**	**852**	**848**	**843**	**839**	**834**	**830**	**825**	**821**
WHOLE STATION ESTIMATE	***85%***	**86%**	**85%**	**85%**	**84%**	**84%**	**83%**	**83%**	**83%**	**82%**

Italics indicates model estimate is based 1:1 spill effectiveness ratio

Table 26. Impacts to the whole station smolt survival estimate obtained using the Initial Injury Rate Model (Model D) for theoretical seasonal flow conditions.

	Percent of Time Flow is Exceeded				
	50	**10**	**25**	**75**	**90**
Theoretical Number of Smolts	*1,000*	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway	*0.301*	0.716	0.577	0.026	0.002
Number of Smolts Passed via Spillway	*301*	716	577	26	2
Spillway/Bypass Survival Rate	*0.816*	0.816	0.816	0.816	0.816
Number Smolts Surviving Spill	*246*	584	471	21	2
Proportion of Smolts to Forebay Canal	*0.699*	0.284	0.423	0.974	0.998
Number of Smolts to Forebay Canal	*699*	284	423	974	998
Bypass Effectiveness Rate	*0.188*	0.188	0.188	0.188	0.188
Number of Smolts Passed via Bypass	*131*	53	80	183	188
Number of Smolts Surviving Bypass	*107*	44	65	149	153
Number of Smolts Passed via Turbines	*568*	231	343	791	810
Proportion of Smolts Passed via Francis units	*0.324*	0.324	0.324	0.324	0.324
Proportion of Smolts Passed via Kaplan unit	*0.676*	0.676	0.676	0.676	0.676
Number of Smolts Passed via Francis	*184*	75	111	256	263
Number of Smolts Passed via Kaplan	*384*	156	232	535	548
Francis Turbine Survival Rate	*0.762*	0.762	0.762	0.762	0.762
Kaplan Turbine Survival Rate	*0.925*	0.925	0.925	0.925	0.925
Number Smolts Surviving Francis	*140*	57	85	195	200
Number Smolts Surviving Kaplan	*355*	144	215	495	507
TOTAL SMOLT SURVIVAL	***848***	**829**	**835**	**860**	**862**
WHOLE STATION ESTIMATE	***85%***	**83%**	**84%**	**86%**	**86%**

Italics indicates our existing model

Table 27. Summary of upstream passage and associated biological data for adult Atlantic salmon at the Lockwood Project during 2006-2011.

Passage Year	# Individuals	Fork Length (cm)			Sea Age (yrs)	
		Min	Max	Mean	Min	Max
2006	15	50.0	79.0	65.0	1	2
2007[a]	15	53.0	87.0	70.2	1	3
2008	22	55.0	80.0	68.4	1	2
2009[b]	32	58.0	81.0	72.1	1	2
2010	5	50.0	76.0	67.1	1	2
2011	64	53.0	82.0	73.5	1	2

a - length and weight data includes one individual captured in Sebasticook River

b - length and weight data based on 28 individuals

Table 28. Estimated percentage of kelts entering the Lockwood Project forebay canal or passing via spillway.

	Discharge (cfs)			Percent of River Discharge			Project Kelt Distribution[5]	
Month	**River Discharge[1]**	**Lockwood [2]**	**Calculated Spill [3]**	**Spill**	**Forebay Canal**	**Kelt Run Distribution[4]**	**Spill**	**Forebay Canal**
April	13,000	5,600	7,400	56.9%	43.1%	40.0%	22.8%	17.2%
May	9,000	5,600	3,400	37.8%	62.2%	40.0%	15.1%	24.9%
October	4,500	4,500	0	0.0%	100.0%	5.0%	0.0%	5.0%
November	6,000	5,600	400	6.7%	93.3%	10.0%	0.7%	9.3%
December	5,750	5,600	150	2.6%	97.4%	5.0%	0.1%	4.9%
TOTAL	-	-	-	-	-	-	**38.7%**	**61.3%**

1 - Monthly median condition as obtained from Project flow duration curves (50% exceedence)

2 - Project capacity

3 - Equal to River discharge - Project capacity

4 - Mean monthly distribution of Atlantic salmon kelt migrations based on Baum (1997)

5 - Based on 1:1 assumption of spill effectiveness

Table 29. Predicted survival rates for salmon kelts passed through Francis Units 1-6 at the Lockwood Project under maximum turbine operating conditions.

Unit	Turbine Type	Maximum Discharge (cfs)	Efficiency at Max. Discharge	Correlation Factor	Predicted Survival (%) by Kelt Length (in)						Unit Average
					16	17	18	19	20	Range	
1	Vertical Francis	721	0.72	0.1	73.3	71.6	69.9	68.3	66.6	66.6 - 73.3	54.9
				0.2	46.5	43.2	39.9	36.5	33.2	33.2 - 46.5	
2	Vertical Francis	679	0.77	0.1	72.5	70.8	69.1	67.4	65.6	65.6 - 72.5	53.6
				0.2	45.0	41.6	38.1	34.7	31.3	31.3 - 45.0	
3	Vertical Francis	710	0.71	0.1	73.0	71.3	69.6	67.9	66.2	66.2 - 73.0	54.4
				0.2	46.0	42.6	39.2	35.8	32.5	32.5 - 46.0	
4	Vertical Francis	666	0.78	0.1	72.4	70.6	68.9	67.2	65.4	65.4 - 72.4	53.4
				0.2	44.7	41.3	37.8	34.4	30.9	30.9 - 44.7	
5	Vertical Francis	676	0.79	0.1	72.3	70.6	68.8	67.1	65.4	65.4 - 72.3	53.2
				0.2	44.6	41.1	37.6	34.2	30.7	30.7 - 44.6	
6	Vertical Francis	670	0.79	0.1	72.4	70.6	68.9	67.2	65.5	65.5 - 72.4	53.4
				0.2	44.7	41.3	37.8	34.4	30.9	30.9 - 44.7	

Table 30. Predicted survival rates for salmon kelts passed through Kaplan Unit 7 at the Lockwood Project under maximum turbine operating conditions.

Correlation Factor	Fish Entry Point (ft)	Predicted Survival (%) by Kelt Length (in)						Unit Average
		16	20	23	27	30	Range	
0.1	blade tip	76.0	70.0	65.5	59.5	55.1	55.1 - 76.0	72.1
	mid-blade	92.2	90.3	88.8	86.9	85.5	85.5 - 92.2	
	near hub	93.2	91.6	90.3	88.6	87.3	87.3 - 93.2	
0.2	blade tip	52.1	40.1	31.1	19.1	10.1	10.1 - 52.1	
	mid-blade	84.5	80.6	77.7	73.8	70.9	70.9 - 84.5	
	near hub	86.5	83.1	80.6	77.2	74.7	74.7 - 86.5	

Table 31. Impacts to the whole station kelt survival estimate for theoretical downstream bypass effectiveness rates.

	Evaluated Downstream Bypass Effectiveness Rates					
	0.188	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Theoretical Number of Kelts	*100*	100	100	100	100	100
Proportion of Kelts to Spillway	*0.387*	0.387	0.387	0.387	0.387	0.387
Number of Kelts to Spillway	*38.7*	38.7	38.7	38.7	38.7	38.7
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963	0.963
Number Kelts Surviving Spill	*37.3*	37.3	37.3	37.3	37.3	37.3
Proportion of Kelts to Forebay Canal	*0.613*	0.613	0.613	0.613	0.613	0.613
Number of Kelts to Forebay Canal	*61.3*	61.3	61.3	61.3	61.3	61.3
Proportion of Kelts to Bypass	*0.188*	0.25	0.45	0.65	0.85	1.00
Number of Kelts to Bypass	*11.5*	15.3	27.6	39.8	52.1	61.3
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963	0.963
Number of Kelts Surviving Bypass	11.1	14.8	26.6	38.4	50.2	59.0
Number of Kelts Directed to Turbines	*49.8*	46.0	33.7	21.5	9.2	0.0
Proportion of Kelts Directed to Francis units	*0.709*	0.709	0.709	0.709	0.709	0.709
Proportion of Kelts Directed to Kaplan unit	*0.291*	0.291	0.291	0.291	0.291	0.291
Number of Kelts Directed to Francis Units	*35.3*	32.6	23.9	15.2	6.5	0.0
Number of Kelts Directed to Kaplan Unit	*14.5*	13.4	9.8	6.2	2.7	0.0
Proportion of Kelts Through 3.5" Racks (Kaplan)	*0.709*	0.709	0.709	0.709	0.709	0.709
Proportion of Kelts Screened at 3.5" Racks (Kaplan) and to Spill	*0.291*	0.291	0.291	0.291	0.291	0.291
Number Kelts Through 3.5" Racks (Kaplan)	*10.3*	9.5	7.0	4.4	1.9	0.0
Number Kelts Screened at 3.5" Racks (Kaplan) and to Spill	*4.2*	3.9	2.9	1.8	0.8	0.0
Kaplan Turbine Survival Rate	*0.721*	0.721	0.721	0.721	0.721	0.721
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963	0.963
Number Kelts Surviving Kaplan	*7.4*	6.8	5.0	3.2	1.4	0.0
Number Kelts Surviving Spill	*4.1*	3.7	2.7	1.7	0.7	0.0
Proportion of Kelts Through 2.0" Racks (Francis)	*0.008*	0.008	0.008	0.008	0.008	0.008
Proportion of Kelts Screened at 2.0" Racks (Francis)	*0.992*	0.992	0.992	0.992	0.992	0.992
Number Kelts Through 2.0" Racks (Francis)	*0.3*	0.3	0.2	0.1	0.1	0.0
Number Kelts Screened at 2.0" Racks (Francis)	*35.0*	32.3	23.7	15.1	6.5	0.0
Proportion of Kelts Screened at 2.0" Racks (Francis) to Kaplan	*1.00*	1.00	1.00	1.00	1.00	1.00
Proportion of Kelts Screened at 2.0" Racks (Francis) to Spill	*0.00*	0.00	0.00	0.00	0.00	0.00
Number of Kelts Screened at 2.0" Racks (Francis) to Kaplan	*35.0*	32.3	23.7	15.1	6.5	0.0
Number of Kelts Screened at 2.0" Racks (Francis) to Spill	*0.0*	0.0	0.0	0.0	0.0	0.0

(continued)

Table 31. (Continued)

	Evaluated Downstream Bypass Effectiveness Rates					
	0.188	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Proportion of Kelts Screened at 2.0" Racks (Francis) but Through 3.5" Racks (Kaplan)	*0.707*	0.707	0.707	0.707	0.707	0.707
Proportion of Kelts Screened at 2.0" Racks (Francis) and 3.5" Racks (Kaplan) to Spill	*0.293*	0.293	0.293	0.293	0.293	0.293
Number of Kelts Screened at 2.0" Racks (Francis) then Through 3.5" Racks (Kaplan)	*24.8*	22.9	16.8	10.7	4.6	0.0
Number of Kelts Screened at 2.0" Racks (Francis) and 3.5" Racks (Kaplan) to Spill	*10.3*	9.5	6.9	4.4	1.9	0.0
Francis Turbine Survival Rate	*0.538*	0.538	0.538	0.538	0.538	0.538
Kaplan Turbine Survival Rate	*0.721*	0.721	0.721	0.721	0.721	0.721
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963	0.963
Number Kelts Surviving Francis	*0.2*	0.1	0.1	0.1	0.0	0.0
Number Kelts Surviving Kaplan	*17.8*	16.5	12.1	7.7	3.3	0.0
Number Kelts Surviving Spill	*9.9*	9.1	6.7	4.3	1.8	0.0
TOTAL KELT SURVIVAL	***87.7***	**88.4**	**90.5**	**92.6**	**94.7**	**96.3**
WHOLE STATION ESTIMATE	***88%***	**88%**	**90%**	**93%**	**95%**	**96%**

Italics indicates model estimate is based on existing conditions

Table 32. Impacts to the whole station kelt survival estimate for theoretical spill effectiveness rates.

	Evaluated Spill Effectiveness Rates					
	1:1	**0.4:1**	**1.2:1**	**1.9:1**	**2.7:1**	**3.5:1**
	0.387	**0.100**	**0.300**	**0.500**	**0.700**	**0.900**
Proportion of River Flow to Spillway	*0.387*	0.387	0.387	0.387	0.387	0.387
Proportion of River Flow to Forebay Canal	*0.613*	0.613	0.613	0.613	0.613	0.613
Theoretical Number of Kelts	*100*	100	100	100	100	100
Proportion of Kelts to Spillway	*0.387*	0.1	0.3	0.5	0.7	0.9
Number of Kelts to Spillway	*38.7*	10.0	30.0	50.0	70.0	90.0
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963	0.963
Number Kelts Surviving Spill	*37.3*	9.6	28.9	48.2	67.4	86.7
Proportion of Kelts to Forebay Canal	*0.613*	0.9	0.7	0.5	0.3	0.1
Number of Kelts to Forebay Canal	*61.3*	90.0	70.0	50.0	30.0	10.0
Proportion of Kelts to Bypass	*0.188*	0.188	0.188	0.188	0.188	0.188
Number of Kelts to Bypass	*11.5*	16.9	13.2	9.4	5.6	1.9
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963	0.963
Number of Kelts Surviving Bypass	11.1	16.3	12.7	9.1	5.4	1.8
Number of Kelts Directed to Turbines	*49.8*	73.1	56.8	40.6	24.4	8.1
Proportion of Kelts Directed to Francis units	*0.709*	0.709	0.709	0.709	0.709	0.709
Proportion of Kelts Directed to Kaplan unit	*0.291*	0.291	0.291	0.291	0.291	0.291
Number of Kelts Directed to Francis Units	*35.3*	51.8	40.3	28.8	17.3	5.8
Number of Kelts Directed to Kaplan Unit	*14.5*	21.3	16.5	11.8	7.1	2.4
Proportion of Kelts Through 3.5" Racks (Kaplan)	*0.709*	0.709	0.709	0.709	0.709	0.709
Proportion of Kelts Screened at 3.5" Racks (Kaplan) and to Spill	*0.291*	0.291	0.291	0.291	0.291	0.291
Number Kelts Through 3.5" Racks (Kaplan)	*10.3*	15.1	11.7	8.4	5.0	1.7
Number Kelts Screened at 3.5" Racks (Kaplan) and to Spill	*4.2*	6.2	4.8	3.4	2.1	0.7
Kaplan Turbine Survival Rate	*0.721*	0.721	0.721	0.721	0.721	0.721
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963	0.963
Number Kelts Surviving Kaplan	*7.4*	10.9	8.5	6.0	3.6	1.2
Number Kelts Surviving Spill	*4.1*	6.0	4.6	3.3	2.0	0.7

(continued)

Table 32. (Continued)

	Evaluated Spill Effectiveness Rates					
	1:1	**0.4:1**	**1.2:1**	**1.9:1**	**2.7:1**	**3.5:1**
	0.387	**0.100**	**0.300**	**0.500**	**0.700**	**0.900**
Proportion of Kelts Through 2.0" Racks (Francis)	*0.008*	0.008	0.008	0.008	0.008	0.008
Proportion of Kelts Screened at 2.0" Racks (Francis)	*0.992*	0.992	0.992	0.992	0.992	0.992
Number Kelts Through 2.0" Racks (Francis)	*0.3*	0.4	0.3	0.2	0.1	0.0
Number Kelts Screened at 2.0" Racks (Francis)	*35.0*	51.4	40.0	28.6	17.1	5.7
Proportion of Kelts Screened at 2.0" Racks (Francis) to Kaplan	*1.00*	1.00	1.00	1.00	1.00	1.00
Proportion of Kelts Screened at 2.0" Racks (Francis) to Spill	*0.00*	0.00	0.00	0.00	0.00	0.00
Number of Kelts Screened at 2.0" Racks (Francis) to Kaplan	*35.0*	51.4	40.0	28.6	17.1	5.7
Number of Kelts Screened at 2.0" Racks (Francis) to Spill	*0.0*	0.0	0.0	0.0	0.0	0.0
Proportion of Kelts Screened at 2.0" Racks (Francis) but Through 3.5" Racks (Kaplan)	*0.707*	0.707	0.707	0.707	0.707	0.707
Proportion of Kelts Screened at 2.0" Racks (Francis) and 3.5" Racks (Kaplan) to Spill	*0.293*	0.293	0.293	0.293	0.293	0.293
Number of Kelts Screened at 2.0" Racks (Francis) then Through 3.5" Racks (Kaplan)	*24.8*	36.3	28.3	20.2	12.1	4.0
Number of Kelts Screened at 2.0" Racks (Francis) and 3.5" Racks (Kaplan) to Spill	*10.3*	15.1	11.7	8.4	5.0	1.7
Francis Turbine Survival Rate	*0.538*	0.538	0.538	0.538	0.538	0.538
Kaplan Turbine Survival Rate	*0.721*	0.721	0.721	0.721	0.721	0.721
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963	0.963
Number Kelts Surviving Francis	*0.2*	0.2	0.2	0.1	0.1	0.0
Number Kelts Surviving Kaplan	*17.8*	26.2	20.4	14.6	8.7	2.9
Number Kelts Surviving Spill	*9.9*	14.5	11.3	8.1	4.8	1.6
TOTAL KELT SURVIVAL	***87.7***	**83.7**	**86.5**	**89.3**	**92.1**	**94.9**
WHOLE STATION ESTIMATE	***88%***	**84%**	**86%**	**89%**	**92%**	**95%**

Italics indicates model estimate is based 1:1 spill effectiveness ratio

Table 33. Approximate river discharge (cfs) for the Kennebec River at Lockwood during April, May, October, November, December for low (i.e. 75 and 90% exceedence) and high (10 and 25% exceedence) conditions.

Percent of Time Flow is Exceeded	River Discharge (cfs)				
	April	**May**	**October**	**November**	**December**
10	32,000	22,000	9,500	15,500	12,500
25	20,500	15,500	6,000	10,250	8,000
50	*13,000*	*9,000*	*4,500*	*6,000*	*5,750*
75	9,000	5,750	3,500	3,750	4,250
90	6,500	4,250	2,750	3,000	3,000

Italics indicates values used for 50% exceedence model

Table 34. Impacts to the whole station kelt survival estimate for seasonal flow conditions.

	Percent of Time Flow is Exceeded				
	50	**10**	**25**	**75**	**90**
Theoretical Number of Kelts	*100*	100	100	100	100
Proportion of Kelts to Spillway	*0.387*	0.74	0.61	0.162	0.055
Number of Kelts to Spillway	*38.7*	74.0	61.0	16.2	5.5
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963
Number Kelts Surviving Spill	*37.3*	71.3	58.7	15.6	5.3
Proportion of Kelts to Forebay Canal	*0.613*	0.26	0.39	0.838	0.945
Number of Kelts to Forebay Canal	*61.3*	26.0	39.0	83.8	94.5
Proportion of Kelts to Bypass	*0.188*	0.188	0.188	0.188	0.188
Number of Kelts to Bypass	*11.5*	4.9	7.3	15.8	17.8
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963
Number of Kelts Surviving Bypass	11.1	4.7	7.1	15.2	17.1
Number of Kelts Directed to Turbines	*49.8*	21.1	31.7	68.0	76.7
Proportion of Kelts Directed to Francis units	*0.709*	0.709	0.709	0.709	0.709
Proportion of Kelts Directed to Kaplan unit	*0.291*	0.291	0.291	0.291	0.291
Number of Kelts Directed to Francis Units	*35.3*	15.0	22.5	48.2	54.4
Number of Kelts Directed to Kaplan Unit	*14.5*	6.1	9.2	19.8	22.3
Proportion of Kelts Through 3.5" Racks (Kaplan)	*0.709*	0.709	0.709	0.709	0.709
Proportion of Kelts Screened at 3.5" Racks (Kaplan) and to Spill	*0.291*	0.291	0.291	0.291	0.291
Number Kelts Through 3.5" Racks (Kaplan)	*10.3*	4.4	6.5	14.0	15.8
Number Kelts Screened at 3.5" Racks (Kaplan) and to Spill	*4.2*	1.8	2.7	5.8	6.5
Kaplan Turbine Survival Rate	*0.721*	0.721	0.721	0.721	0.721
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963
Number Kelts Surviving Kaplan	*7.4*	3.1	4.7	10.1	11.4
Number Kelts Surviving Spill	*4.1*	1.7	2.6	5.5	6.3

(continued)

Table 34. (Continued)

	Percent of Time Flow is Exceeded				
	50	**10**	**25**	**75**	**90**
Proportion of Kelts Through 2.0" Racks (Francis)	*0.008*	0.008	0.008	0.008	0.008
Proportion of Kelts Screened at 2.0" Racks (Francis)	*0.992*	0.992	0.992	0.992	0.992
Number Kelts Through 2.0" Racks (Francis)	*0.3*	0.1	0.2	0.4	0.4
Number Kelts Screened at 2.0" Racks (Francis)	*35.0*	14.8	22.3	47.9	54.0
Proportion of Kelts Screened at 2.0" Racks (Francis) to Kaplan	*1.00*	1.00	1.00	1.00	1.00
Proportion of Kelts Screened at 2.0" Racks (Francis) to Spill	*0.00*	0.00	0.00	0.00	0.00
Number of Kelts Screened at 2.0" Racks (Francis) to Kaplan	*35.0*	14.8	22.3	47.9	54.0
Number of Kelts Screened at 2.0" Racks (Francis) to Spill	*0.0*	0.0	0.0	0.0	0.0
Proportion of Kelts Screened at 2.0" Racks (Francis) but Through 3.5" Racks (Kaplan)	*0.707*	0.707	0.707	0.707	0.707
Proportion of Kelts Screened at 2.0" Racks (Francis) and 3.5" Racks (Kaplan) to Spill	*0.293*	0.293	0.293	0.293	0.293
Number of Kelts Screened at 2.0" Racks (Francis) then Through 3.5" Racks (Kaplan)	*24.8*	10.5	15.7	33.8	38.2
Number of Kelts Screened at 2.0" Racks (Francis) and 3.5" Racks (Kaplan) to Spill	*10.3*	4.4	6.5	14.0	15.8
Francis Turbine Survival Rate	*0.538*	0.538	0.538	0.538	0.538
Kaplan Turbine Survival Rate	*0.721*	0.721	0.721	0.721	0.721
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963
Number Kelts Surviving Francis	*0.2*	0.1	0.1	0.2	0.2
Number Kelts Surviving Kaplan	*17.8*	7.6	11.4	24.4	27.5
Number Kelts Surviving Spill	*9.9*	4.2	6.3	13.5	15.2
TOTAL KELT SURVIVAL	***87.7***	**92.7**	**90.8**	**84.6**	**83.0**
WHOLE STATION ESTIMATE	***88%***	**93%**	**91%**	**85%**	**83%**

Italics indicates model estimate is based 1:1 spill effectiveness ratio

Table 35. Impacts to the whole station kelt survival estimate for behavioral route selection rates.

	Evaluated Behavioral Route Selection Rates						
	1.00	**0.00**	**0.10**	**0.30**	**0.50**	**0.70**	**0.90**
Theoretical Number of Kelts	*100*	100	100	100	100	100	100
Proportion of Kelts to Spillway	*0.387*	0.387	0.387	0.387	0.387	0.387	0.387
Number of Kelts to Spillway	*38.7*	38.7	38.7	38.7	38.7	38.7	38.7
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963	0.963	0.963
Number Kelts Surviving Spill	*37.3*	37.3	37.3	37.3	37.3	37.3	37.3
Proportion of Kelts to Forebay Canal	*0.613*	0.613	0.613	0.613	0.613	0.613	0.613
Number of Kelts to Forebay Canal	*61.3*	61.3	61.3	61.3	61.3	61.3	61.3
Proportion of Kelts to Bypass	*0.188*	0.188	0.188	0.188	0.188	0.188	0.188
Number of Kelts to Bypass	*11.5*	11.5	11.5	11.5	11.5	11.5	11.5
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963	0.963	0.963
Number of Kelts Surviving Bypass	11.1	11.1	11.1	11.1	11.1	11.1	11.1
Number of Kelts Directed to Turbines	*49.8*	49.8	49.8	49.8	49.8	49.8	49.8
Proportion of Kelts Directed to Francis units	*0.709*	0.709	0.709	0.709	0.709	0.709	0.709
Proportion of Kelts Directed to Kaplan unit	*0.291*	0.291	0.291	0.291	0.291	0.291	0.291
Number of Kelts Directed to Francis Units	*35.3*	35.3	35.3	35.3	35.3	35.3	35.3
Number of Kelts Directed to Kaplan Unit	*14.5*	14.5	14.5	14.5	14.5	14.5	14.5
Proportion of Kelts Through 3.5" Racks (Kaplan)	*0.709*	0.709	0.709	0.709	0.709	0.709	0.709
Proportion of Kelts Screened at 3.5" Racks (Kaplan) and to Spill	*0.291*	0.291	0.291	0.291	0.291	0.291	0.291
Number Kelts Through 3.5" Racks (Kaplan)	*10.3*	10.3	10.3	10.3	10.3	10.3	10.3
Number Kelts Screened at 3.5" Racks (Kaplan) and to Spill	*4.2*	4.2	4.2	4.2	4.2	4.2	4.2
Kaplan Turbine Survival Rate	*0.721*	0.721	0.721	0.721	0.721	0.721	0.721
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963	0.963	0.963
Number Kelts Surviving Kaplan	*7.4*	7.4	7.4	7.4	7.4	7.4	7.4
Number Kelts Surviving Spill	*4.1*	4.1	4.1	4.1	4.1	4.1	4.1

(continued)

Table 35. (Continued)

	Evaluated Behavioral Route Selection Rates						
	1.00	**0.00**	**0.10**	**0.30**	**0.50**	**0.70**	**0.90**
Proportion of Kelts Through 2.0" Racks (Francis)	*0.008*	0.008	0.008	0.008	0.008	0.008	0.008
Proportion of Kelts Screened at 2.0" Racks (Francis)	*0.992*	0.992	0.992	0.992	0.992	0.992	0.992
Number Kelts Through 2.0" Racks (Francis)	*0.3*	0.3	0.3	0.3	0.3	0.3	0.3
Number Kelts Screened at 2.0" Racks (Francis)	*35.0*	35.0	35.0	35.0	35.0	35.0	35.0
Proportion of Kelts Screened at 2.0" Racks (Francis) to Kaplan	*1.00*	0.00	0.10	0.30	0.50	0.70	0.90
Proportion of Kelts Screened at 2.0" Racks (Francis) to Spill	*0.00*	1.00	0.90	0.70	0.50	0.30	0.10
Number of Kelts Screened at 2.0" Racks (Francis) to Kaplan	*35.0*	0.0	3.5	10.5	17.5	24.5	31.5
Number of Kelts Screened at 2.0" Racks (Francis) to Spill	*0.0*	35.0	31.5	24.5	17.5	10.5	3.5
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963	0.963	0.963
Number Kelts Surviving Spill	*0.0*	33.7	30.3	23.6	16.9	10.1	3.4
Proportion of Kelts Screened at 2.0" Racks (Francis) but Through 3.5" Racks (Kaplan)	*0.707*	0.707	0.707	0.707	0.707	0.707	0.707
Proportion of Kelts Screened at 2.0" Racks (Francis) and 3.5" Racks (Kaplan) to Spill	*0.293*	0.293	0.293	0.293	0.293	0.293	0.293
Number of Kelts Screened at 2.0" Racks (Francis) then Through 3.5" Racks (Kaplan)	*24.8*	0.0	2.5	7.4	12.4	17.3	22.3
Number of Kelts Screened at 2.0" Racks (Francis) and 3.5" Racks (Kaplan) to Spill	*10.3*	0.0	1.0	3.1	5.1	7.2	9.2
Francis Turbine Survival Rate	*0.538*	0.538	0.538	0.538	0.538	0.538	0.538
Kaplan Turbine Survival Rate	*0.721*	0.721	0.721	0.721	0.721	0.721	0.721
Spillway/Bypass Survival Rate	*0.963*	0.963	0.963	0.963	0.963	0.963	0.963
Number Kelts Surviving Francis	*0.2*	0.2	0.2	0.2	0.2	0.2	0.2
Number Kelts Surviving Kaplan	*17.8*	0.0	1.8	5.4	8.9	12.5	16.1
Number Kelts Surviving Spill	*9.9*	0.0	1.0	3.0	4.9	6.9	8.9
TOTAL KELT SURVIVAL	***87.7***	**93.7**	**93.1**	**91.9**	**90.7**	**89.5**	**88.3**
WHOLE STATION ESTIMATE	***88%***	**94%**	**93%**	**92%**	**91%**	**90%**	**88%**

Italics indicates model estimate is based 1:1 spill effectiveness ratio

APPENDIX A

Table A-1. Site characteristics and study parameters for turbine survival studies conducted using the Hi-Z Turb'N Tag method.

Site Name	**Species Tested**	**Sampling Method**	**Unit Type**	**Normal head (ft)**	**RPM**	**Wicket Gate (%)**	**Unit Flow (cfs)**	**No. of Blades or Buckets**	**Runner Diameter (ft)**	**Water Temp. (^oC)**	**Test Season or Month**	**Test Fish Size (mm)**			**Control Fish Size (mm)**			**No. of Fish Released**		**Immediate Survival (1-hr)**	**24-hr Survival**	**48-hr Survival**	**72-hr Survival**	**Reference**
												Min	**Max**	**Avg**	**Min**	**Max**	**Avg**	**T**	**C**					
West Buxton, ME	Atlantic salmon	Hi-Z Turb'N Tag	Francis	26.8	150	100	611	16	4.0	15.0	May	192	250	217	192	226	210	73	20	85.0	85.0	-	-	Normandeau 1999
Vernon, VT	Atlantic salmon	Hi-Z Turb'N Tag	Francis	34	133.3	75	1,280	14	5.2	-	May	123	194	-	110	208	-	25	80	85.1	-	85.1	-	Normandeau 1996
Vernon, VT [1]	Atlantic salmon	Hi-Z Turb'N Tag	Francis	34	74	75 & 100	1,350 & 1,800	15	13.0	-	May	120	214	-	110	208	-	105	80	95.9 & 100.0	-	94.9 & 100.0	-	Normandeau 1996
Briar Rolfe, NH	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	35	150	73.3-76.3	-	5	9.84	13.0	May	174	228	192.7	180	219	194.1	70	30	95.7	-	95.7	-	Normandeau 2004
Bar Mills, ME [1]	Atlantic salmon	Hi-Z Turb'N Tag	Propeller	19.5	120	50 & 100	960 & 1,560	5	11.2	14-16.5	May	177	238	204	175	238	205	100	50	88.0 & 94.0	-	-	88.0 & 88.0	Normandeau and FPL 2002
Lairg, Scotland	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	-	167	-	-	4	8.5	7.0-8.5	April	90	136	111.4	96	147	112.8	100	75	91.0	-	91.0	-	Normandeau and Fishtrack 1998
Cliff, Ireland	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	32.8	115.3	-	-	5	14.1	-	April	121	155	136	108	150	132	78	50	92.3	-	92.2	-	Normandeau and Fishtrack 2002
Cathleens Falls, Ireland	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	93.5	187.5	-	-	5	12.6	-	April	122	150	136	121	152	136	75	50	89.3	-	88.0	-	Normandeau and Fishtrack 2002
Ardnacrusha, Ireland [1]	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	93	167	-	-	5	16.4	9.5-10.1	April	148	214	181	161	225	189	190	60	96.3 & 95.2	-	96.3 & 87.5	-	Normandeau and Fishtrack 2004
Wilder, VT-NH	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	51	112.5	74-84	-	5	9.0	8.5-10.0	May	163	218	187.9	162	220	186.3	125	125	96.0	-	94.3	-	Normandeau 1994
Vernon, VT [1]	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	34	144	-	1,250 & 1,600	5	10.2	-	May	152	305	223	183	322	224	273	107	94.7 & 98.5	-	92.3 & 89.3	-	Normandeau 2009
West Buxton, ME [1]	Atlantic salmon	Hi-Z Turb'N Tag	Propeller	26.8	120	55 & 80	1,360 & 1,800	6	11.1	15.0	May	190	244	214	192	226	210	40	20	100.0 & 94.0	100.0 & 94.0	-	-	Normandeau 1999
McIndoes, NH [1]	Atlantic salmon	Hi-Z Turb'N Tag	Propeller	26	150	-	800 & 1,600	4	10.0	-	May	133	248	207	141	245	203	310	100	100.0 & 96.1	-	100.0 & 94.8	-	Normandeau 2006b

1 - Tested two different settings

APPENDIX B

The following methodology was provided by Don Dow (NOAA) for the development of the set of monthly flow duration curves for the Lockwood Project used in the modeling of smolt and kelt survival described in this Report.

Lockwood Hydroelectric Project FERC No. 2574-ME - Flow Duration Curves

Prepared by Don Dow, PE, National Marine Fisheries Service, Orono, Maine

The flow duration curve is based upon 32 years (1979-2010) of daily stream flow. In order to understand how the flow from various USGS gages was prorated to the site, it is important to understand the locations of the gages and their drainage areas.

The Sebasticook River flows into the Kennebec River downstream of the Lockwood Project. The entire Sebasticook River has a drainage area of 946 mi^2. There is a gage on the Sebasticook River which is USGS Gage No. 01049000 Sebasticook River near Pittsfield, Maine that has a drainage area of 572 mi^2. For the periods of January 1, 1979 to September 30, 1993 and October 1, 2000 to present, USGS Gage No. 01049265 Kennebec River at North Sidney, Maine was operating. This gage is located some distance downstream of the confluence of the Sebasticook and Kennebec Rivers and has a drainage area of 5,403 mi^2. For the period of October 1, 1993 to September 30, 2000, USGS Gage No. 01049205 Kennebec River near Waterville, ME was in operation. This gage is located just downstream of the confluence of the Sebasticook and Kennebec Rivers and has a drainage area of 5,179 mi^2. The drainage area of the Kennebec just above the confluence with the Sebasticook River is 5,179 mi^2 less 946 mi^2 which is 4,233 mi^2. The drainage area at the project which is upstream of the confluence with the Sebasticook is 4,228 mi^2.

Therefore, for the period where the North Sydney gage was in operation, the flow at the site was prorated from the following formula:

$$QLockwood = (Qns \times (5{,}179\ mi^2 / 5{,}403\ mi^2)^{0.85} - Qseb \times (946\ mi^2/572\ mi^2)^{0.85}) \times (4228\ mi^2/4{,}233\ mi^2)^{0.85}$$

Where:

QLockwood = Average Daily Flow at the Project
Qns= Average Daily Flow at the North Sydney Gage
Qseb= Average Daily Flow at the Sebasticook Gage

For the period where the Waterville gage was in operation, the flow at the site was prorated from the following formula:

$$QLockwood = (Qwat - Qseb \times (946\ mi^2/572\ mi^2)^{0.85}) \times (4228\ mi^2/4{,}233\ mi^2)^{0.85}$$

Where:

Qwat = Average Daily Flow at the Waterville Gage

APPENDIX C

The following comments were generated during discussions regarding the NextEra white papers at the technical committee meeting held on 26 April 2011 in Augusta, ME.

Comment 1: Investigate other potential sources of salmon smolt timing distribution. Potential sources suggested during the meeting were the Sheepscot and Narraguagus Rivers (C. Lipsky, NOAA; J. Kocik, NOAA).

Response 1: Following the technical committee meeting (26 April 2011), both Christine Lipsky and John Kocik were contacted in an attempt to obtain additional data related to the timing and proportioning of the smolt run during the months of April, May and June. A 15 year data set (1996-2010) of initial, median and last smolt capture dates for the Narraguagus River was obtained. Although useful for confirming our window of outmigration as the months of April-June, without the corresponding abundance information for those years we were unable to proportion runs for that 15 year period into monthly percentages.

Comment 2: Investigate potential sources of data related to differences in smolt timing distribution due to wild or hatchery-reared origin of smolts. Potential sources suggested during the meeting were UMaine theses by C. Holbrook and M. Bailey.

Response 2: As requested, Holbrook (2007) and Bailey (2009) were reviewed as potential data sources related to differences in the smolt timing distribution of wild and hatchery-reared Atlantic salmon. Additional information from Holbrook (2007) was added to the report section on smolt run timing to acknowledge potential differences. However, given the lack of differentiation between hatchery-reared and wild smolts in the studies used in this report for determining the timing and seasonal distribution of downstream movement (GNP 1997; USASAC 2005), no changes to the current model input were made.

Comment 3: It was suggested that colder water temperatures in the Sandy River (source for smolts moving through NextEra Projects) could cause them to move later during the season. It was suggested that P. Christman may have some water temperature data for the Sandy River.

Response 3: Data from the Sandy River during the smolt outmigration (2007) was provided by G. Wippelhauser (MDMR). That information was incorporated into the smolt migration discussion section of this report.

Comment 4: F. Seavey asked if the model developed by Normandeau for the NextEra Projects could be validated by using a Penobscot River Project and data to validate the results.

Response 4: The basic survival model used in our analysis for Lockwood, Shawmut, Weston and Brunswick is transferable to other Projects. That model was made available to the technical committee via the SharePoint site for those interested in using it elsewhere.

Comment 5: It was requested (J. Murphy) that a working definition of survival be incorporated into the white papers.

Response 5: NextEra and its consultants will work with NMFS to develop a working definition of survival. In our opinion, that definition would be more appropriate within the framework of the Habitat Conservation Plan document than in these supporting white papers.

Comment 6: It was requested (J. Murphy) that a table of smolt injuries reported in empirical studies included in the white papers be included.

Response 6: Detailed injury information obtained from Normandeau Hi-Z Turb'N Tag studies conducted for Atlantic salmon smolts passed through spillways/sluices, Kaplan units and Francis units has been added to the "Smolt Spillway and Downstream Bypass Passage Survival Assessment" and "Smolt Entrainment Rates and Passage Survival Assessment" sections of this report. Information includes the overall injury rates for test and control fish as well as injury types and frequency of occurrence among injured and the total number of smolts examined.

Comment 7: Following a lengthy discussion related to the Franke formula, it was requested that additional information helping to define that formula be included in the white paper. A search of available peer-reviewed/published literature related to the Franke formula was also requested.

Response 7: Additional information related to the Franke formula has been added to this report. An attempt was made to provide the reader with more insight into the formula and what it is modeling. This information was added to the report subsection "Modeled Estimates of Smolt Passage Turbine Survival" in the "Turbine Passage Smolt Survival Assessment" section. Peer-reviewed use of the Franke formula for blade-strike calculations is limited. Ferguson et al. (2008) made use of the Bell (1991) blade strike model formulas to assess outmigration of Atlantic salmon from Swedish rivers. They noted that the Franke et al. (1997) models were virtually identical to those derived by Bell (1991). Other than that mention, they did not provide any insight into the use of the Franke blade strike formula.

Comment 8: It was requested that Normandeau conduct an additional sensitivity analysis for varying turbine efficiency.

Response 8: An additional sensitivity analysis for varying turbine efficiencies was not conducted. Modeling in this report was conducted for the period of the year with greatest river flows (spring months, April-June). It was assumed that river discharge available to NextEra operations would not be a limiting factor and that the range of operating efficiencies over the three month spring period would be narrow. Turbine efficiency can have an effect on fish survival when viewed over a broad range (i.e. the extreme ends of the turbine operating range) (Cada 2001). However, when viewed over a narrow range of that operating window, there may not be a direct relationship between turbine operating efficiency and survival (Cada 2001). As a result, the turbine survival models for the NextEra projects rely on the maximum turbine discharge and its associated efficiency.

Comment 9: It was recommended (J. Murphy) that the white papers present Franke formula estimates for kelt passage through Project turbines.

Response 9: The white paper has been revised to include Franke estimates for turbine passage of kelts.

Comment 10: It was suggested (J. Burrows) that outmigration studies on Atlantic salmon kelts may exist for Canadian Rivers and if so then they should be included in the white papers.

Response 10: Follow-up correspondence with J. Burrows with the Atlantic Salmon Federation regarding these potential kelt outmigration studies did not produce any additional data. However, two additional sources of smolt information from the St. John River in Canada were forwarded (Carr 1999; Carr 2001).

Comment 11: It was suggested (D. Dow) that more recent flow duration curves may exist for the NextEra projects and if so, the impact of those should be examined.

Response 11: Don Dow (NOAA) provided NextEra and its consultants with updated flow duration curves for the Lockwood Project. Those curves have been incorporated into the whole station survival models for Atlantic salmon smolts and kelts described in this report.

Comment 12: It was suggested that the ratios examined during the spill effectiveness sensitivity analysis be added to the report.

Response 12: These values were added to all report tables for smolts and kelts that examined the impacts of spill effectiveness on modeled whole station survival estimates.

The following comments regarding the NextEra white papers were sent via email from Jeff Murphy to the technical committee on 20 May 2011.

Comment 1: Please provide a definition of total station survival that accounts for injuries, delays, predation in the impoundment/tailrace, passage through turbines, passage over spillways, and passage through downstream bypasses.

Response 1: NextEra and its consultants will work with NMFS to develop a working definition of survival. In our opinion, that definition would be more appropriate within the framework of the Habitat Conservation Plan document than in these supporting white papers.

Comment 2: The reports should note that survival data used from efficiency/fish movement studies do not represent actual survival at the project. True survival estimates can only be obtained through actual survival studies.

Response 2: The original report empirical data provided only from Hi-Z Turb'N Tag studies as they provide a true estimate of actual survival. No data obtained from efficiency or fish movement studies were used in the effort to provide a primary estimate of survival at any of the NextEra Projects. An additional statement has been added to the report for clarification. Wording where data from efficiency or fish movement studies were used in a supporting role to validate primary estimates was also clarified.

Comment 3: Please indicate in the report for each empirical data point whether it was derived from actual survival studies or efficiency/fish movement studies. Data from actual survival studies should be weighted higher than efficiency/movement studies.

Response 3: Data presented in the report and pertaining to survival was derived from studies designed to assess survival. Data from efficiency/fish movement studies (Normandeau 2008) was used for the determination of smolt outmigration routes and as anecdotal observations to support survival estimate. We have added clarification to the report.

Comment 4: We question whether control group survival of >50% represents reasonable precision levels. Shouldn't this being higher (e.g., >75%)?

Response 4: The report has been adjusted to reflect that request. We have also assumed that any control smolts that were not recovered during the initial test did not survive. As a result, we dropped the Lowell study (Normandeau 2003) from our empirical data set for Kaplan turbines. It should be noted that the turbine survival percentages for control fish from Hi-Z Turb'N Tag studies used in this report ranged from 96.3% - 100.0% (average = 99.1%) at 1-hr and from 90.0% - 100.0% (average = 96.2%) at 48-hr.

Site Name	Unit Type	No. of Control Fish Released	No. Recap Alive	No. Recap Dead	Not Recovered	% Alive (INITIAL)	No. Held for Latent (48 hr)	No. Alive at 48 hr.	% Alive (LATENT)	Reference
West Buxton, ME [2]	Francis	20	20	0	0	100.0%	20	18	90.0%	Normandeau 1999
Vernon, VT	Francis	80	79	0	1	98.8%	79	79	98.8%	Normandeau 1996
Vernon, VT [1]	Francis	80	79	0	1	98.8%	79	79	98.8%	Normandeau 1996
Briar Rolfe, NH	Kaplan	30	30	0	0	100.0%	30	30	100.0%	Normandeau 2004
Bar Mills, ME [1]	Propeller	50	49	0	1	98.0%	49	49	98.0%	Normandeau and FPL 2002
Lairg, Scotland	Kaplan	75	75	0	0	100.0%	75	75	100.0%	Normandeau and Fishtrack 1998
Cliff, Ireland	Kaplan	50	50	0	0	100.0%	50	46	92.0%	Normandeau and Fishtrack 2002
Cathleens Falls, Ireland	Kaplan	50	49	0	1	98.0%	49	49	98.0%	Normandeau and Fishtrack 2002
Ardnacrusha, Ireland[1]	Kaplan	60	59	0	1	98.3%	59	54	90.0%	Normandeau and Fishtrack 2004
Wilder, VT-NH	Kaplan	125	125	0	0	100.0%	123	123	98.4%	Normandeau 1994
Vernon, VT [1]	Kaplan	107	103	1	3	96.3%	103	103	96.3%	Normandeau 2009
West Buxton, ME [1]	Propeller	20	20	0	0	100.0%	20	18	90.0%	Normandeau 1999
McIndoes, NH [1]	Propeller	100	100	0	0	100.0%	100	100	100.0%	Normandeau 2006b

1 - Tested two different settings

2 - Latent survival for this study was completed at 16 hours

Bypass survival percentages for control fish from Hi-Z Turb'N Tag studies used in this report ranged from 99.0% - 100.0% (average = 99.7%) at 1-hr and from 98.0% - 100.0% (average = 99.5%) at 48-hr.

Site Name	Spill Type	No. of Control Fish Released	No. Recap Alive	No. Recap Dead	Not Recovered	% Alive (INITIAL)	No. Held for Latent (48 hr)	No. Alive at 48 hr.	% Alive (LATENT)	Reference
Garvins Falls, NH	Bypass	20	20	0	0	100.0%	20	20	100.0%	Normandeau 2005
Amoskeag, NH	Bypass	30	30	0	0	100.0%	30	30	100.0%	Normandeau 2006a
Bellows Falls, VT	Sluice	100	99	0	1	99.0%	99	98	98.0%	RMC 1991
Wilder, VT	Sluice	145	144	0	1	99.3%	144	144	99.3%	RMC 1992
Vernon, VT	Sluice	25	25	0	0	100.0%	25	25	100.0%	Normandeau 1995

Comment 5: The report states that "Estimates did not appear too extreme for species/size groups relative to estimates from similar to that species/size group(s). This entailed qualitative, professional judgment." Please provide more specificity concerning the parameters used to make these judgments.

Response 5: This statement was removed from the white papers. No studies were excluded based upon this line of reasoning and as a result it is not necessary to include it.

Comment 6: The use of 1-hr survival is inappropriate. Absolute survival is needed.

Response 6: The sections of the report presenting empirical data from other hydroelectric projects related to the survival of Atlantic salmon smolts through bypass/sluices, Kaplan units and Francis units have been modified to present delayed survival (48-hr) information in addition to the initial (1-hr) survival. In the revised report, four models intended to estimated whole station survival of smolts passing the Lockwood Project were constructed using the available empirical and modeled survival estimates for both spill and turbine passage. The four individual models were:

1) Initial Survival Rate Model: Spill survival based on 1-hr empirical survival data and Kaplan and Francis turbine survival based on 1-hr empirical survival data

2) Delayed Survival Rate Model: Spill survival based on 48-hr empirical survival data and Kaplan and Francis turbine survival based on 48-hr empirical survival data

3) Delayed/Calculated Survival Rate Model: Spill survival based on 48-hr empirical survival data and Kaplan and Francis turbine survival based Franke estimates

4) Initial Injury Rate Model: survival based on 1-hr empirical injury data and Kaplan and Francis turbine survival based on 1-hr empirical injury data

Comment 7: Please don't include data from empirical studies that did not classify injury type and magnitude.

Response 7: Empirical data used in the original report to describe smolt survival at other hydroelectric projects (Normandeau Associates Hi-Z Turb'N Tag studies) all include additional information related to injury type and magnitude. That information has been summarized and included in this report version.

Comment 8: Please prepare a table indicating selection criteria for each empirical study used (e.g., turbine characteristic, species tested, location, survival vs. efficiency/movement study, etc.)

Response 8: Selection criteria for the empirical survival results used in this study can be found Table 4 of the original report for spillways and sluices and in Tables 6, 7, and Appendix Table A for Kaplan and Francis units.

Comment 9: NMFS does not believe use of the strike correlation factor is appropriate for use with Atlantic salmon smolts. The strike correlation factor attempts to use a length related fraction to assess the significance of injury related to survival. Franke et.al. (1997) states that "this factor has not been quantified numerically at this time". Atlantic salmon smolts are a very sensitive species as the undergo smoltification. Barton et al (1986) noted that stresses to smolts may interact with one another or act additively to the detriment of smolt survival. Factors that may not be directly lethal may increase susceptibility to predation. Zydlewski et al (2010) demonstrated significant impact to smolts from modest (10% of body area) descaling. Thus, practically any injury to a smolt may compromise its ability to osmoregulate as it enters salt water. In developing the strike correlation factor, Franke et al. did not account for osmoregulation in fish.

Response 9: The use of a range of correlation factors brackets the expected fish survival in passage through turbines. These values then can be compared with the empirically derived estimates as was done in the original report. In developing the formula, Franke et al. (1997) considered previous work that calculated turbine strike probability and new information developed by the authors. Existing empirical data were used to validate their model. The use of an appropriate correlation factor (0.1 or 0.2) was tested with empirical data collected at Wanapum and Hadley Falls. Results of that comparison suggested that a value of 0.1 was acceptable. A thorough discussion of the derivation and application of the formulas is provided in Franke et al. (1997).

Franke's equation is a modification of Von Raben's equation (Bell 1981). Ferguson (NMFS 2008) utilized Von Raben's equation to predict Atlantic salmon smolt turbine passage survival in his model. Both equations implicitly assume that any strike results in immediate fish mortality whether the fish actually died, was injured, or not.

Comment 10: Please assume smolts will not spill over spillways/flashboards at spillage depths <6".

Response 10: The model has not been yet been modified to reflect this request. NextEra and its consultants would like to complete their review of empirical data for radio-tagged smolts released under a range of spill conditions during the spring, 2011, within the Kennebec River upstream of the Lockwood Project.

Comment 11: Please indicate type and magnitude of injuries reported for all fish tested in Table 6 and 7.

Response 11: This information has been added to the revised report. Please see #6 in the comment/response section for comments generated during discussions regarding the NextEra white papers at the technical committee meeting held on 26 April 2011 in Augusta, ME.

Comment 12: Only data obtained from Hi-Z floy tag studies were used for empirical estimates. Data from full-draft tube netting survival studies should also be used.

Response 12: Survival studies conducted using multiple techniques (Hi-Z Turb'N Tag, discharge netting, radio-telemetry, etc) were considered for use during our original review. A review of the EPRI and Franke study summaries revealed a limited number of studies for Atlantic salmon smolts. Radio-telemetry studies were disregarded as survival data used from fish movement studies do not represent actual survival at the project and true survival estimates can only be obtained through actual survival studies. A single netting study for Atlantic salmon was described in EPRI (1997). We were unable to locate a copy of the original document. The EPRI (1997) database provides only initial (1-hr) survival rates (since determined by NMFS to be inappropriate for this analysis). In addition, the EPRI (1997) database does not provide any information related to observed injury types or their magnitude (since determined by NMFS to be a prerequisite for inclusion of empirical survival data).

Comment 13: For projects with trashracks greater[5] than 2", NMFS would assume that kelts (especially post-spawned grilse) could experience turbine entrainment. Please use the model to predict kelt survival at each project using the smolt passage route assumptions.

Response 13: As requested, an initial attempt at modeling whole station survival for Atlantic salmon kelts was made. Where data specific to kelts was unavailable, empirical data collected for Atlantic salmon smolts was used as a surrogate.

Comment 14: Please assign a predation rate for smolts emigrating through project impoundments.

Response 14: Available data from radio-telemetry studies involving smolt passage through Kennebec River impoundments has been assembled and included in the revised report.

Comment 15: With respect to the Lockwood and Brunswick Projects, please address the estimated upstream delays that occur while fish are attempting to find the fishway entrances. Also, please address the time needed to completely negotiate the fishways.

Response 15: Given the lack of site-specific data, a summary of available studies from the Penobscot River related to upstream delays for adult Atlantic salmon has been included in the report. It is possible that the ongoing adult telemetry study (MDMR) on the Androscoggin may provide some insight into adult salmon passage at the Brunswick Project. Once returning salmon have located the fishway entrance at the Lockwood fish passage facility, upstream passage is provided via a lift and delays in passage using that technology should be minimal.

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[5] Comment was modified to read "greater than 2 inches" rather than "less than 2 inches".

Comment 16: With respect to the Lockwood and Brunswick Projects, please discuss known predators on upstream migrating Atlantic salmon in the tailraces of the projects and how delays at the fishways may be affecting predation.

Response 16: Although existing data related to predation on adult salmon is limited, an attempt was made to include information on potential tailwater predators in this section 8 of this report.

The following comments were generated during discussions regarding the NextEra white papers at the technical committee meeting held on 7 September 2011 in Augusta, ME.

Comment 1: It was asked if the question of smolts needing a minimum six inch spill depth to pass over a spillway would be addressed in the next round of white paper revisions.

Response 1: During the technical committee meeting on 7 September 2011, NextEra and its consultants acknowledged this comment and stated that spill data collected during the spring 2011 telemetry study at Lockwood would be reviewed for appropriateness in answering that question. During the preparation of the Lockwood smolt telemetry draft report (which was provided to the technical committee on 21 October 2011), spill depth over the flashboards and dam crest for dates where smolt passage was documented was reviewed. During the 2011 spring field season, smolt passage by Lockwood via spill was documented on nine dates. The mean spill depth over the flashboards on those dates was 1.91 ft (range 0.73 ft – 3.76 ft). It should be noted that during the spring of 2011, various sections of flashboards were missing during all smolt releases. As a result, calculated spill depths over the flashboards may not have been representative of actual spill conditions. The mean spill depth over the dam crest for dates where smolt passage was documented was 3.51 ft (range 2.33 ft – 5.36 ft). Assessment of minimum spill depths for smolts passing the Lockwood Project will be made during a lower flow year.

Comment 2: It was suggested (John Burrows, ASF) that additional information on frequency of kelt repeat spawning is available for the Miramichi River.

Response 2: ASF provided a Canada DFO summary report (Chaput and Douglas 2010) of salmon runs in the Miramichi River for the period 1970-2010. Data within that report related to the estimated contribution of repeat spawners to the overall spawning population in the Miramichi were added to Section 7.2 (Summary of Modeled Estimates for Whole Station Survival of Kelts) of the white paper.

*Comment 3:*Following discussion of the seasonal run timing component of the kelt model for Lockwood and the other Projects, Norm Dube (MDMR) noted that their observations are that kelt are rarely moving downstream during October and the months of November and December would be more appropriate to include in the model. Similarly, Norm and John Burrows (ASF) noted that spring outmigration of kelts generally occurs during April and May rather than June.

Response 3: Based on discussion during the 7 September 2011 TAC meeting as well as follow up comments from several TAC members, the whole station survival kelt models for Lockwood, Shawmut, Weston and Brunswick have been adjusted to represent a spring kelt movement period of April to May and a fall kelt movement period of mid-October to mid-December.

Comment 4: Steve Shepard (USFWS) cited Great Northern and Bangor Hydro studies as showing rack spacing great enough to allow for passage of kelts still deterred fish from entering the units. Jeff Murphy (NMFS) offered to provide a summary of kelt outmigration study data collected at Weldon for use in the white papers.

Response 4: Steve Shepard provided citations for several reports detailing kelt studies conducted at Weldon Dam on the Penobscot River. Observations of radio-tagged kelt behavior from studies conducted at Weldon Dam suggest that the models of whole station survival constructed for the Lockwood, Weston, Shawmut and Brunswick Projects are likely conservative with regards to behavioral interactions with trashracks and turbine passage. A reference to these studies was included in the revised white papers. However, due to the lack of site-specific kelt data, the behavioral assumption in the whole station survival estimate remains unchanged. As was provided in the previous draft, a sensitivity analysis examining the impacts of varying kelt behavioral responses to trashracks is provided. A draft summary of historical kelt studies conducted at Weldon Dam on the Penobscot River was provided by Jeff Murphy. That information was reviewed by NextEra and its consultants.

Comment 5: It was suggested (Nick Bennett, NRCM) that survival estimates be presented to the whole percent, rather than to the tenths place. There was general concurrence with the TAC with this suggestion.

Response 5: The Lockwood, Shawmut, Weston and Brunswick white papers have been updated to reflect this request. Whole station survival estimates for smolts and kelts are now presented to the nearest whole percent.

Comment 6: Jeff Murphy (NMFS) requested that the individual smolt models be more clearly identified throughout the document. He suggested referring to them as Model A, B, etc..

Response 6: The Lockwood, Shawmut, Weston and Brunswick white papers have been updated to reflect this request. The four smolts models are defined as A, B, C, and D upon their initial presentation in the report and that terminology is carried through the smolt section.

Comment 7: Jeff Murphy (NMFS) expressed concern over the wide range of results produced by the use of 0.1 and 0.2 as correlation coefficients in the Franke equation calculations.

Response 7: Use of correlation coefficient values of 0.1 and 0.2 produce a range of estimates that likely contain the actual estimate of turbine survival. NextEra and its consultants chose to take a conservative route and present all possible estimates of blade strike probability within that range rather than a selected portion.

Comment 8: Jeff Murphy (NMFS) indicated that the white papers should be updated to include study results from the 2011 spring smolt study at Lockwood.

Response 8: The Lockwood white paper has been updated to include results collected during the 2011 smolt bypass effectiveness study. The smolt and kelt whole station survival models for the Lockwood Project have been updated to represent the effectiveness rate obtained during the 2011 study. Impacts of varying the bypass setting between 4% and 6% of powerhouse flow have also been examined.

Comment 9: Jeff Murphy (NMFS) suggested that the summary tables presented as part of the discussion at the 7 September 2011 technical committee meeting be included in the white papers.

Response 9: A detailed summary of the Project white papers compiled for Lockwood, Shawmut, Weston and Brunswick will be provided within the HCP document. Summary tables for smolt and kelt whole station survival models will be included.

Comment 10: Jeff Murphy (NMFS) noted that he had come up with a different total on Figure 13 of the Lockwood white paper.

Response 10: The NextEra consulting team reviewed this figure and found that the summed totals presented in Figure 14 of the revised draft (formerly Figure 13) agrees with values presented in the text.

Comment 11: Jeff Murphy (NMFS) recommended that the Vernon Francis Unit study be removed from comparison with units at Lockwood due to differences in rotation speed.

Response 11: The Lockwood white paper has been updated to reflect this request.

Comment 12: Jeff Murphy (NMFS) requested that the results from the Franke formula calculations also be presented as a range within their respective tables.

Response 12: Tables containing Franke estimates for smolt and kelt passage through Francis and Kaplan units have been updated to include a column with the range of estimates at each unit and for each correlation factor as well as an additional column showing the average survival estimate for each individual Unit.

Comment 13: Jeff Murphy (NMFS) requested that a single table be created which shows station survival by each path (units, bypass, spill).

Response 13: A detailed summary of the Project white papers compiled for Lockwood, Shawmut, Weston and Brunswick will be provided within the HCP document. Summary tables detailing whole station survival via individual paths will be included within that write up.

The following comments regarding the NextEra white papers were sent via email from John Burrows (ASF) to the technical committee on 8 September 2011.

Comment 1: In addition, Andy and I can try to get some additional information on the contributions of repeat spawning salmon in a healthy salmon population. As I mentioned yesterday, I think the info in the white paper on repeat spawners greatly diminishes their importance. On the Miramichi, about 25% of annual returns are repeat spawners, which contribute 35 to 40% of egg deposition. For 2010, 52% of the large salmon were repeat spawners, the highest number ever recorded.

Response 1: ASF provided a Canada DFO summary report (Chaput and Douglas 2010) of salmon runs in the Miramichi River for the period 1970-2010. Data within that report related to the estimated contribution of repeat spawners to the overall spawning population in the Miramichi were added to Section 7.2 (Summary of Modeled Estimates for Whole Station Survival of Kelts) of the white paper.

The following comments regarding the NextEra white papers were sent via email from Norm Dube (MDMR) to the technical committee on 8 September 2011.

Comment 1: After giving this a little thought, I suggest that the timing for downstream passage in the kelt model needs to be adjusted to mid-October to mid-December (or ice-in, whichever is the latest). We generally start looking for redds around October 20 – salmon would have begun spawning before Oct. 20 (typically around Oct. 15, give or take a couple of days) when water temperature declines below 10°C. Following spawning, one would expect downstream movement of salmon. A subset of the spawners will remain in the river over the winter and the remaining salmon will migrate to the ocean right away. The overwintering salmon will migrate in the spring shortly after ice-out and, if they survive, will return to spawn in approximately 15 months (we refer to these fish as long-absence repeat spawners and will be the larger salmon in the run). The salmon which return to ocean immediately after spawning will return in approximately 9 months (and are referred to as short-absence repeat spawners and will essentially be the same size or slightly larger than they were during their maiden spawning run). Baum 1997 stated that long-absence repeat spawners comprised 90% of all the repeat spawners in Maine. As John Burrows pointed out, repeat spawners are extremely valuable in that they are more fecund than maiden spawners.

Response 1: Based on discussion during the 7 September 2011 TAC meeting as well as follow up comments from several TAC members, the whole station survival kelt models for Lockwood, Shawmut, Weston and Brunswick have been adjusted to represent a spring kelt movement period of April to May and a fall kelt movement period of mid-October to mid-December.

With regards to repeat spawners, ASF provided NextEra and its consultants with a data report from the Miramichi River. Data from that document was used to enhance the discussion of repeat spawning in Atlantic salmon within the white papers.

The following comments regarding the NextEra white papers were sent via email from Jeff Murphy (NMFS) to the technical committee on 3 October 2011.

Comment 1: With regards to all four white papers, NMFS notes that Franke et al. 1997 does not consider that anadromy may affect turbine survival.

Response 1: As used in this report, the blade strike probability models provided in Franke et al. (1997) predicts the probability of contact between a leading edge within a turbine unit and a fish body of a known length.

Comment 2: With regards to all four white papers, data concerning smolt migration timing for the Kennebec and Androscoggin Rivers is lacking.

Response 2: NextEra and its consultants are aware of the lack of data related to run timing of smolt outmigration within the Kennebec and Androscoggin Rivers. Given the lack of system-specific data, the models in the four NextEra whole station survival estimates use surrogate data from nearby Maine Rivers (Penobscot and Narraguagus).

Comment 3: With regards to Lockwood, please provide data concerning delays at the fishway and powerhouse for all test smolts.

Response 3: Delay data for outmigrating smolts (as reported in Normandeau 2011) has been summarized and added to the summary section for modeled estimates of whole station survival for smolts.

Comment 4: With regards to Lockwood, on page 25, please clarify what “inappropriately sized” means.

Response 4: Results from an initial attempt at assessing passage routes for kelts through the Lockwood Project during 2007 were suspect due to the use of inappropriately sized hatchery-reared fish (Normandeau and FPL 2008). Kelts obtained from the hatchery for use during that study were smaller than had been anticipated and relative size of implanted radio-tags may have been a factor. As requested, clarification of that statement was added to the Lockwood white paper.

Comment 5: With regards to Lockwood, please remove Vernon (74 rpm) from applicable survival models since Lockwood’s turbines are much faster.

Response 5: The Lockwood white paper has been updated to reflect this request.

Comment 6: With regards to Shawmut, please remove Vernon (74 rpm) from applicable survival models since Shawmut’s turbines are much faster.

Response 6: The Shawmut white paper has been updated to reflect this request.

Comment 7: With regards to Brunswick, of all the empirical studies, only Cathlene’s Falls approaches the high rpm of the Brunswick’s horizontal units.

Response 7: The rotational speed of the units tested at Cathleens Falls, Ireland is indeed most similar to the rotational speeds for Brunswick Units 2 and 3. The rotational speed for Brunswick Unit 1 is only 90 rpm and is more similar to some of the lower speed units within the empirical data set used in this assessment. For the purpose of maintaining simplicity within the theoretical models of whole station smolt survival constructed using empirical turbine survival data from other hydroelectric projects, the empirical data sets for smolt models have not been changed.

A REVIEW OF EFFECTS OF THE SHAWMUT PROJECT ON THE KENNEBEC RIVER, MAINE ON ATLANTIC SALMON (*SALMO SALAR*) SMOLT AND KELT DOWNSTREAM PASSAGE AND ADULT UPSTREAM PASSAGE

January 20, 2012

A Review of the Effects of the Shawmut Project on the Kennebec River, Maine on Atlantic Salmon (*Salmo salar*) Smolt and Kelt Downstream Passage and Adult Upstream Passage

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January 20, 2012

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1.0 Introduction

In 2009, the Gulf of Maine population of Atlantic salmon was listed as an endangered species under the Endangered Species Act (ESA). The Shawmut Project located on the Kennebec River is within the designated critical habitat for the species. Consequently, continued operation of the hydropower project will require the Licensee (FPL Energy Maine Hydro, LLC (FPLE)) to prepare a habitat conservation plan (HCP) and secure an incidental take permit (ITP). In order to issue an ITP, the HCP must outline measures to be undertaken by the Licensee to avoid, minimize and mitigate Project impacts, so as to assure that there is “no jeopardy" to the species as a result of continued operation of the Project. A first step in considering appropriate performance standards and measures to be included in the HCP, is a common understanding of the effect of the Project on Atlantic salmon and its habitat. The purpose of this white paper is to evaluate current Project effects and examine whole station survival on downstream migrating Atlantic salmon smolts and kelts. The whole station survival of downstream migrating Atlantic salmon smolts was modeled based on available environmental, biological and physical data related to or similar to the Shawmut Project. The construction and output of that modeling process are discussed in Sections 3, 4 and 5 of this paper. Additionally, the whole station survival of downstream migrating Atlantic salmon kelts was also modeled based on available environmental, biological and physical data related to or similar to the Shawmut Project. The construction and output of that modeling process are discussed in Sections 6 and 7 of this report. Additional considerations such as predation are discussed in Section 8.

This white paper has been revised from the original draft (provided during April, 2011) based on comments received from agencies and other members of the HCP Technical Advisory Committee (TAC). A summary of comments and a description of how comments were addressed in both the August, 2011 and this version (December 2011) of the white paper is provided in Appendix C of the Lockwood white paper.

2.0 Background

2.1 Project Facilities and Operation

The Shawmut Project, owned by FPL Energy Maine Hydro LLC is located at river mile 70 (24.5 miles above head-of-tide in Augusta) and is the third dam on the mainstem of the Kennebec River. The Shawmut Project includes a 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 (Figure 1). 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 4.46 ft high when inflated and a 25 ft wide by 8 ft deep log 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 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 original 1924 powerhouse located to the east and the newer 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 7 ft Taintor gate, a 6 ft by 6 ft deep gate and a surface sluice (4 ft wide by 22 in deep passing 35 cfs) which discharges into a 3 ft deep man-made plunge pool which serves as interim downstream anadromous fish passage. In the old powerhouse, the intake section has 6 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 in clear spacing in front of Units 1-6 and 3.5 in clear spacing in front of Units 7 and 8. The original powerhouse contains six horizontal Francis-design units and the newer powerhouse contains two horizontal propeller units, having a total combined installed capacity of 8.74 MW and combined flow of approximately 6,700 cfs. The project's tailrace channels are excavated riverbed located downstream of the powerhouses. The project boundary extends upstream about 12 miles.

The Project is typically operated in a run-of-river mode, normally passing a minimum flow of 2,110 cfs, with a target reservoir elevation of about 112.0 ft during normal conditions.

2.2 Target Species: Atlantic salmon

Numerous reviews detailing the life history of Atlantic salmon exist (NRC 2004, Fay et al. 2006, NMFS 2009) and their life cycle is summarized here. Adult Atlantic salmon begin to return to freshwater rivers during the spring. Redds are constructed and fertilized eggs are buried during the late fall. Following the fall spawn, approximately 20% of spent adult salmon (kelts) move back downstream and into the ocean; but the majority move back downstream and into the ocean the following spring (Baum 1997). Eggs remain in the gravel until hatching during the early spring. Following a three to six week period, the young salmon emerge from the gravel as fry and begin to actively seek food. As fry begin to feed they develop cryptic vertical stripes and are then known as parr. Atlantic salmon remain in the parr stage for one to three years and remain resident to freshwater during that period. Following that period, each parr undergoes a series of physiological and morphological changes known as smoltification. It is at that time that these fish move downstream through the freshwater river system and into the ocean. This downstream migration takes place during the spring season (April-June) with the majority of Maine smolts entering the ocean during May (NFMS 2009). A review of downstream migration timing data from the Penobscot and Narraguagus Rivers indicates that approximately 2% of smolts depart during April, 77% during May and 21% during June (GNP 1997, USUSUC 2005). Those individuals remain in the ocean for a period of 1-2 years prior to returning as adults and continuing the cycle.

2.3 Fish Passage Operations at Shawmut Project

Downstream smolt and kelt passage at Shawmut currently occurs via unregulated spillage and a surface sluice (4 ft wide by 22 in deep) which discharges into a 3 ft deep man-made plunge pool. The surface sluice is located next to Unit 6 and is capable of passing up to 35 cfs with all stoplogs removed. During the spring smolt migration season (April 1 – June 15) and the fall kelt migration season (Oct 15 - Dec 15) the sluice passes 35 cfs. Upstream passage is provided by the trap, lift and transport system located downstream at the Lockwood Project.

In 2011, Licensee in consultation with resource agencies was developing designs for a new combined intake structure and downstream fish bypass facility at the Project. At that time, the proposed facility included the use of new full depth one inch angled trashracks and a new surface sluice and flume leading to the river. The proposed location of this facility was upstream of the existing intake structure. Licensee and the agencies had invested significant efforts in hydraulic modeling and evaluation of alternatives to create the design concept. Licensee was scheduled to finish the design consultation and the permitting process for this new facility by the fall of 2011 and install it in 2011-2012. Effectiveness studies with salmon smolts were scheduled to begin in the spring of 2013 after resource agency consultation and approval of the study plan. The new facility would have required an amendment to the existing FERC license and NMFS was not ready to approve the facility because it was also reevaluating the existing downstream fish passage design criteria. In addition, the amendment process to the FERC license would impact the ongoing HCP/ITP process, potentially delaying it, and upon further consultation with NMFS and USFWS it was determined that the proposed facility should be "reassessed as part of the HCP/ITP process."

Within the Kennebec River, returning adult salmon are collected at the Lockwood fish lift and are trucked upstream around the Lockwood, Hydro Kennebec (owned and operated by Brookfield), Shawmut, and Weston Projects and are released into the Sandy River. It is assumed that these fish spawn in the Sandy River (approximately 12 river miles upstream from Weston, 25.5 miles upstream from Shawmut and 32.5 miles upstream from Lockwood). Radio-tagged sea run Atlantic salmon transported to the Sandy River during 2007 and 2008 showed a high degree of fidelity to that river with 89% (8 of 9) of tagged fish remaining in the Sandy River through the fall spawning season during both 2007 and 2008 (MDMR 2008, MDMR 2009). The Sandy River has the greatest biological value for both spawning and rearing habitat within the occupied range of the Merrymeeting Bay Salmon Habitat Recovery Unit (NMFS 2009). Given the combination of geographical distance between quality habitat in the Sandy River and the downstream projects and territorial nature of both the fry and parr life stages to that quality rearing habitat (Danie et al. 1984) it is unlikely that either life stage would be significantly impacted by passage through the existing hydroelectric projects on the Kennebec. The focus of this assessment is the potential Project impacts to downstream migrating Atlantic salmon smolts (Sections 3, 4, and 5) as well as an initial consideration to the impact on kelts (Sections 6.0 and 7.0).

3.0 Methods: Downstream Migrating Smolt Survival

Outmigrating Atlantic salmon smolts encountering the Shawmut Project must pass downstream via the spillway or enter the forebay canal. Currently, smolts within the forebay canal are able to pass downstream via an interim downstream bypass (surface sluice adjacent to Unit 7) or one of the eight Project turbines. Those three potential routes of passage were considered and incorporated into the model of whole station survival at the Shawmut Project (Figure 2). Information from the primary literature, reports and literature reviews on fish passage through turbines and non-turbine exit routes was assembled for examination and analysis for application to the Shawmut Project. Necessary components for assessing the impact of safe fish passage at the Shawmut Project included: smolt run timing, prevailing river flows, proportion diverted to Project spillways and the associated survival rate, proportion diverted into the Project forebay canal, proportion passed downstream via the forebay taintor gate and the associated survival, proportion transported through the turbines and the associated survival through two turbine types (2 propeller and 6 Francis Units). Propeller turbines have blades set at fixed positions and typically operate over a narrow range of unit flows. Francis turbines contain a runner which has water passages through it formed by curved vanes. Each of the six Francis-design units include two, twin-runner turbines configured on a common shaft, driving a single generator.

3.1 Smolt Downstream Bypass Efficiency

There is no site-specific data for the effectiveness rate of the interim downstream bypass located adjacent to Unit 7 in the forebay canal at the Shawmut Project for downstream passage of smolts. For the purposes of estimating the downstream bypass efficiency component of whole station survival, smolts passing through the forebay canal were partitioned by assuming an equal distribution to that of river flow passing through the forebay canal.

A number of technical plans for downstream passage of Atlantic salmon smolts are currently being reviewed for installation at the Shawmut Project (See Section 2.3). Estimated impacts for a theoretical downstream bypass to the whole station survival estimate for Shawmut Station are evaluated in Section 5.2 of this report.

3.2 Spillway and Downstream Bypass Passage Smolt Survival Assessment

Due to the lack of site-specific field-test information, estimates for passage survival of Atlantic salmon smolts through the Shawmut spillway and downstream bypass were developed based on existing empirical studies conducted at other hydroelectric projects with similar characteristics. The principal causes of injury and mortality for fish passed through either a spillway or bypass sluice are shear forces, turbulence, rapid deceleration, terminal velocity, impact against the base of the spillway, scraping against the rough concrete face of the spillway and rapid pressure changes (Heisey et al. 1996). Empirical studies related to spillway and bypass survival were pooled into a single data set. Existing studies described in the peer-reviewed primary literature and gray literature reports were collected and reviewed for potential application to the Shawmut Project. Professional judgment was used to sort through the existing studies and select those appropriate for and similar to Shawmut. Selection criteria used for this assessment included physical characteristics of the spillways/sluices at those projects, fish species tested, and geographical location.

Acceptability criteria for spillway and bypass survival studies were as follows:

- Completeness of the reported data on the important spill characteristics known to affect fish survival, information on the tested species, and other relevant information such as environmental conditions.
- Ensure control group survival >75% and sample size >25. The use of a control group allows for the isolation of effects due to the experimental treatment from those associated with the experimental procedure (e.g., handling stress or scale loss injury due to netting). Low control group survival may mask treatment effects or indicate that the experimental design and/or implementation were flawed to an extent that the results may not be reliable. Adequate sample size is important to achieve reasonable precision levels and to reduce the importance of each individual fish in a given test. For example, if 100 fish are used in a treatment group, each fish represents 1% of the sample. However, if 10 fish are used, each fish represents 10% of the sample. As control group survival decreases or the recapture rate of treatment and control fish decreases, the sample size must increase to achieve a particular level of precision.

3.3 Turbine Passage Smolt Survival Assessment

Due to the lack of site-specific information, estimates of turbine passage survival of Atlantic salmon smolts at Shawmut were developed using a combination of existing empirical studies and modeled calculations. Existing studies described in the peer-reviewed primary literature, gray literature reports, review documents and databases were collected and reviewed for potential application to the Shawmut Project. Professional judgment was used to sort through the existing studies and select those appropriate for Shawmut estimates. Selection criteria used for this assessment included physical characteristics of the projects, characteristics of the turbines at those projects, fish species tested, and geographical location. In addition to existing empirical data from similar hydroelectric projects, established models for determination of blade strike probabilities for fish passing through different turbine types were constructed for Units 1 through 8 at Shawmut.

An examination of the results of recent studies indicate that turbine passage survival is largely a function of fish size relative to size of the water passageway (as indexed by runner diameter), clearance between structural components (*e.g.*, spacing between runner blades or buckets, wicket gates, and turbine housing), flow, angle of flow, and the number of buckets/blades, though other non-mechanical factors (*e.g.*, hydraulic) may also contribute to fish injury/mortality. Thus, species *per se* is not as important as fish size (Heisey et al. 1996; Franke et al. 1997) in safe passage through turbines.

3.3.1 Empirical Estimates of Smolt Turbine Passage Survival

Acceptance criteria were established prior to the review of existing empirical data for turbine survival studies. Following determination of suitability, the studies were put into two databases, one for Kaplan or propeller turbines and another for Francis turbines. Acceptability criteria were as follows:

- Completeness of the reported data on the important turbine characteristics known to affect fish survival and information on the tested species, fish size, and other relevant information such as station discharge or environmental conditions.
- Ensure control group survival >75% and sample size >25. The use of a control group allows for the isolation of effects due to the experimental treatment from those associated with the experimental procedure (e.g., handling stress or scale loss injury due to netting). Low control group survival may mask treatment effects and indicates that the experimental design and/or implementation were flawed to an extent that the results may not be reliable. Adequate sample size is important to achieve reasonable precision levels

and to reduce the importance of each individual fish in a given test. For example, if 100 fish are used in a treatment group, each fish represents 1% of the sample. However, if 10 fish are used, each fish represents 10% of the sample. As control group survival decreases or the recapture rate of treatment and control fish decreases, the sample size must increase to achieve a particular level of precision.

3.3.2 Modeled Estimates of Smolt Turbine Passage Survival

Franke et al. (1997) defined the three primary risks to outmigrating fish passing through the turbine environment as 1) mechanical mechanisms, 2) fluid mechanisms, and 3) pressure mechanisms. Mechanical mechanisms were primarily defined as forces on fish body resulting from direct contact with turbine structural components (e.g. rotating runner blades, wicket gates, stay vanes, discharge ring, draft tube, passage through gaps between the blades and hub or at the distal end of blades or other structures placed into the water passageway). The probability of that contact is dependent on distance between blades, number of blades and fish body length. Additional sources of mechanical injury may include gap grinding, abrasion, wall strike and mechanical chop. Fluid mechanisms were defined as shear-turbulence (the effect on fish of encountering hydraulic forces due to rapidly changing water velocities) and cavitation (injury resulting from forces on fish body due to vapor pockets imploding near fish tissue). Impacts to fish from pressure resulted from the inability of fish to adjust from the regions of high pressure immediately upstream of turbine to regions of low pressure immediately downstream of turbines. Results from most studies indicate that mechanical related injuries are the dominant source of mortality for fish in the turbine environment at low head (< 30 m or 100 ft) projects (Franke et al. 1997). Blade strike is considered the primary mechanism of mortality when fish pass through turbines (Eicher Associates Inc. 1987; Cada 2001). Franke et al. (1997) noted that pressure related injuries appear to be of minor secondary importance when working at low head (< 30 m or 100 ft) hydroelectric projects. In addition, Franke et al. (1997) noted that tolerance to pressure reduction is greater for physostomous fish species, such as salmonids. Physostomous fish species are defined by having a pneumatic duct connecting the air bladder to the esophagus so that gasses from the air bladder can quickly dissipate through the mouth to accommodate changing pressures. Franke et al. (1997) noted that although evidence of injuries due to fluid shear forces does exist, relative to other injury types, they are not a dominant source of mortality during turbine passage.

Given that mechanical related injuries comprise the dominant source of mortality for fish passing through low head (< 30 m or 100 ft) hydroelectric projects, blade strike probabilities and turbine passage survival at Units 1 through 8 of the Shawmut Project was estimated for outmigrating Atlantic salmon smolts using the Advanced Hydro Turbine model developed by Franke et al. (1997). The Franke et al. (1997) blade strike model was developed as part of the U.S. Department of Energy program to develop more “fish friendly” turbines and is a modified form of the equation originally proposed by VonRaben (Bell 1981). Franke et al. (1997) refined the VonRaben model to consider tangential projection of the fish length and calculation of flow angles based on overall operating head and discharge parameters because most turbine passage mortality is likely caused by fish striking a blade or other component of the turbine unit. The Franke blade strike model predicts the probabilities of leading edge strikes (a possible mechanical injury source). Those strikes could result from contact between a fish body and a blade, a gap between blade and an adjacent structure, stay vane leading edge, wicket gate leading edge, or leading edge to any support pieces in the intake or draft tube.

The probability (*P*) of direct contact between a fish and a leading edge depends on a number of factors including the number of turbine blades (or buckets; N), fish length (L), runner blade speed (rpm), turbine type, runner diameter (D), and total discharge. Additionally, a correlation function (λ) is added to the equations to account for several factors (Franke et al. 1997). Among these are that an individual fish may not lie entirely in the plane of revolution due either to internal forces within the turbine or the physical movement of the individual fish. Additionally, a length-related fraction could be applied to account for the fact that an impact on a sensitive portion of the fish body (i.e. the head) may be more damaging than an impact to a less sensitive portion (i.e. the tail) of the fish (Franke et al. 1997). The use of the correlation factor also extends the applicability for the blade strike equations to all injury mechanisms related to the variable NL/D (number of blades*body length / runner diameter). These include both mechanical (leading edge strikes and gap grinding) and fluid mechanisms (Franke et al. 1997). As used in this analysis, the equation assumes that any strike results in immediate mortality whether the fish actually died, was injured, or not. The probability of survival predicted by this model will provide a useful perspective for fish sizes where site-specific data is not available.

Turbine passage survival was calculated for a range of fish body lengths (5-9 inches) considered to be representative of outmigrating salmon smolts in Maine rivers (NRC 2004; Fay et al. 2006). The blade strike probability for Propeller units was calculated using Equation 1:

$$P = \lambda \frac{N \cdot L}{D} \cdot \left[\frac{\cos \alpha\alpha}{8\, Q_{\omega d}} + \pi \frac{r}{R} \right] \qquad \text{(Equation 1)}$$

where Equation 2 was used to calculate the value of α_α for a Propeller Unit (.i.e, Units 7 & 8):

$$\tan \alpha_\alpha = \frac{\frac{\pi}{2} \cdot E_{\omega d} \cdot \eta}{Q_{\omega d} \frac{r}{R}} + \frac{\frac{\pi}{8} \frac{r}{R}}{Q_{\omega d}} - \tan \beta \qquad \text{(Equation 2)}$$

and Equation 3 was used to calculate the value of tan β.

$$\tan \beta = \frac{\frac{\pi}{8} \frac{r}{R}}{Q_{opt}} \qquad \text{(Equation 3)}$$

The blade strike probability for Francis units (.i.e Units 1-6) was calculated using Equation 4:

$$P = \lambda \frac{N \cdot L}{D} \cdot \left[\frac{\frac{\sin \alpha_t \cdot \frac{B}{D_1}}{2\, Q_{\omega d}} + \cos \alpha_t}{\pi} \right] \qquad \text{(Equation 4)}$$

where Equation 5 was used to calculate the value of α_t:

$$\tan(90 - \alpha_t) = \frac{2\pi E_{\omega d} \cdot \eta}{Q_{\omega d}} \cdot \frac{B}{D_1} + \frac{\pi \cdot 0.707^2}{2Q_{\omega d}} \frac{B}{D_1} \left(\frac{D_2}{D_1} \right)^2 - 4 \cdot 0.707 \cdot \tan \beta \frac{B}{D_1} \frac{D_1}{D_2} \qquad \text{(Equation 5)}$$

and Equation 6 was used to calculate the value of tan β.

$$\tan\beta = \frac{0.707\frac{\pi}{8}}{\xi \cdot Q_{\omega d}opt\frac{D_1}{D_2}^{3}}$$ (Equation 6)

Input parameters for Equations 1 through 6 were defined as:

B = Runner height at inlet
D = Diameter of runner
D_1 = Diameter of runner at the inlet
D_2 = Diameter of runner at the discharge
g = Acceleration due to gravity
H = Turbine head
L = Length of fish
N = Number of turbine blades or buckets
P = Predicted strike probability
Q = Turbine discharge
Q_{opt} = Turbine discharge at best efficiency
r = Fish entry point (along blade)
R = Radius
RPM = Revolutions per minute
α_α = Angle to axial of absolute flow upstream of runner (for Kaplan and Propeller units)
α_t = Angle to tangential of absolute flow upstream of runner (for Francis units)
β = Relative flow angle at runner discharge
ξ = Ratio between Q with no exit swirl and Q_{opt} (typical value = 1.1)
λ = Strike mortality correlation factor
η = Turbine efficiency
ω = Rotational speed (calculated as $\omega = RPM \cdot \frac{2\pi}{60}$)
$E_{\omega d}$ = Energy coefficient (calculated as $E_{\omega \mathbf{d}} = \frac{gH}{(\omega \mathbf{d})^2}$)
$Q_{\omega d}$ = Discharge coefficient (calculated as $Q_{\omega \mathbf{d}} = \frac{Q}{\omega \mathbf{D}^3}$)

Calculated blade strike probabilities (P) generated by leading edge strike equations for propeller and Francis turbines were converted into a percent survival (S) using equation 7.

S = 100 – P (Equation 7)

4.0 Results: Downstream Migrating Smolt Survival

4.1 Smolt Run Timing

In order to model whole station survival for Atlantic salmon smolts passing the Shawmut Project, it is necessary to know the timing and seasonal distribution of smolts moving downstream. Seasonal distribution data for smolt downstream migration on the Kennebec River is unavailable. As a result, distribution data collected from the smolt downstream migration on other Maine rivers was used as a surrogate. Seasonal run timing data was collected from seven different sampling years and two Maine rivers. Smolt passage was assessed during the months of April, May and June during 1988, 1989, 1990, 1993, 1994, and 1995 at the Mattaceunk Project (Weldon Dam) on the Penobscot River (Table 1; GNP 1997). During those six sampling years, a total of 16,114 Atlantic salmon smolts were collected. The average seasonal distribution for smolts during those six years was 0.09% during April (range = 0-0.46%), 71.94 during May (range = 38.0-93.84%) and 27.96 during June (range = 6.13-62.0%) (Table 2). Additional sampling was conducted and data was available related to smolt outmigration in the Penobscot River during 2004 (USASAC 2005). Total catch of Atlantic salmon smolts within Penobscot River rotary screw traps during spring 2004 is presented in Figure 6 (Note – this figure is reprinted from USASAC 2005). Based on visual assessment of Penobscot River data in Figure 6, it was estimated that approximately 10% of the Atlantic salmon smolt run took place during April, approximately 88% of the run took place during May and the remaining approximately 2% of the run took place during June. Rotary screw trap data from the Narraguagus River was also collected during 2004 (USASAC 2005). Based on visual assessment of Narraguagus River data in Figure 6, it was estimated that approximately 4% of the Atlantic salmon smolt run took place during April, approximately 96% of the run took place during May and 0% took place during June.

For the purposes of estimating whole station survival for downstream migrating Atlantic salmon smolts moving past the Shawmut Project it was assumed the average smolt distribution from the seven years of available data on seasonal smolt distribution from the Penobscot and Narraguagus Rivers would account for annual variation and be representative of patterns observed within the Kennebec River. Patterns in mean daily discharge for the three rivers were examined for the years 2006-2010 and similar trends in the timing of spring run-off events were observed. Although not readily available, it is likely that spring water temperatures are also similar among the three rivers. Similarity in spring water temperatures and run-off timing for the three rivers supports the extrapolation of smolt run timing from those systems for application to the Kennebec River. As a result, the model presented here is based on a seasonal distribution of Atlantic salmon smolts of 1.8% during April, 77.0% during May and 21.2% during June (Table 2). Variations in this seasonal distribution and their impacts to whole station survival are examined in Section 5.1 of this report.

4.1.1 Additional Considerations Related to Smolt Run Timing

There are additional ecological and anthropogenic factors that may influence smolt run timing in the Kennebec River on an annual basis. Potential sources of variation to the seasonal distribution of Atlantic salmon smolts used in the model presented in this report could include smolt origin (hatchery-reared vs. wild) as well as differences in river temperature between upstream smolt rearing areas and the downstream hydroelectric Projects.

Smolt Origin:

Differences in the timing and seasonal distribution for smolts moving downstream may vary depending on the origin of the individuals (hatchery-reared vs. wild). Holbrook (2007) observed hatchery-reared smolts released during April (2005 and 2006) to exhibit downstream migratory behavior earlier than wild smolts within the Penobscot River. It was theorized that premature smolting of hatchery-reared individuals may potentially cause them to miss the natural environmental "window of opportunity" for successful outmigration. This "window of opportunity" (McCormick et al. 1998) is defined by impacts to smolt survival based on a number of physiological and ecological factors. The impact of potential differences in the timing and seasonal distribution of hatchery-reared and wild smolts is complicated by the long history of hatchery supplementation for the species (Holbrook 2007). Collections of outmigrating smolts during the studies used in this white paper assessment (and the resulting models for the NextEra Projects) did not distinguish between hatchery-reared or wild individuals.

Source Water Temperatures:

It has been suggested that rising spring water temperatures may be the key environmental trigger for initiation of outmigration of Atlantic salmon smolts from freshwater systems with the peak of migration occurring at water temperatures of approximately 10°C (Ruggles 1980). Currently, Kennebec River smolts originate in the upper reaches of the Sandy River. Water temperature data recorded by MDMR at three locations (upper Orbeton spawning shoals, Route 4 Bridge, and Old Sandy River dam site) in the Sandy River during 2007 was examined in an attempt to provide support for the seasonal distribution of smolts used in this report (G. Wippelhauser, MDMR, personal communication). Daily average water temperatures (based on 24-hour records) were calculated for the period 23 April – 27 May 2007 at the most upstream (upper Orbeton spawning shoals) and most downstream (Old Sandy River dam site) water temperature sampling sites. Those two sampling sites are separated by approximately 60 miles of river. During 2007, Sandy River water temperatures first hit 10°C in the upper reaches of the river on 24 May. Given the literature-reported peak of smolt migration (10°C; Ruggles 1980) and the temporal occurrence of that peak temperature within the upper reaches of the Sandy River during 2007 , the seasonal distribution of Atlantic salmon smolts at the Projects of 1.8% during April, 77.0% during May and 21.2% during June seems reasonable. Given the lack of smolt outmigration data from the Sandy and Kennebec Rivers, the models for smolt outmigration presented in this report will rely on the data acquired from other Maine Rivers and described in Section 4.1.

4.2 Kennebec River Flows

Flow duration curves were obtained for the Kennebec River at the Shawmut Project during the months of April, May and June (D. Dow, NOAA, personal communication)[1]. Shawmut Project flow duration curves were based on the flow record for the period 1979 through 2010. A description of the methodology used in the development of these curves can be found in Appendix B of this report. For the purposes of modeling project survival of Atlantic salmon smolts migrating past the Shawmut Project, the median flow condition (i.e. the value with 50% flow exceedence) was used. It is likely that the use of the 50% flow exceedence value will provide a conservative estimate of the percentage of smolts passing via spill (as well as a conservative estimate of whole station survival). Once environmental cues thought to initiate the smolt outmigration period (such as water temperature) are triggered and the smolt migration is underway, it is likely that during years with seasonal pulses of flow greater than the 50% flow exceedence

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[1] The 1979-2010 flow duration curves provided by Don Dow (NOAA) replace the Lockwood Project 1978-1998 curves (Merimil 2002) that were used in the April 2011 draft of this paper.

value will pass a greater number of smolts via spill. The median flow condition at the Shawmut Project during April was approximately 13,000 cfs (Figure 3), during May was approximately 9,000 cfs (Figure 4) and during June was approximately 5,750 cfs (Figure 5). Impacts to the model of whole station smolt survival during years of high flow (10 and 25% flow exceedence) and low flow (75 and 90% flow exceedence) are examined in Section 5.1 of this report.

4.3 Smolt Downstream Route Determination

River discharge during the spring migration period will dictate the proportion of Atlantic salmon smolts passed downstream of the Shawmut Project though the spillway (and conversely, through the forebay canal). Determination of the spill effectiveness, defined as the proportion of smolts passed through spill relative to the total number passing the project, is the first step in assessing whole station survival (Figure 2). Spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (i.e., spilling 50% of total river flow results in 50% of smolts passing via the spillway). Although a number of site specific factors may impact spill effectiveness (i.e. project configuration and operations, forebay bathymetry, fish behavior, etc) the 1:1 spill effectiveness assumption has been validated at other hydroelectric projects (Normandeau 2010) and serves as a good initial value for this model. To date, no on site studies have been conducted to provide any empirical evidence to confirm the 1:1 assumption for spill effectiveness at the Shawmut Project.

An overall spill effectiveness for the period April through June of 20.6% was used for the assessment of whole station survival at Shawmut. This value was calculated using a Project capacity of 6,700 cfs, the monthly distribution of Atlantic salmon smolt outmigration for the nearby Penobscot and Narraguagus Rivers (Section 4.1), monthly median Kennebec River flow conditions (Section 4.2) and the assumption of 1:1 spill effectiveness. Table 3 provides a summary of that calculation as well as the monthly values used for the assessment of Shawmut Project spill effectiveness.

4.4 Smolt Downstream Bypass Efficiency

Interim downstream passage for Atlantic salmon smolts entering the forebay canal at Shawmut is currently provided by a surface sluice (4 ft wide by 22 in deep) which discharges into a 3 foot deep man-made plunge pool. The surface sluice is located next to Unit 7 and is capable of passing up to 35 cfs with all stoplogs removed. Given the lack of site specific data related to movement patterns through the forebay canal at Shawmut Station, it was assumed (for modeling purposes) that the distribution of smolt passage is equal to the distribution of outflow. The downstream bypass efficiency rate was allowed to vary by month to account for occasions when river discharge was less than the Project operating flow. For example, as presented in Table 3, the monthly median Kennebec River discharge (cfs) values during April and May were greater than the Project operating flow of 6,700 cfs. In those instances, the downstream bypass efficiency rate (assuming passage distribution of smolts through the forebay canal is equal to the distribution of outflow through the powerhouse and downstream bypass) was calculated as 0.5% ((35 cfs/6,700 cfs)*100 = 0.5%). However, during June, the monthly median Kennebec River discharge (cfs) value was 5,750 cfs. For that month, the downstream bypass efficiency rate (assuming passage distribution of smolts through the forebay canal is equal to the distribution of outflow through the powerhouse and downstream bypass) was calculated as 0.6% ((35 cfs/5,750 cfs)*100 = 0.6%). The remainder of the forebay canal flow passes via the turbine units.

4.5 Smolt Spillway and Downstream Bypass Passage Survival Assessment

The Shawmut Project spillway is 1,135 ft long. The spillway consists of 380 ft of hinged flashboards, 730 ft of rubber dam and a 25 ft wide log sluice. The log sluice (25 ft wide by 8 ft deep) is located near the center of the spillway section.

As the principal causes of injury and mortality for fish passed through either a spillway or bypass sluice are similar (Heisey et al. 1996) empirical studies related to spillway and bypass survival were pooled into a single data set. Injury/scale loss rates for Atlantic salmon smolt test and control fish released through sluices and bypasses at five different hydroelectric projects are presented in Table 4. Initial (1-hr) injury rates were available at all five projects and for test fish varied widely from 0% to 59% (average 18.4%) while those for control fish ranged from 0% to 4%. When initial (1-hr) test fish injuries from each of the five locations were pooled (Table 5), bruising/hemorrhaging had the greatest frequency of occurrence, being noted on 47.7% of individual smolts with injuries (10.9% of all individuals examined). Minor scale loss (<25% of body), major scale loss (>25% scale loss) and lacerations/tears were noted on 42.1%, 22.4%, and 8.4%, respectively of the individual smolts with injuries (9.6%, 5.1%, and 1.9%, respectively, of all individuals examined). Delayed (48-hr) injury rates were available at three of the five projects and for both test and control fish varied from 0% to 18% (average 6.0%). When delayed (48-hr) test fish injuries from each of the three locations were pooled (Table 5), minor scale loss (<25% of body) had the greatest frequency of occurrence, being noted on 85.7% of individual smolts with injuries (6.1% of all individuals examined). Bruising/hemorrhaging was noted on 14.3% of the individual smolts with injuries (1.0% of all individuals examined). Note that multiple injury types could be assigned to a single individual during each of the studies included in Tables 4 and 5.

Table 6 presents the measured initial (1-hr) and delayed (48-hr) survival for Atlantic salmon smolts passed through sluices and bypasses at five different hydroelectric projects. Selection of studies was limited to only those using the Hi-Z balloon tag method so that survival estimates were based solely on direct impacts from passage through the spill and not from indirect effects such as predation. Survival data collected from efficiency or fish movement studies do not represent actual Project survival and as a result, were not used in this analysis. Immediate survival (1-hr) estimates for Atlantic salmon smolts following passage through sluiceways and bypasses ranged from 93.3 to 100.0%, resulting in a mean overall spill survival of 97.1%. Delayed survival (48-hr) estimates for Atlantic salmon smolts following passage through sluiceways and bypasses ranged from 91.1 to 100.0%, resulting in a mean overall spill survival of 96.3%.

A review of 17 different spillway and sluice Hi-Z balloon tag studies conducted by Franke et al. (1997) reported an average immediate survival (1-hr) of 97.2%. That review included studies conducted for Atlantic salmon, Chinook salmon, American shad and blueback herring. Additionally, observations of post-passage movements for a limited number (N=18) of radio-tagged Atlantic salmon smolts which passed the nearby Lockwood Project via the spillway or surface sluice during 2007 (Normandeau 2008) were determined to have survived passage.

4.6 Smolt Entrainment Rates and Turbine Passage Survival Assessment

The Shawmut powerhouses contain a total of eight generating units (six horizontal Francis and two horizontal propeller units) and have a total Project generating capacity of 8.74 MW. Maximum capacity (cfs) ranges from 641-742 cfs for the six horizontal Francis units and peak capacity for the two propeller units is 1,312 and 1,347 for units 7 and 8, respectively (Table 7). Total unit flow for the Project is approximately 6,700 cfs. Normal operating head for the Shawmut Project is 23 ft. The trash racks screening the intakes are 1.5 in clear spacing in front of Units 1-6 and 3.5 in clear spacing in front of Units 7 and 8. Additional turbine characteristics for Shawmut Units 1 through 8 are provided in Table 7.

4.6.1 Turbine Entrainment Rates

Given the lack of site-specific data related to movement patterns through the forebay canal at Shawmut Station, it was assumed (for modeling purposes) that the distribution of smolt passage out of the forebay canal is equal to the distribution of outflow from the forebay canal. Based on maximum Francis and propeller unit capacities of approximately 4,015 cfs and 2,650 cfs, respectively) the theoretical entrainment rates for the portion of forebay canal flow not passing via the interim downstream bypass at the Shawmut Project are 60.0% through the Francis units and 40.0% through the propeller units. The remaining forebay canal flow is passed through the interim downstream bypass.

4.6.2 Empirical Estimates of Turbine Passage Survival

Although existing information for turbine passage survival for Kaplan, propeller and Francis turbines is extensive (e.g. Franke et al. 1997, EPRI 1997), studies specific to the passage of Atlantic salmon are not as plentiful. Injury/scale loss rates for Atlantic salmon smolt test and control fish having passed through Kaplan, propeller or Francis turbines at eleven different hydroelectric projects are presented in Table 8. Smolts recaptured during Normandeau turbine tag studies were assessed for scale loss and injuries following their initial recapture. Individuals were then held for a 48-hr period after which any incidence of latent mortality was recorded. Initial (1-hr) injury rates for test fish varied widely from 0% to 30.8% (Kaplan average = 7.5%; Francis average = 23.8%) while those for control fish ranged from 0% to 2%. When initial (1-hr) test fish injuries from each of the studies involving Kaplan units were pooled (Table 9), mechanical related injuries such as severed body/back bone, bruised head/body, and operculum/gill damage had the highest frequency of occurrence, being noted on 28.9%, 20.6%, and 15.5% of individual smolts with injuries (2.1%, 1.5%, and 1.1%, respectively, of all individuals examined). Smolts displaying a loss of equilibrium (i.e. dazed) had a 25.8% frequency of occurrence in smolts injured passing through Kaplan units (1.8% of all individuals examined following Kaplan passage).

When initial (1-hr) test fish injuries from each of the studies involving Francis units were pooled (Table 9), incidences of severed body/back bone and minor scale loss (<25%) had the highest frequency of occurrence, being noted on 31.3%, and 18.8% of individual smolts with injuries (7.9%, and 4.8%, respectively, of all individuals examined) having passed through a Francis unit. Smolts displaying a loss of equilibrium (i.e. dazed) had a 43.8% frequency of occurrence in smolts injured passing through Francis units (11.1% of all individuals examined following Francis passage). Note that multiple injury types could be assigned to a single individual during each of the studies included in Tables 8 and 9.

Tables 10 and 11 present the initial (1-hr) and delayed (48-hr) survival rates and basic Project characteristics for turbine passage survival studies conducted to evaluate turbine survival for Atlantic salmon smolts passing though Francis units (Table 10) and Kaplan/propeller units (Table 11). Selection of studies was limited to only those using the Hi-Z balloon tag method so that estimates were based solely on direct impacts from passage through a turbine unit. Survival data collected from efficiency or fish movement studies do not represent actual Project survival and as a result, were not used in this analysis. Additional study-specific information related to each study presented in Tables 10 and 11 is presented in Appendix A of this report.

Francis:

Previously conducted studies evaluating the survival of Atlantic salmon smolts passed through Francis turbines are limited. Results for two different studies conducted at two different hydroelectric projects are presented in Table 10. Initial survival (1-hr) estimates for Atlantic salmon smolt survival from individual tests (N=2) for Francis units ranged from 85.0 to 85.1%, resulting in a mean overall survival of 85.1%. Delayed survival (~48-hr) estimates for Atlantic salmon smolts from individual tests (N=2) following passage through Francis units ranged from 85.0 to 85.1%, resulting in a mean overall delayed survival of 85.1%.

Propeller:

A greater number of passage survival studies conducted on Atlantic salmon smolts passing through Kaplan and propeller turbines exist than are available for Francis units. Results for ten different studies conducted at ten different hydroelectric projects are presented in Table 11. Initial survival (1-hr) estimates of Atlantic salmon smolt survival from individual tests (N=15) for Kaplan/propeller units ranged from 88.0 to 100.0%, resulting in a mean overall survival of 94.7%. Delayed survival (~48-hr) estimates for Atlantic salmon smolts from individual tests (N=15) following passage through Kaplan units ranged from 87.5 to 100.0%, resulting in a mean overall delayed survival of 92.8%.

4.6.3 Modeled Estimates of Turbine Passage Survival

Survival estimates for turbine passage were generated for two propeller and six Francis units in operation at Shawmut. Estimates were calculated for five body lengths considered representative of the range of total length for outmigrating Atlantic salmon smolts (5, 6, 7, 8, and 9 inches). Two correlation factors (λ) were used in this analysis (0.1 and 0.2). Franke et al. (1997) recommended the value for the correlation factor be within the range of 0.1 to 0.2 based on a review of empirical results associated with a substantial number of salmonid survival studies. Survival estimates for Shawmut units1-6 were modeled using the maximum turbine discharge (cfs) and the associated efficiency. The maximum turbine discharges were selected for use in the model under the assumption that the Project would be in full operation during the spring period of high seasonal river flow. Maximum turbine discharge and associated efficiency values were not available for modeling strike probabilities for salmon smolts passing through the Shawmut units 7 and 8. As a result, survival estimates for those two units were modeled using the peak turbine discharge (cfs) and the associated efficiency.

Francis:

Model runs for five body lengths and two correlation factors resulted in a total of 10 survival estimates which are likely to bracket the actual survival for salmon smolts passing through Francis units 1-6 at the Shawmut Project. Predicted survival values for salmon smolts passing through the Shawmut Francis units ranged from a high value of 94.6% for a five inch smolt to a low value of 68.2% for a nine inch smolt (Table 12). The range of survival estimates were similar for Francis units 1-6 and the predicted survival probability increased as smolt body length decreased. The average survival of salmon smolts passing through the Francis units at Shawmut was determined by averaging the 10 modeled survival estimates for each unit. Those values ranged from a high of 88.8% at Unit 5 to a low of 81.4% at Unit 6 with an overall calculated mean survival of 84.7% for all Shawmut Francis units combined.

Propeller:

Model runs for five body lengths, two correlation factors and three *r* values resulted in a total of 30 survival estimates which likely bracket the actual survival for salmon smolts passing through the two propeller units at Shawmut (Units 7 and 8). The three *r* values represent the point along the runner radius that the fish enters the turbine. Values for *r* used in this assessment were 0.1, 0.5, and 0.9% of the runner radius.

Predicted survival values for salmon smolts passing through Unit 7 at Shawmut ranged from a high of 98.3% for a five inch smolt to a low of 83.1% for a nine inch smolt and at Unit 8 from a high of 98.4% for a five inch smolt to a low of 83.1% for a nine inch smolt (Table 13). Predicted survival probabilities increased as smolt body length and entry point proximity to the turbine hub decreased. The average survival of salmon smolts passing through the propeller units at Shawmut was determined by averaging the modeled survival estimates for each combination of fish length, entry point and λ at Units 7 and 8. The calculated mean survival for the Shawmut propeller units was 94.3%.

4.6.4 Comparison of Modeled and Empirical Passage Survival

Francis:

Initial (1-hr) and delayed (48-hr) survival estimates for Francis turbines obtained from empirical data collected at other hydroelectric projects were compared with the predictive models developed specifically for the Shawmut Project Units 1-6. As expected, the average modeled survival rate for Shawmut Francis units (84.7%) was most similar to empirical data collected from other smaller-sized Francis units (as indicated by runner diameter) than empirical data collected from larger Francis units. Turbines characterized by narrower water passage areas (as defined by small runner diameter and/or more runner blades) relative to fish size pose greater risks associated with mechanical damage to a fish (Franke et al. 1997).

Propeller:

Initial (1-hr) and delayed (48-hr) survival estimates for propeller and Kaplan turbines obtained from empirical data collected at other hydroelectric projects were compared with the predictive model developed specifically for the Shawmut Project Units 7 and 8. The average modeled survival rate for the Shawmut propeller units (94.3%) was within the observed range (88.0-100.0%) of empirical survival estimates for Kaplan/propeller turbines at other hydroelectric projects.

5.0 Estimated Project Impact on Outmigrating Atlantic salmon Smolts

5.1 Modeled Estimate of Whole Station Survival for Smolts

Whole station survival for the Shawmut Project was estimated by integrating Kennebec River discharge, Project operating flows, the proportion of smolts diverted towards the spillway and forebay canal, spillway survival rate (as estimated from empirical data), turbine passage survival rates (as estimated through a combination of empirical and modeled data), interim downstream bypass efficiency, and fish bypass passage survival rate (as estimated from empirical data). Four models intended to estimate whole station survival of smolts passing the Shawmut Project were constructed using the available empirical and modeled survival estimates for both spill and turbine passage. The four individual models were:

1) Initial Survival Rate Model (Model A): Spill survival based on 1-hr empirical survival data and Propeller and Francis turbine survival based on 1-hr survival empirical data
2) Delayed Survival Rate Model (Model B): Spill survival based on 48-hr empirical survival data and Propeller and Francis turbine survival based on 48-hr survival empirical data
3) Delayed/Calculated Survival Rate Model (Model C): Spill survival based on 48-hr empirical survival data and Propeller and Francis turbine survival based Franke estimates
4) Initial Injury Rate Model (Model D): survival based on 1-hr empirical injury data and Propeller and Francis turbine survival based on 1-hr empirical injury data

5.1.1 Whole Station Smolt Survival Modeled Using Initial Survival Rates

The Model A whole station smolt survival estimate was generated using initial (1-hr) survival rates for spill and turbine passed fish obtained from empirical data collected at other hydroelectric projects. The following values for each of the necessary model parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in this calculation of whole station survival for salmon smolts at the Shawmut Project:

- Kennebec River Flow – monthly medians of 13,000 cfs (April), 9,000 cfs (May) and 5,750 cfs (June);
- Project operating flow – 6,700 cfs;
- Proportion of salmonid smolts diverted – utilized a ratio of 1:1 fish to river flow;
- Project spillway survival – 97.1% (based on review of initial (1-hr) empirical survival data from other hydroelectric projects);
- Fish bypass guidance efficiency – as determined on a monthly basis based on the relationship of bypass discharge (35 cfs) and Project operating flow;
    - April: (35 cfs / 6,700 cfs)*100 = 0.5%
    - May: (35 cfs / 6,700 cfs)*100 = 0.5%
    - June: (35 cfs / 5,750 cfs)*100 = 0.6%
- Proportion of smolts in forebay canal entrained at turbines – as determined on a monthly basis as 100% - fish bypass guidance efficiency
    - April: 100% - 0.5% = 99.5%
    - May: 100% - 0.5% = 99.5%

  - June: 100% - 0.6% = 99.4%
- Entrainment rates by turbine type – 60% to propeller units and 40% to Francis units (based on distribution of river flow at maximum Unit capacity);
- Propeller turbine passage survival – 94.7% (based on review of initial (1-hr) empirical survival data from other hydroelectric projects);
- Francis turbine passage survival – 85.1% (based on review of initial (1-hr) empirical survival data from other hydroelectric projects);
- Fish bypass system survival – 97.1% (based on review of initial (1-hr) empirical survival data from other hydroelectric projects).

The integration of the above values is presented in Table 14 for a hypothetical case of 1,000 Atlantic salmon smolts approaching the Shawmut Project during the spring migration period (April-June). The Model A whole station survival estimate for Atlantic salmon smolts passing the Shawmut Project generated using initial (1-hr) empirical data for spillway and turbine survival estimates is 91%[2].

5.1.1.1 Impacts to Estimated Smolt Survival Associated with Bypass Efficiency Assumption

The Initial Survival Rate Model (Model A) for Shawmut can be manipulated to provide insight into potential impacts to whole station survival based on modifying the various input parameters. Increased effectiveness of the downstream bypass would reduce the impact of turbine passage on outmigrating smolts and should increase whole station survival. The effectiveness of floating guidance devices (Normandeau 2008) and angled bar racks (Normandeau 1994a; Simmons 2000) have been assessed at other locations for guiding salmonids past hydroelectric turbines. Table 15 provides whole station survival estimates for a range of theoretical bypass efficiency rates. Theoretical bypass effectiveness rates between 25 and 100% were modeled and produced a range of whole station survival estimates for outmigrating Atlantic salmon smolts between 92% and 97%.

5.1.1.2 Impacts to Estimated Smolt Survival Associated with Seasonal Distribution Assumption

In cases with no site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (e.g., spilling 50% of total river flow results in 50% of smolts passing via the spillway). A basic implication of the deviation from the 1:1 assumption is that if a proportionally smaller percentage of smolts relative to the river flow enter the Project forebay then the calculated station-related smolt survival would be higher. Under these conditions, a greater percentage of smolts would pass the project via spill and would avoid impacts associated with turbine passage. Alternatively, if a proportionally higher percentage of smolts are entering the Project forebay than the calculated station related smolt survival would be lower. Under these conditions, a lower percentage of smolts would pass the project via spill and a greater number would be entrained through the Project turbines.

The sensitivity of the Initial Survival Rate Model (Model A) associated with deviation from the assumed 1:1 ratio of fish to flow at the Shawmut Project is presented in Table 16. A range of spill effectiveness rates for Atlantic salmon smolts from 5% (0.2:1) to 90% (4.4:1) was evaluated. For conditions where a proportionately lower percentage of smolts relative to river flow entered the forebay canal (i.e. spill effectiveness rates of 30% and greater), the estimates for whole station survival were equal to or greater than that observed under the assumption of 1:1 spill effectiveness and ranged from 91% to 96%. For conditions where a proportionately higher percentage of smolts relative to river flow entered the forebay

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[2] Whole station survival estimates are reported to the nearest whole percentage so as to not overstate the accuracy of these models. This was done following comments made at the Technical Advisory Committee meeting held on 7 September 2011.

canal (i.e. a spill effectiveness rate of 5%), the estimate for whole station survival (89%) was lower than that observed under the assumption of 1:1 spill effectiveness.

5.1.1.3 Impacts to Estimated Smolt Survival Associated with Seasonal Flow Assumption

The Initial Survival Rate Model (Model A) for Shawmut was constructed using the assumption of median Kennebec River flows (i.e. 50% exceedence) during the months of April, May and June. Two “low flow” conditions (75 and 90% exceedence) and two “high flow” conditions (10 and 25% exceedence) were also examined. Estimated monthly Kennebec River flows for the months of April, May and June under the 10, 25, 75, and 90% exceedence conditions are presented in Table 17. Table 18 presents the modeled whole station survival estimates for downstream migrating Atlantic salmon smolts under the additional low and high flow conditions. Under the low flow conditions (i.e. those exceeded 75 and 90 % of the time) the estimated whole station survival for salmon smolts at the Shawmut Project decreased to 89%. Under the high flow conditions (i.e. those exceeded only 10 or 25% of the time) the estimated whole station survival for salmon smolts at the Shawmut Project increased to 94% and 93%, respectively.

5.1.2 Whole Station Smolt Survival Modeled Using Delayed Survival Rates

The Model B whole station smolt survival estimate was generated using delayed (48-hr) survival rates for spill and turbine passed fish obtained from empirical data collected at other hydroelectric projects. The following values for each of the necessary model parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in this calculation of whole station survival for salmon smolts at the Shawmut Project:

- Kennebec River Flow – monthly medians of 13,000 cfs (April), 9,000 cfs (May) and 5,750 cfs (June);
- Project operating flow – 6,700 cfs;
- Proportion of salmonid smolts diverted – utilized a ratio of 1:1 fish to river flow;
- Project spillway survival – 96.3% (based on review of delayed (48-hr) empirical survival data from other hydroelectric projects);
- Fish bypass guidance efficiency – as determined on a monthly basis based on the relationship of bypass discharge (35 cfs) and Project operating flow;
    - April: (35 cfs / 6,700 cfs)*100 = 0.5%
    - May: (35 cfs / 6,700 cfs)*100 = 0.5%
    - June: (35 cfs / 5,750 cfs)*100 = 0.6%
- Proportion of smolts in forebay canal entrained at turbines – as determined on a monthly basis as 100% - fish bypass guidance efficiency
    - April: 100% - 0.5% = 99.5%
    - May: 100% - 0.5% = 99.5%
    - June: 100% - 0.6% = 99.4%
- Entrainment rates by turbine type – 60% to propeller units and 40% to Francis units (based on distribution of river flow at maximum Unit capacity);
- Propeller turbine passage survival – 92.8% (based on review of delayed (48-hr) empirical survival data from other hydroelectric projects);
- Francis turbine passage survival – 85.1% (based on review of delayed (48-hr) empirical survival data from other hydroelectric projects);

- Fish bypass system survival – 96.3% (based on review of delayed (48-hr) empirical survival data from other hydroelectric projects).

The integration of the above values is presented in Table 19 for a hypothetical case of 1,000 Atlantic salmon smolts approaching the Shawmut Project during the spring migration period (April-June). The Model B whole station survival estimate for Atlantic salmon smolts passing the Shawmut Project generated using delayed (48-hr) empirical data for spillway and turbine survival estimates is 90%.

5.1.2.1 Impacts to Estimated Smolt Survival Associated with Bypass Efficiency Assumption

The Delayed Survival Rate Model (Model B) for Shawmut can be manipulated to provide insight into potential impacts to whole station survival based on modifying the various input parameters. Increased effectiveness of the downstream bypass would reduce the impact of turbine passage on outmigrating smolts and should increase whole station survival. The effectiveness of floating guidance devices (Normandeau 2008) and angled bar racks (Normandeau 1994a; Simmons 2000) have been assessed at other locations for guiding salmonids past hydroelectric turbines. Table 20 provides whole station survival estimates for a range of theoretical bypass efficiency rates. Theoretical bypass effectiveness rates between 25 and 100% were modeled and produced a range of whole station survival estimates for outmigrating Atlantic salmon smolts between 91% and 96%.

5.1.2.2 Impacts to Estimated Smolt Survival Associated with Seasonal Distribution Assumption

In cases with no site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (e.g., spilling 50% of total river flow results in 50% of smolts passing via the spillway). A basic implication of the deviation from the 1:1 assumption is that if a proportionally smaller percentage of smolts relative to the river flow enter the Project forebay then the calculated station-related smolt survival would be higher. Under these conditions, a greater percentage of smolts would pass the project via spill and would avoid impacts associated with turbine passage. Alternatively, if a proportionally higher percentage of smolts are entering the Project forebay than the calculated station related smolt survival would be lower. Under these conditions, a lower percentage of smolts would pass the project via spill and a greater number would be entrained through the Project turbines.

The sensitivity of the Delayed Survival Model (Model B) associated with deviation from the assumed 1:1 ratio of fish to flow at the Shawmut Project is presented in Table 21. A range of spill effectiveness rates for Atlantic salmon smolts from 5% (0.2:1) to 90% (4.4:1) was evaluated. For conditions where a proportionately lower percentage of smolts relative to river flow entered the forebay canal (i.e. spill effectiveness rates of 30% and greater), the estimates for whole station survival were greater than that observed under the assumption of 1:1 spill effectiveness and ranged from 91% to 95%. For conditions where a proportionately higher percentage of smolts relative to river flow entered the forebay canal (i.e. a spill effectiveness rate of 5%), the estimate for whole station survival (89%) was lower than that observed under the assumption of 1:1 spill effectiveness.

5.1.2.3 Impacts to Estimated Smolt Survival Associated with Seasonal Flow Assumption

The Delayed Survival Model (Model B) for Shawmut was constructed using the assumption of median Kennebec River flows (i.e. 50% exceedence) during the months of April, May and June. Two "low flow" conditions (75 and 90% exceedence) and two "high flow" conditions (10 and 25% exceedence) were also examined. Estimated monthly Kennebec River flows for the months of April, May and June under the 10, 25, 75, and 90% exceedence conditions are presented in Table 16. Table 22 presents the modeled whole station survival estimates for downstream migrating Atlantic salmon smolts under the additional low and high flow conditions. Under the low flow conditions (i.e. those exceeded 75 and 90 % of the time) the estimated whole station survival for salmon smolts at the Shawmut Project decreased to 88%. Under the high flow conditions (i.e. those exceeded only 10 or 25% of the time) the estimated whole station survival for salmon smolts at the Shawmut Project increased to 94% and 92%, respectively.

5.1.3 Whole Station Smolt Survival Modeled Using Delayed/Calculated Survival Rates

The Model C whole station smolt survival estimate was generated using delayed (48-hr) survival rates for spill obtained from empirical data collected at other hydroelectric projects in conjunction with modeled estimates of turbine passed fish obtained using the Franke (Franke et al. 1997) formula. The following values for each of the necessary model parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in this calculation of whole station survival for salmon smolts at Shawmut Project:

- Kennebec River Flow – monthly medians of 13,000 cfs (April), 9,000 cfs (May) and 5,750 cfs (June);
- Project operating flow – 6,700 cfs;
- Proportion of salmonid smolts diverted – utilized a ratio of 1:1 fish to river flow;
- Project spillway survival – 96.3% (based on review of delayed (48-hr) empirical survival data from other hydroelectric projects);
- Fish bypass guidance efficiency – as determined on a monthly basis based on the relationship of bypass discharge (35 cfs) and Project operating flow;
    - April: (35 cfs / 6,700 cfs)*100 = 0.5%
    - May: (35 cfs / 6,700 cfs)*100 = 0.5%
    - June: (35 cfs / 5,750 cfs)*100 = 0.6%
- Proportion of smolts in forebay canal entrained at turbines – as determined on a monthly basis as 100% - fish bypass guidance efficiency
    - April: 100% - 0.5% = 99.5%
    - May: 100% - 0.5% = 99.5%
    - June: 100% - 0.6% = 99.4%
- Entrainment rates by turbine type – 60% to propeller units and 40% to Francis units (based on distribution of river flow at maximum Unit capacity);
- Propeller turbine passage survival – 94.3% (based on modeled values generated using site-specific turbine parameters);
- Francis turbine passage survival – 84.7% (based on modeled values generated using site-specific turbine parameters);
- Fish bypass system survival – 96.3% (based on review of delayed (48-hr) empirical survival data from other hydroelectric projects).

The integration of the above values is presented in Table 23 for a hypothetical case of 1,000 Atlantic salmon smolts approaching the Shawmut Project during the spring migration period (April-June). The Model C whole station survival estimate for Atlantic salmon smolts passing the Shawmut Project generated using delayed (48-hr) empirical data for spillway survival and site-specific modeled data for turbine survival estimates is 90%.

5.1.3.1 Impacts to Estimated Smolt Survival Associated with Bypass Efficiency Assumption

The Delayed/Calculated Survival Model for Shawmut can be manipulated to provide insight into potential impacts to whole station survival based on modifying the various input parameters. Increased effectiveness of the downstream bypass would reduce the impact of turbine passage on outmigrating smolts and should increase whole station survival. The effectiveness of floating guidance devices (Normandeau 2008) and angled bar racks (Normandeau 1994a; Simmons 2000) have been assessed at other locations for guiding salmonids past hydroelectric turbines. Table 24 provides whole station survival estimates for a range of theoretical bypass efficiency rates. Theoretical bypass effectiveness rates between 25 and 100% were modeled and produced a range of whole station survival estimates for outmigrating Atlantic salmon smolts between 92% and 96%.

5.1.3.2 Impacts to Estimated Smolt Survival Associated with Seasonal Distribution Assumption

In cases with no site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (e.g., spilling 50% of total river flow results in 50% of smolts passing via the spillway). A basic implication of the deviation from the 1:1 assumption is that if a proportionally smaller percentage of smolts relative to the river flow enter the Project forebay then the calculated station-related smolt survival would be higher. Under these conditions, a greater percentage of smolts would pass the project via spill and would avoid impacts associated with turbine passage. Alternatively, if a proportionally higher percentage of smolts are entering the Project forebay than the calculated station related smolt survival would be lower. Under these conditions, a lower percentage of smolts would pass the project via spill and a greater number would be entrained through the Project turbines.

The sensitivity of the Delayed/Calculated Survival Model (Model C) associated with deviation from the assumed 1:1 ratio of fish to flow at the Shawmut Project is presented in Table 25. A range of spill effectiveness rates for Atlantic salmon smolts from 5% (0.2:1) to 90% (4.4:1) were evaluated. For conditions where a proportionately lower percentage of smolts relative to river flow entered the forebay canal (i.e. spill effectiveness rates of 30% and greater), the estimates for whole station survival were greater than that observed under the assumption of 1:1 spill effectiveness and ranged from 91% to 96%. For conditions where a proportionately higher percentage of smolts relative to river flow entered the forebay canal (i.e. a spill effectiveness rate of 5%), the estimate for whole station survival (89 %) was lower than that observed under the assumption of 1:1 spill effectiveness.

5.1.3.3 Impacts to Estimated Smolt Survival Associated with Seasonal Flow Assumption

The Delayed/Calculated Survival Model (Model C) for Shawmut was constructed using the assumption of median Kennebec River flows (i.e. 50% exceedence) during the months of April, May and June. Two "low flow" conditions (75 and 90% exceedence) and two "high flow" conditions (10 and 25% exceedence) were also examined. Estimated monthly Kennebec River flows for the months of April, May and June under the 10, 25, 75, and 90% exceedence conditions are presented in Table 16. Table 26 presents the modeled whole station survival estimates for downstream migrating Atlantic salmon smolts under the additional low and high flow conditions. Under the low flow conditions (i.e. those exceeded 75 and 89% of the time) the estimated whole station survival for salmon smolts at the Shawmut Project decreased to 91%. Under the high flow conditions (i.e. those exceeded only 10 or 25% of the time) the estimated whole station survival for salmon smolts at the Shawmut Project increased to 94% and 92%, respectively.

5.1.4 Whole Station Smolt Survival Modeled Using Initial Injury Rates

The Model D whole station smolt survival estimate was generated using initial (1-hr) injury rates for spill and turbine passed fish obtained from empirical data collected at other hydroelectric projects. Comparisons of initial injury assessment and delayed survival rates for Atlantic salmon smolts subjected to mark-recapture spill and turbine passage studies suggest that not all injuries sustained by smolts during dam passage will result in mortality. However, for the purposes of this analysis, it was assumed that any fish subjected to an injury (regardless of the magnitude of that injury) suffered mortality. Model D was intended to provide a "worst case" scenario for Atlantic salmon smolts passing the Shawmut Project. The following values for each of the necessary model parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in this calculation of whole station survival for salmon smolts at Shawmut Project:

- Kennebec River Flow – monthly medians of 13,000 cfs (April), 9,000 cfs (May) and 5,750 cfs (June);
- Project operating flow – 6,700 cfs;
- Proportion of salmonid smolts diverted – utilized a ratio of 1:1 fish to river flow;
- Project spillway survival – 81.6% (based on review of initial (1-hr) empirical injury data from other hydroelectric projects used as a surrogate for survival);
- Fish bypass guidance efficiency – as determined on a monthly basis based on the relationship of bypass discharge (35 cfs) and Project operating flow;
    - April: (35 cfs / 6,700 cfs)*100 = 0.5%
    - May: (35 cfs / 6,700 cfs)*100 = 0.5%
    - June: (35 cfs / 5,750 cfs)*100 = 0.6%
- Proportion of smolts in forebay canal entrained at turbines – as determined on a monthly basis as 100% - fish bypass guidance efficiency
    - April: 100% - 0.5% = 99.5%
    - May: 100% - 0.5% = 99.5%
    - June: 100% - 0.6% = 99.4%
- Entrainment rates by turbine type – 60% to propeller units and 40% to Francis units (based on distribution of river flow at maximum Unit capacity);
- Propeller turbine passage survival – 92.5% (based on review of initial (1-hr) empirical injury data from other hydroelectric projects used as a surrogate for survival);
- Francis turbine passage survival – 76.2% (based on review of initial (1-hr) empirical injury data from other hydroelectric projects used as a surrogate for survival);
- Fish bypass system survival – 81.6% (based on review of initial (1-hr) empirical injury data from other hydroelectric projects used as a surrogate for survival).

The integration of the above values is presented in Table 27 for a hypothetical case of 1,000 Atlantic salmon smolts approaching the Shawmut Project during the spring migration period (April-June). The Model D whole station survival estimate for Atlantic salmon smolts passing the Shawmut Project generated using initial (1-hr) empirical injury data as a surrogate for spillway and turbine survival estimates is 82%.

5.1.4.1 Impacts to Estimated Smolt Survival Associated with Bypass Efficiency Assumption

The Initial Injury Rate Model (Model D) for Shawmut can be manipulated to provide insight into potential impacts to whole station survival based on modifying the various input parameters. Increased effectiveness of the downstream bypass would reduce the impact of turbine passage on outmigrating smolts and should increase whole station survival. The effectiveness of floating guidance devices (Normandeau 2008) and angled bar racks (Normandeau 1994a; Simmons 2000) have been assessed at other locations for guiding salmonids past hydroelectric turbines. Table 28 provides whole station survival estimates for a range of theoretical bypass efficiency rates. Theoretical bypass effectiveness rates between 25 and 100% were modeled and produced values similar to the estimate of whole stations survival based on the interim downstream bypass structure.

5.1.4.2 Impacts to Estimated Smolt Survival Associated with Seasonal Distribution Assumption

In cases with no site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (e.g., spilling 50% of total river flow results in 50% of smolts passing via the spillway). A basic implication of the deviation from the 1:1 assumption is that if a proportionally smaller percentage of smolts relative to the river flow enter the Project forebay then the calculated station-related smolt survival would be higher. Under these conditions, a greater percentage of smolts would pass the project via spill and would avoid impacts associated with turbine passage. Alternatively, if a proportionally higher percentage of smolts are entering the Project forebay than the calculated station related smolt survival would be lower. Under these conditions, a lower percentage of smolts would pass the project via spill and a greater number would be entrained through the Project turbines.

The sensitivity of the Initial Injury Rate Model (Model D) associated with deviation from the assumed 1:1 ratio of fish to flow at the Shawmut Project is presented in Table 29. A range of spill effectiveness rates for Atlantic salmon smolts from 5% (0.2:1) to 90% (4.4:1) was evaluated. For conditions where a proportionately lower percentage of smolts relative to river flow entered the forebay canal (i.e. spill effectiveness rates of 30% and greater), the estimates for whole station survival were equal to o that observed under the assumption of 1:1 spill effectiveness. For conditions where a proportionately higher percentage of smolts relative to river flow entered the forebay canal (i.e. a spill effectiveness rate of 5%), the estimate for whole station survival (83%) was greater than that observed under the assumption of 1:1 spill effectiveness.

5.1.4.3 Impacts to Estimated Smolt Survival Associated with Seasonal Flow Assumption

The Initial Injury Rate Model (Model D) for Shawmut was constructed using the assumption of median Kennebec River flows (i.e. 50% exceedence) during the months of April, May and June. Two “low flow” conditions (75 and 90% exceedence) and two “high flow” conditions (10 and 25% exceedence) were also examined. Estimated monthly Kennebec River flows for the months of April, May and June under the 10, 25, 75, and 90% exceedence conditions are presented in Table 16. Table 30 presents the modeled whole station survival estimates for downstream migrating Atlantic salmon smolts under the additional low and high flow conditions. Under the low flow conditions (i.e. those exceeded 75 and 90 % of the time) the estimated whole station survival for salmon smolts at the Shawmut Project increased to 83%. Under the high flow conditions (i.e. those exceeded only 10 or 25% of the time) the estimated whole station survival for salmon smolts at the Shawmut Project was equal to that observed under the assumption of median river flow.

5.2 Summary of Modeled Estimate of Whole Station Survival for Smolts

Four models of whole station survival of Atlantic salmon smolts at the Shawmut Project were constructed using available empirical and modeled survival rates for passage via spill and through turbine units. The primary estimates of whole station survival generated by those four models ranged from 91% to 82% with modifications during the various sensitivity analyses expanding those bounds to 97% and 82%. Model A (Initial Survival Rate Model) yielded the highest estimates of whole station smolt survival. Model D, the Initial Injury Rate model (using 1-hr empirical spill and turbine injury rates as a surrogate for survival) produced the lowest estimate of whole station smolt survival. The Initial Injury Rate model (Model D) was constructed under the assumption that any fish subjected to an injury (regardless of the magnitude of that injury) suffered mortality. It should be noted that comparisons of initial injury assessment and delayed survival rates for Atlantic salmon smolts subjected to mark-recapture spill and turbine passage studies suggest that not all injuries sustained by smolts during dam passage will result in mortality. In addition, the sensitivity analyses for Model D showed an increase in whole station survival as a greater proportion of smolts were passed via turbine units. This was due to the relatively low survival rate (81.6%) when empirical injury data collected at other hydroelectric projects for spill passed salmon smolts was used as a surrogate for survival. The majority of injuries observed for Atlantic salmon smolts passed via spill (Table 5) were minor scale loss and bruising/hemorrhaging. Although some studies have suggested that descaling of smolts may reduce performance and decrease survival during migration (Gadomski et al. 1994; Zydlewski et al. 2010), another study has suggested that the required time (in freshwater) for a smolt to recover from a loss of scales that would be lethal in saltwater is within one day (Bouck and Smith 1979). While injuries to smolts passed via spill and turbines will lead to mortality for a percentage of individuals, it is likely that the Initial Injury Rate Model (using 1-hr injury rates as a surrogate for survival) underestimates whole station smolt survival at Shawmut. Model C, the Delayed/Calculated Survival Rate Model, provides the most conservative and reliable estimate of whole station smolt survival at Shawmut (90%).

6.0 Atlantic Salmon Adults and Kelts

6.1 Adult Upstream Migration

Within the Kennebec River, returning adult salmon are collected at the Lockwood fish lift and are trucked upstream around the Lockwood, Hydro Kennebec, Shawmut, and Weston Projects and are released into the Sandy River. There are no upstream passage facilities at the Shawmut Project. Collection totals for the previous six years (2006-2011) at Lockwood have ranged from a low of five individuals during 2010 to a high of 64 individuals during 2011 (Table 31). The average adult fork length for years 2006-2011 has ranged between 65.0-73.5 cm and the majority of individuals were aged at 1 or 2 years at sea.

6.1.1 Upstream Migration Delays

Delays to the upstream migration of Atlantic salmon have been observed below hydroelectric facilities. Fay et al. (2006) provided a review of available literature (Dube 1988; Shepard 1989; Shepard and Hall 1991; Shepard 1995) related to the observed passage delays at a number of hydroelectric projects on the Penobscot River. Results from these radio-telemetry studies indicate that the duration of delay varies widely among year and hydroelectric facility. Yearly pooled median passage times for adult Atlantic salmon at Veazie ranged from 4.7 to 33.2 days over five years of study. Yearly pooled median passage times for adult Atlantic salmon at Great Works ranged from 1.4 to 2.7 days over four years of study. Yearly pooled median passage times for adult Atlantic salmon at Milford Dam ranged from 1.0 to 5.3 days over five years of study. A recent (2005/2006) radio-telemetry assessment of upstream passage for Atlantic salmon adults at Penobscot River projects reported individual passage times (defined as interval between first tailrace detection and first upstream detection) for a limited number of fish at Veazie, Great Works and Milford Dams (Holbrook et al. 2009). Individual passage times (2005) for adult salmon approaching Veazie from Penobscot Bay were 2.0 and 3.3 days (for 2 of 4 individuals detected in tailrace) and for salmon approaching Great Works were 1.9, 13.1, and 25.4 days (for 3 of 6 individuals detected in tailrace). Individual passage times for all adult salmon having passed Great Works were 0.1, 2.9, and 3.7 days at Milford. Individual passage times (2006) for adult salmon reapproaching Veazie (following passage over the dam) were 2.1, 6.8 and 58.4 days (for 3 of 7 individuals detected in tailrace) and for salmon approaching Great Works were 8.6, 8.7, and 12.5 days (for 3 of 25 individuals detected in tailrace).

There are no delays to the upstream migration of adult salmon caused by the Shawmut Project due to the current Kennebec River management practice of trap and truck for returning sea-run Atlantic salmon at the Lockwood Project upstream to the Sandy River.

6.2 Kelt Downstream Migration

Following the fall season spawning period, Atlantic salmon kelts either outmigrate during the fall or remain in the freshwater portion of the river before outmigrating during the following spring. Baum (1997) indicated that following the fall spawn, approximately 20% of kelts move back downstream with the remainder (80%) moving downstream and the following spring. Quantitative data obtained from studies regarding timing, duration and survival of Atlantic salmon kelts during their downstream migration in the Kennebec River and through the Shawmut Project are unavailable.

Although sample size and information related to passage routes are limited, successful downstream passage through four hydroelectric projects on the lower Kennebec River was observed for a single kelt radio tagged as part of a study on the Sandy River (MDMR 2009). A total of 18 sea-run Atlantic salmon were captured at the Lockwood Project, radio tagged and trucked to the Sandy River during the spring seasons of 2007 and 2008 (MDMR 2008, MDMR 2009). The majority (8 of 9) of those fish were determined to have remained in the Sandy River through the spawning season during both years. A single individual released in the Sandy River during early June 2008 successfully passed downstream of the Weston Project and was located in the mainstem of the Kennebec River during August and September of 2008. That same individual was next detected downstream of Lockwood during January 2009. Detection of that fish below Lockwood demonstrates that it successfully passed downstream past the Weston, Shawmut, and Lockwood projects as well as Hydro Kennebec (owned and operated by Brookfield Power).

6.3 Modeled Downstream Migrating Kelt Survival

Limited data for Atlantic salmon kelts make it difficult to assess the specific effects of the Shawmut Project on kelt survival. Observations on the Penobscot and other river systems in the Northeast suggest that kelts tend to linger in spawning areas and in parts of the freshwater river system, including hydropower reservoirs and facilities. Similar to the behavior recorded on the Penobscot River, anecdotal observations by Normandeau personnel working on the Merrimack River, NH have noted adult salmon to remain within the forebay canal of the Garvins Falls Project and individuals are often visible within the upper portion of the water column at that site. Kelts are not thought to sound frequently and that notion is supported through the reduction in turbine passage at Weldon following the installation of tightly spaced 1 in trashracks over the upper 16 feet of the intakes. In addition, adult salmon are strong swimmers and have the ability to avoid turbine intakes. Observed burst speeds for adult salmon range between 14.1 to 19.7 ft/s with a maximum sustained swim speed of 3.4 f/s (Beamish 1978). These behaviors suggest that salmon could be successful at locating and using surface bypasses. Similar to the whole station survival estimate generated for outmigrating Atlantic salmon smolts in Sections 4.0 and 5.0 of this report, this section will attempt to predict kelt survival at the Shawmut Project. Where passage related data is unavailable for the kelt life stage, it will be assumed that outmigration behaviors are similar to those of the smolt life stage.

6.3.1 Kelt Run Timing

In order to model whole station survival for Atlantic salmon kelts passing the Shawmut Project, it is necessary to know the timing and seasonal distribution of their downstream migration. Seasonal distribution data for kelt downstream migration specific to the Kennebec River is unavailable. Baum (1997) indicated that following the fall spawn, approximately 20% of kelts move back downstream and into the ocean but the majority move back downstream and into the ocean the following spring. Based on observations during MDMR redd surveys, outmigration of kelts immediately following the fall spawn occurs during the latter half of October, November, and the first half of December (N. Dube, MDMR, personal communication). For the purposes of estimating whole station kelt survival at Shawmut, it was assumed that the percentage of the total kelt outmigration occurring during the fall (20%) would be partitioned among the known salmon outmigration months of October (5%), November (10%) and December (5%). Likewise, the percentage of the total kelt outmigration occurring during the spring (80%) would be divided between the known salmon outmigration months of April (40%) and May (40%). Variations in this seasonal distribution and their impacts to whole station survival are examined in Section 7.1.1.2 of this report.

6.3.2 Kennebec River Flows

Flow duration curves were obtained for the Kennebec River at the Shawmut Project during the months of April, May, October, November, and December (D. Dow, NOAA, personal communication). Shawmut Project flow duration curves were based on the flow record for the period 1979 through 2010. A description of the methodology used in the development of these curves can be found in Appendix B of this report. For the purposes of modeling project survival of Atlantic salmon kelts migrating past the Shawmut Project, the median monthly flow condition (i.e. the value with 50% flow exceedence) was used. Median flow conditions at the Shawmut Project used to estimate whole station survival for outmigrating kelts were the same as those used for smolts during the spring months of April and May (Section 4.2). The median monthly condition for April was approximately 13,000 cfs (Figure 3), during May was approximately 9,000 cfs (Figure 4), during October was approximately 4,500 cfs (Figure 7), during November was approximately 6,000 cfs (Figure 8), and during December was approximately 5,750 cfs (Figure 9). Impacts to the model of whole station kelt survival during years of high flow (10 and 25% flow exceedence) and low flow (75 and 90% flow exceedence) are examined in Section 7.1.1.3 of this report.

6.3.3 Kelt Downstream Route Determination

Similar to the assumption for outmigrating smolts, it was assumed that river discharge during the months of October, November, December, April and May will dictate the proportion of Atlantic salmon kelts passed downstream of the Shawmut Project though the spillway (and conversely, through the forebay canal). This is likely a conservative estimate given the strong swimming ability of adult salmon and their behavioral reluctance to sound. Determination of the spill effectiveness, defined as the proportion of kelts passed through spill relative to the total number passing the project, is the first step in assessing whole station survival. As was done for smolts, it was assumed that the Project spillway has a 1:1 ratio of percent total fish to percent total river flow passed (i.e., spilling 50% of total river flow results in 50% of kelts passing via the spillway). An overall spill effectiveness for the outmigration months of October, November, December, April and May of 29.6% was used for the assessment of whole station kelt survival at Shawmut. This value was calculated using a Project capacity of 6,700 cfs, the monthly distribution of Atlantic salmon kelt outmigration (Section 6.3.1), monthly median Kennebec River flow conditions (Section 6.3.2) and the assumption of 1:1 spill effectiveness. Table 32 provides a summary of that calculation as well as the monthly values used for the assessment of Shawmut Project spill effectiveness for kelts.

6.3.4 Kelt Downstream Bypass Efficiency

Given the lack of downstream bypass efficiency studies for Atlantic salmon kelts at the Projects on the Kennebec River the guidance efficiency rate used for the smolt model (Section 4.4) was used as a surrogate value for estimation of whole station survival for kelts. That efficiency rate was based on the assumption that the distribution of kelt passage was equal to the distribution of outflow. The downstream bypass efficiency rate was allowed to vary by month to account for occasions when river discharge was less than the Project operating flow. For example, as presented in Table 32, the monthly median Kennebec River discharge (cfs) values during April and May were greater than the Project operating flow of 6,700 cfs. In those instances, the downstream bypass efficiency rate (assuming passage distribution of kelts through the forebay canal is equal to the distribution of outflow through the powerhouse and downstream bypass) was calculated as 0.5% ((35 cfs/6,700 cfs)*100 = 0.5%). However, during October, the monthly median Kennebec River discharge (cfs) value was 4,500 cfs. For that month, the downstream bypass efficiency rate (assuming passage distribution of kelts through the forebay canal is equal to the distribution of outflow through the powerhouse and downstream bypass) was calculated as 0.8% ((35 cfs/4,500 cfs)*100 = 0.8%). The remainder of the forebay canal flow passes via the turbine units. Variations in bypass efficiency and their impacts to whole station survival are examined in Section 7.1.1.1 of this report.

6.3.5 Kelt Spillway and Downstream Bypass Passage Survival Assessment

The Shawmut Project spillway is 1,135 ft long. The spillway consists of 380 ft of hinged flashboards, 730 ft of rubber dam and a 25 ft wide log sluice. The log sluice (25 ft wide by 8 ft deep) is located near the center of the spillway section.

Based on the lack of survival studies conducted for Atlantic salmon kelts at the NextEra and other hydroelectric projects, it was assumed that survival for Atlantic salmon kelts passing the Project via the downstream bypass or spillway was 96.3%. That value was based on a review of empirical studies conducted for Atlantic salmon smolts passed through sluices and bypasses at five different hydroelectric projects (See Section 4.5). Delayed survival (48-hr) estimates for Atlantic salmon smolts following passage through sluiceways and bypasses ranged from 91.1 to 100.0%, resulting in a mean overall spill survival of 96.3%.

6.3.6 Kelt Entrainment Rates and Turbine Passage Survival

The Shawmut powerhouses contain a total of eight generating units (six horizontal Francis and two horizontal propeller units) and have a total Project generating capacity of 8.74 MW. Maximum capacity (cfs) ranges from 641-742 cfs for the six horizontal Francis units and peak capacity for the two propeller units is 1,312 and 1,347 for units 7 and 8, respectively (Table 7). Total unit flow for the Project is approximately 6,700 cfs. Normal operating head for the Shawmut Project is 23 ft. The trash racks screening the intakes are 1.5 in clear spacing in front of Units 1-6 and 3.5 in clear spacing in front of Units 7 and 8. Additional turbine characteristics for Shawmut Units 1 through 8 are provided in Table 7.

Turbine Entrainment Rates

Empirical data related to the route selection of Atlantic salmon kelts using the Shawmut turbine units to move downstream of the project does not exist. Based on maximum Francis and propeller unit capacities of approximately 4,015 cfs and 2,650 cfs, respectively) the theoretical entrainment rates for the portion of forebay canal flow not passing via the interim downstream bypass at the Shawmut Project are 60.0% through the Francis units and 40.0% through the propeller units. The remaining forebay canal flow is passed through the interim downstream bypass.

Ten records of adult Atlantic salmon total lengths (762 – 821mm) and maximum body widths (79-100mm) were obtained from sea-run returns to the Deerfield River during spring 2011 (B. Hanson, Normandeau, personal communication). Total lengths from that data set were converted to fork lengths using the equation FL = 0.9173TL (Carlander 1969) where FL = fork length and TL = total length. The linear relationship for the log-transformed (ln) fork length and body width was determined to be ln(width) = 1.3113(lnFL) – 4.1717. Although the relationship was weak ($r^2 = 0.155$), it was used to predict body widths for theoretical salmon fork lengths to determine the longest fork length that would fit through the 1.5 in trash rack spacing in front of Units 1-6 and 3.5 in trash rack spacing in front of propeller Units 7-8. Based on that relationship, it was determined that adult Atlantic salmon with a fork length of greater than 15.6 inches would have achieved a body width greater than the 1.5 in trash rack spacing at Shawmut Units 1-6 and adult Atlantic salmon with a fork length of greater than 29.4 inches would have achieved a body width greater than the 3.5 in trash rack spacing at Shawmut Units 7-8.

Fork length data was obtained for sea-run Atlantic salmon returns collected within the Kennebec and Sebasticook Rivers during the years 2006-2010 (P. Christman, MDMR, personal communication) as well as at the Veazie fishway trap on the Penobscot River for the years 1978-2009 (J. Murphy, NMFS, personal communication). Fork lengths recorded for returning Atlantic salmon (86 individuals) to the Kennebec drainage had a mean fork length of 27.3 in (range 19.7-34.3 in). Fork lengths recorded for 25,721 individual Atlantic salmon to the Penobscot River ranged from 15.7-40.9 in (mean 27.5in).

The length-frequency distribution for sea run returns to the Penobscot River was used as a surrogate for outmigrating kelts on the Kennebec due to the robust nature of the data set. It was assumed that fork lengths of kelts approaching both Francis and propeller units at Shawmut would be of a similar length-frequency distribution to that of the Penobscot River data set. For Atlantic salmon kelts approaching the propeller units (Units 7-8), 70.9% of individuals were predicted to pass through the 3.5 in trash racks and be subjected to turbine passage. The remaining 29.1% would be excluded from turbine passage at both Unit types and were assumed to pass via bypass spill. For Atlantic salmon kelts approaching the Francis units, no individuals were predicted to pass through the 1.5 in trash racks and be subjected to turbine passage. There were no individuals in either the Penobscot or Kennebec River adult salmon data sets with a fork length 15.6 in or less (i.e. predicted body widths were all greater than the 1.5 in trash rack spacing). Due to the lack of information regarding the movement of kelts in the Shawmut forebay canal, it was assumed that all kelts expected to pass via the Francis units but prevented from doing so by their predicted body widths relative to the 1.5 in trash racks would next attempt passage via the propeller units. For those kelts denied downstream passage via the Francis units, 70.9% of those individuals were predicted to pass through the 3.5 in trash racks and be subjected to propeller turbine passage. The remaining 29.1% would be excluded from turbine passage at both Unit types and were assumed to pass via bypass spill. Impacts to the model of whole station kelt survival related to the assumption that all kelts screened from passage through the Francis units would next attempt downstream passage through the Shawmut Project propeller units (Units 7-8) are examined in Section 7.1.1.4 of this report.

Turbine Passage Survival

Kelt survival estimates for turbine passage were generated for the propeller units (Units 7-8) in operation at Shawmut using the same equations (Franke et al. 1997) as used for smolts and detailed in Section 3.3.2 of this report. Estimates for Atlantic salmon kelts passing through the propeller units were calculated for five body lengths considered representative of individuals capable of passing through 3.5 in trash racks (16, 20, 23, 27, and 30 inches). Two correlation factors (λ) were used in this analysis (0.1 and 0.2). Survival estimates for Shawmut units 7-8 were modeled using the peak turbine discharge (cfs) and the associated efficiency. Estimates were not generated for Francis units 1-6 since kelt body widths were predicted to be wider than the 1.5 in trash rack spacing in front of those units for the entire observed length frequency distribution of both Penobscot and Kennebec River sea run returns.

Propeller:

Model runs for five body lengths, two correlation factors and three *r* values resulted in a total of 30 survival estimates which likely bracket the actual survival for Atlantic salmon kelts passing through the propeller units at Shawmut (Units 7-8). The three *r* values represent the point along the runner radius that the fish enters the turbine. Values for *r* used in this assessment were 0.1, 0.5, and 0.9% of the runner radius.

Predicted survival values for salmon kelts capable of passing through the 3.5 in trash racks screening the Shawmut propeller units (Units 7-8) ranged from a high of 94.7% for a 16 inch kelt to a low of 43.7% for a 30 inch kelt (Table 33). Predicted survival probabilities increased as kelt body length and entry point proximity to the turbine hub decreased. The average survival of salmon kelts passing through the propeller units at Shawmut was determined by averaging the 30 modeled survival estimates for each combination of fish length, entry point and λ as calculated at Units 7 and 8. The calculated mean survival for Atlantic salmon kelts passing through the Shawmut propeller units was 81.1%.

7.0 Estimated Project Impact on Outmigrating Atlantic Salmon Kelts

7.1 Modeled Estimate of Whole Station Survival for Kelts

Whole station survival for outmigrating kelts at the Shawmut Project was estimated by integrating Kennebec River flows, Project operating flows, the proportion of kelts diverted towards the spillway and powerhouse, spillway survival rate (as estimated from empirical data for smolts), screening effectiveness of turbine trash racks, turbine passage survival rates (as estimated by modeled data), bypass guidance efficiency, and fish bypass passage survival rate (as estimated from empirical data for smolts). The following values for each of the above parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in the calculations of whole station survival for salmon kelts at Shawmut Project:

7.1.1 Modeled Estimate of Whole Station Survival for Kelts

Whole station kelt survival was modeled using delayed (48-hr) smolt survival rates for spill obtained from empirical data collected at other hydroelectric projects and model derived estimates for turbine passed fish. The following values for each of the necessary model parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in this calculation of whole station survival for salmon kelts at the Shawmut Project:

- Kennebec River Flow – monthly medians of 13,000 cfs (April), 9,000 cfs (May), 4,500 cfs (October), 6,000 cfs (November), and 5,750 cfs (December);
- Project operating flow – 6,700 cfs;
- Proportion of kelts diverted – utilized a ratio of 1:1 fish to river flow;
- Project spillway survival – 96.3% (based on review of delayed (48-hr) empirical survival data for smolts from other hydroelectric projects);
- Fish bypass guidance efficiency – as determined on a monthly basis based on the relationship of bypass discharge (35 cfs) and Project operating flow;
    - April: (35 cfs / 6,700 cfs)*100 = 0.5%
    - May: (35 cfs / 6,700 cfs)*100 = 0.5%
    - October: (35 cfs / 4,500 cfs)*100 = 0.8%
    - November: (35 cfs / 6,000 cfs)*100 = 0.6%
    - December: (35 cfs / 5,750 cfs)*100 = 0.6%
- Proportion of smolts in forebay canal entrained at turbines – as determined on a monthly basis as 100% - fish bypass guidance efficiency
    - April: 100% - 0.5% = 99.5%
    - May: 100% - 0.5% = 99.5%
    - October: 100% - 0.5% = 99.2%
    - November: 100% - 0.5% = 99.4%
    - December: 100% - 0.5% = 99.4%
- Entrainment rates by turbine type – 60% to propeller units and 40% to Francis units (based on distribution of river flow at maximum Unit capacity);

- Proportion of kelts screened from passage through turbines – based on Penobscot River length-frequency data and derived FL-width relationship
- Propeller turbine passage survival – 81.1% (based on modeled values generated using site-specific turbine parameters);
- Fish bypass system survival – 96.3% (based on review of delayed (48-hr) empirical survival data for smolts from other hydroelectric projects).

The integration of the above values is presented in Table 34 for a hypothetical case of 100 Atlantic salmon kelts approaching the Shawmut Project during the outmigration period (April-May, October-December). The whole station survival estimate for Atlantic salmon kelts passing the Shawmut Project generated using delayed (48-hr) empirical data for spillway and modeled turbine survival estimates is 89%.

7.1.1.1 Impacts to Estimated Kelt Survival Associated with Bypass Efficiency Assumption

The model for estimating whole station survival for outmigrating kelts at Shawmut can be manipulated to provide insight into potential impacts based on modifying the various input parameters. Increased effectiveness of the downstream bypass would reduce the impact of turbine passage on outmigrating kelts and should increase whole station survival. The effectiveness of floating guidance devices (Normandeau 2008) and angled bar racks (Normandeau 1994a; Simmons 2000) have been assessed at other locations for guiding salmonids past hydroelectric turbines. Table 35 provides whole station kelt survival estimates for a range of theoretical bypass efficiency rates. Theoretical bypass effectiveness rates between 25 and 100% were modeled and produced a range of whole station survival estimates for outmigrating Atlantic salmon kelts between 89% and 96%.

7.1.1.2 Impacts to Estimated Kelt Survival Associated with Seasonal Distribution Assumption

In cases with no site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (e.g., spilling 50% of total river flow results in 50% of fish passing via the spillway). A basic implication of the deviation from the 1:1 assumption is that if a proportionally smaller percentage of kelts relative to the river flow enter the Project forebay then the calculated station-related kelt survival would be higher. Under these conditions, a greater percentage of kelts would pass the project via spill and would avoid impacts associated with turbine passage. Alternatively, if a proportionally higher percentage of kelts are entering the station forebay than the calculated station related kelt survival would be lower. Under these conditions, a lower percentage of kelts would pass the project via spill and a greater number would be entrained through the Project turbines.

Potential impacts to the model estimating whole station kelt survival associated with deviation from the assumed 1:1 ratio of fish to flow at the Shawmut Project are presented in Table 36. A range of spill effectiveness rates for Atlantic salmon kelts from 5% (0.2:1) to 90% (3:1) was evaluated. For conditions where a proportionately lower percentage of kelts relative to river flow entered the forebay canal (i.e. spill effectiveness rates of 50, 70, and 90%), the estimates for whole station survival were greater than that observed under the assumption of 1:1 spill effectiveness and ranged from 91% to 95%. For conditions where a proportionately higher percentage of kelts relative to river flow entered the forebay canal (i.e. spill effectiveness rates of 5% or 10%), the estimates for whole station survival were lower (86% to 87%) than that observed under the assumption of 1:1 spill effectiveness.

7.1.1.3 Impacts to Estimated Kelt Survival Associated with Seasonal Flow Assumption

The model for estimating whole station survival for outmigrating kelts at Shawmut was constructed using the assumption of median Kennebec River flows (i.e. 50% exceedence) during the months of April, May, October, November, and December. Two "low flow" conditions (75 and 90% exceedence) and two "high flow" conditions (10 and 25% exceedence) were also examined. Estimated monthly Kennebec River flows for the months of April, May, October, November, and December under the 10, 25, 75, and 90% exceedence conditions are presented in Table 37. Table 38 presents the modeled whole station survival estimates for downstream migrating Atlantic salmon kelts under the additional low and high flow conditions. Under the low flow conditions (i.e. those exceeded 75 and 90 % of the time) the estimated whole station survival for salmon kelts at the Shawmut Project decreased to 87% and 86%, respectively. Under the high flow conditions (i.e. those exceeded only 10 or 25% of the time) the estimated whole station survival for salmon kelts at the Shawmut Project increased to 93% and 91%, respectively.

7.1.1.4 Impacts to Estimated Kelt Survival Associated Forebay Behavioral Assumption

For the purposes of modeling whole station kelt survival, it was assumed that kelts effectively screened from passing downstream by the 1.5 in trash racks in front of the Francis units would all make a second downstream passage attempt through the propeller units. Those kelts whose body width (>3.5 in) prevented them from passing through the propeller trash racks would then be subjected to passage via bypass spill. This assumption presents the worst case scenario for the kelts predicted to be passed via Francis units but prevented from doing so by the 1.5 in trash rack spacing. The conservative nature of the behavioral assumption made here is supported by observations of radio-tagged kelts at the Weldon Project on the Penobscot River which were reluctant or unable to migrate through trashracks even though they demonstrated a strong tendency to move downstream (GNP 1987; GNP 1988; GNP 1989). Table 39 presents the modeled whole station kelt survival estimates for a range of behavioral responses for kelts excluded from Francis turbine passage by the 1.5 in trash racks. Behavioral responses of 0, 10, 30, 50, 70, and 90% of kelts excluded from Francis turbines by the 1.5 in trash racks opting to pass via bypass spill (rather than propeller) were modeled. Should all kelts excluded from Francis turbine passage by the 1.5 in trash racks pass via bypass spill, the whole station survival estimate for kelts would increase to 93%.

7.2 Summary of Modeled Estimate of Whole Station Survival for Kelts

A single model of whole station survival of Atlantic salmon kelts at the Shawmut Project was constructed using available empirical and modeled survival rates for passage via spill and through turbine units. Where data was unavailable for the kelt lifestage, empirical data from smolt studies was used as a surrogate. The model constructed for whole station survival of Atlantic salmon kelts at the Shawmut Project generated a survival estimate of 89% with modifications during the various sensitivity analyses expanding those bounds to 86%- 96%. A percentage of kelts will over winter in freshwater and resume feeding following the fall spawn (Danie et al. 1984). Although mortality is high upon reentry to saltwater, a percentage of kelts which successfully migrate to ocean feeding grounds may become repeat spawners (Danie et al. 1984). Baum (1997) states that repeat spawners can reach weights approaching 30 pounds and contain an average of approximately 11,300 eggs. For comparison, a first time returning two sea-winter salmon will contain an average of approximately 7,500 eggs. In the National Research Council's book "Atlantic Salmon in Maine" (NRC 2007) it was stated that most Atlantic salmon are semelparous, spawning once and then dying. It was estimated that 1%-6% of anadromous Atlantic salmon are iteroparous and will survive to make a second spawning run the following year. Baum (1997) notes that data collected during the 1960's and 1970's suggested that 5-10% of the salmon run in Maine rivers was composed of repeat spawners. Baum (1997) indicates that value has declined in recent years to less than 1% due primarily to commercial fisheries during the 1960's to early 1990's. During the five year period (1992-1996) wild salmon repeat spawners in the Magaguadavic River (New Brunswick) were noted to represent an overall percentage of 6% (Carr et al. 1997). Within the Miramichi River, considered to have the largest run of Atlantic salmon in eastern North America, the proportion of repeat spawners within the annual run has ranged from a low of approximately 2% to a high of approximately 53% during the forty year period of 1970-2010 (Chaput and Douglas 2010). The proportion of repeat spawners within the Miramichi River was greater than 10% during 34 of the 40 years, greater than 20% during 22 of the 40 years, greater than 30% during 16 of the 40 years, greater than 40% during 6 of the 40 years and greater than 50% during 2 of the 40 years.

8.0 Predation

8.1 Smolt Predation

The smolt survival model presented in Section 5.0 of this report represents mortality associated directly with smolt/Project interactions and does not account for indirect mortality (such as predation). Atlantic salmon smolts are a potential food source for a number of fish (i.e. black bass, northern pike), avian (i.e. cormorants, gulls and osprey) and mammalian predators which may frequent the Kennebec River below the Shawmut Project. However, direct quantification of predation rates for Atlantic salmon smolts passing the Shawmut Project is not available.

Due to the lack of predation rate data for outmigrating salmon smolts in the Kennebec River, a rate was estimated based on that used for Habitat Conservation Plans for the Rocky Reach hydroelectric project on the mid-Columbia River, Washington. Combined predation (upstream and downstream) for that project was estimated at 2.0% of smolts and was derived from site-specific empirical data as well as observations at other Columbia River hydroelectric projects (S. Hayes, personal communication). In the Columbia River, predation on juvenile salmonids by piscivorous fishes has been investigated in detail (Rieman et al 1991; Zimmerman 1999) and has resulted in an extensive management program to control smolt loss to predation by northern pikeminnow (Beamesderfer et al. 1996; Friesen and Ward 1999).

Given the absence of site-specific data, an estimate of 1.0% loss was used to represent predation that may occur in the tailwater area. This was based on the absence of a major controlling predator such as the northern pikeminnow on the Columbia River.

In addition to predation in the hydroelectric project tailwaters, outmigrating Atlantic salmon smolts are also subjected to predation within the impounded river portions located upstream of hydroelectric projects (Ruggles 1980; Blackwell et al. 1997; Jepsen et al. 1998). Although not intended to directly assess predation rates, the release of radio-tagged smolts into impounded portions of the Kennebec River upstream of the Lockwood and Hydro-Kennebec (owned and operated by Brookfield Power) Projects can be used to estimate impoundment predation. During May and June, 2011, a total of 98 radio-tagged smolts were released into the impoundment approximately 0.6 miles upstream of the Hydro-Kennebec Project. Of those smolts, only 3 individuals (3.1%) did not pass the Project and may have been predated. Similarly, a total of 60 radio-tagged smolts were released into the impoundment approximately 0.5 miles upstream of the Lockwood Project. Of those smolts, only 1 individual (1.6%) did not pass the Project and may have been predated. A total of 22 radio-tagged smolts were released into the impoundment approximately 0.5 miles upstream of the Lockwood Project during the 2007 (Normandeau 2008) bypass efficiency evaluation. During that study, no individuals released in the impoundment above Lockwood were reported to have not passed the Project. It should be noted that these telemetry studies were not intended to directly assess natural predation rates and other factors such as tag retention, desmoltification, or behavioral differences associated with having been hatchery-reared may factor into the lack of downstream movement observed for some smolts. Based on the limited rates of loss for radio-tagged smolts in Kennebec River impoundments (3.1%, 1.6%, and 0.0%) a mean average rate of 1.6% was estimated for predation on Atlantic salmon smolts that may occur in the impoundment area.

8.2 Adult Predation

Outmigrating adult Atlantic salmon potentially delayed by the presence of the Shawmut Project may be exposed to predation risks. Atlantic salmon adults are a potential food source for a limited number of mammalian predators which may frequent the Kennebec River above the Shawmut Project. Additionally, mortality associated with catch and release angling injuries or poaching may also impact adult salmon delayed upstream of the Project. At this point, absent any data, it is unreasonable to assign a predation rate to adult salmon delayed upstream of the Shawmut project.

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FIGURES

Figure 1. Design plan and physical layout of the Shawmut Project. (need to cleanup font and add rubber dam)

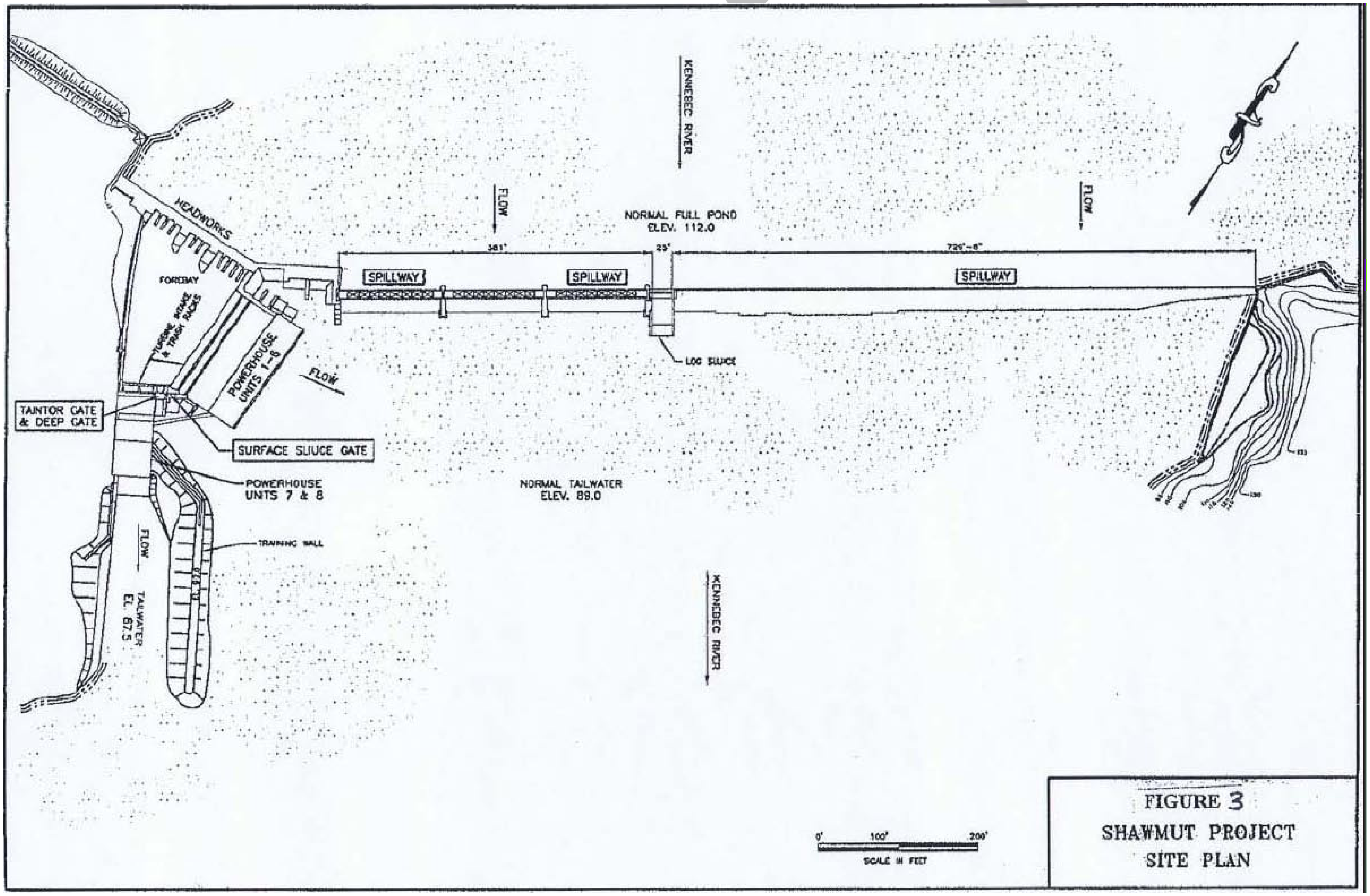


Figure 2. Potential downstream passage routes at the Shawmut Project.

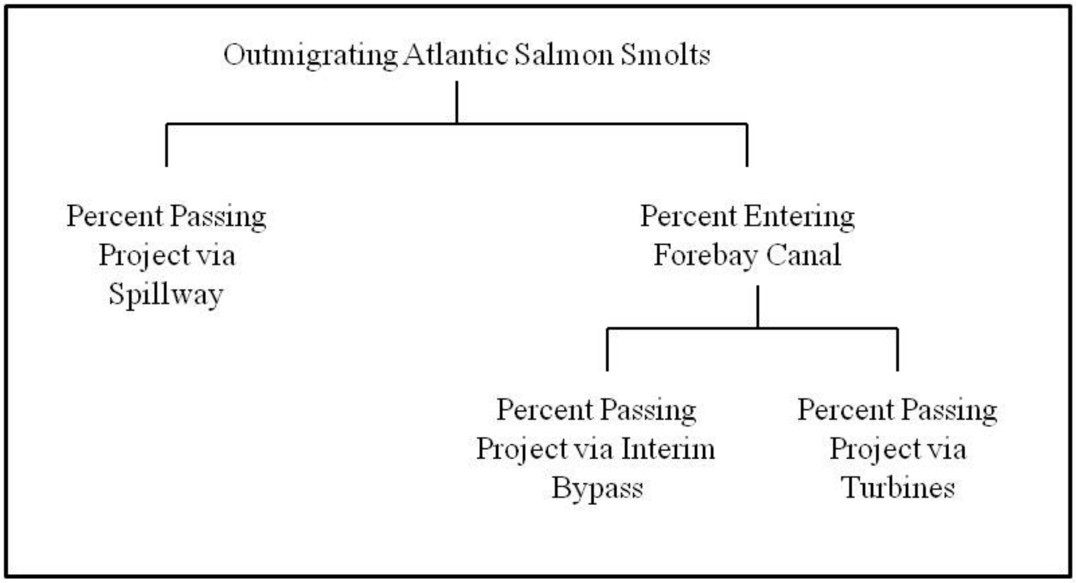


Figure 3. Kennebec River (Shawmut Project) flow duration curve for April.

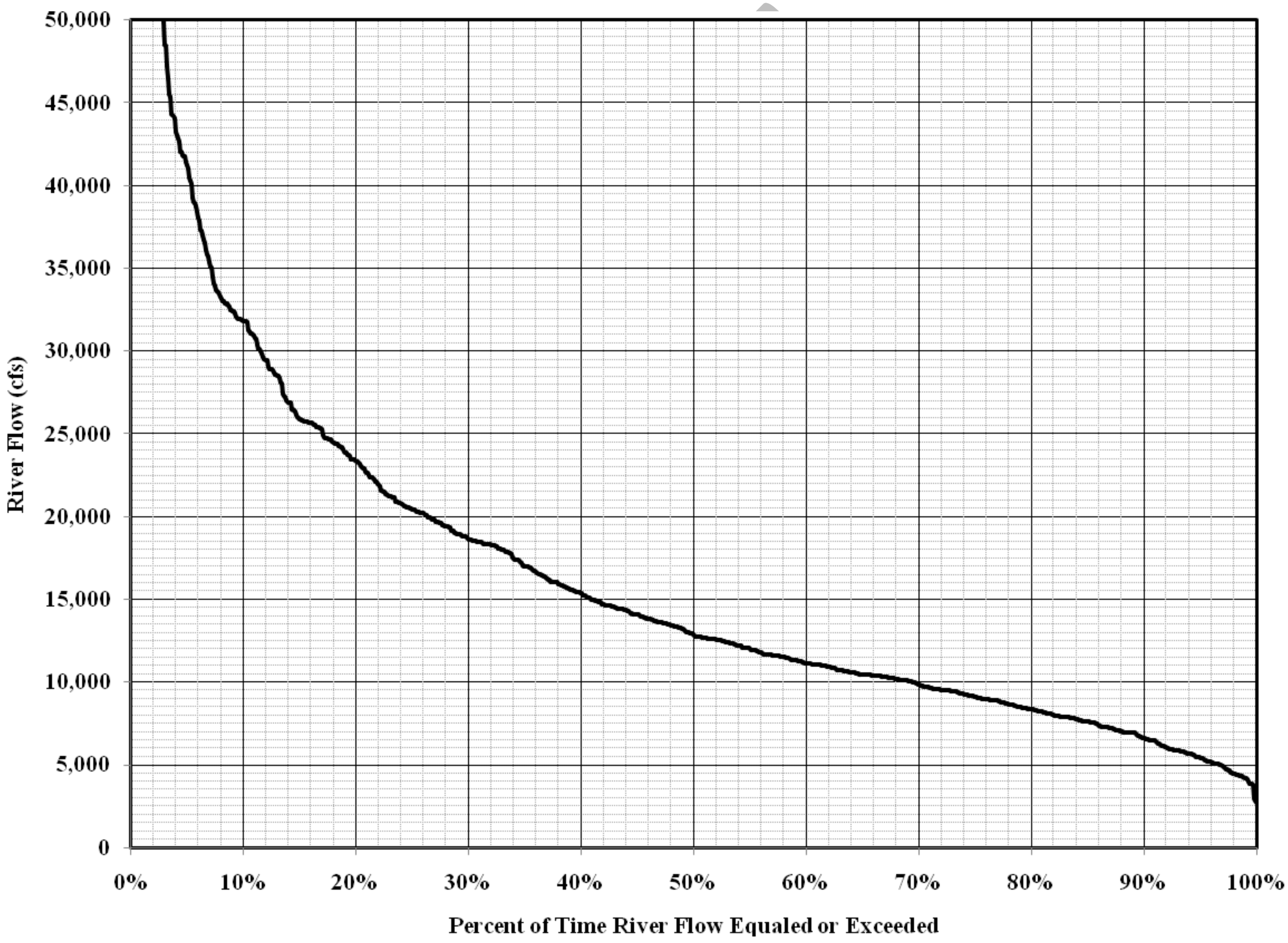


Figure 4. Kennebec River (Shawmut Project) flow duration curve for May.

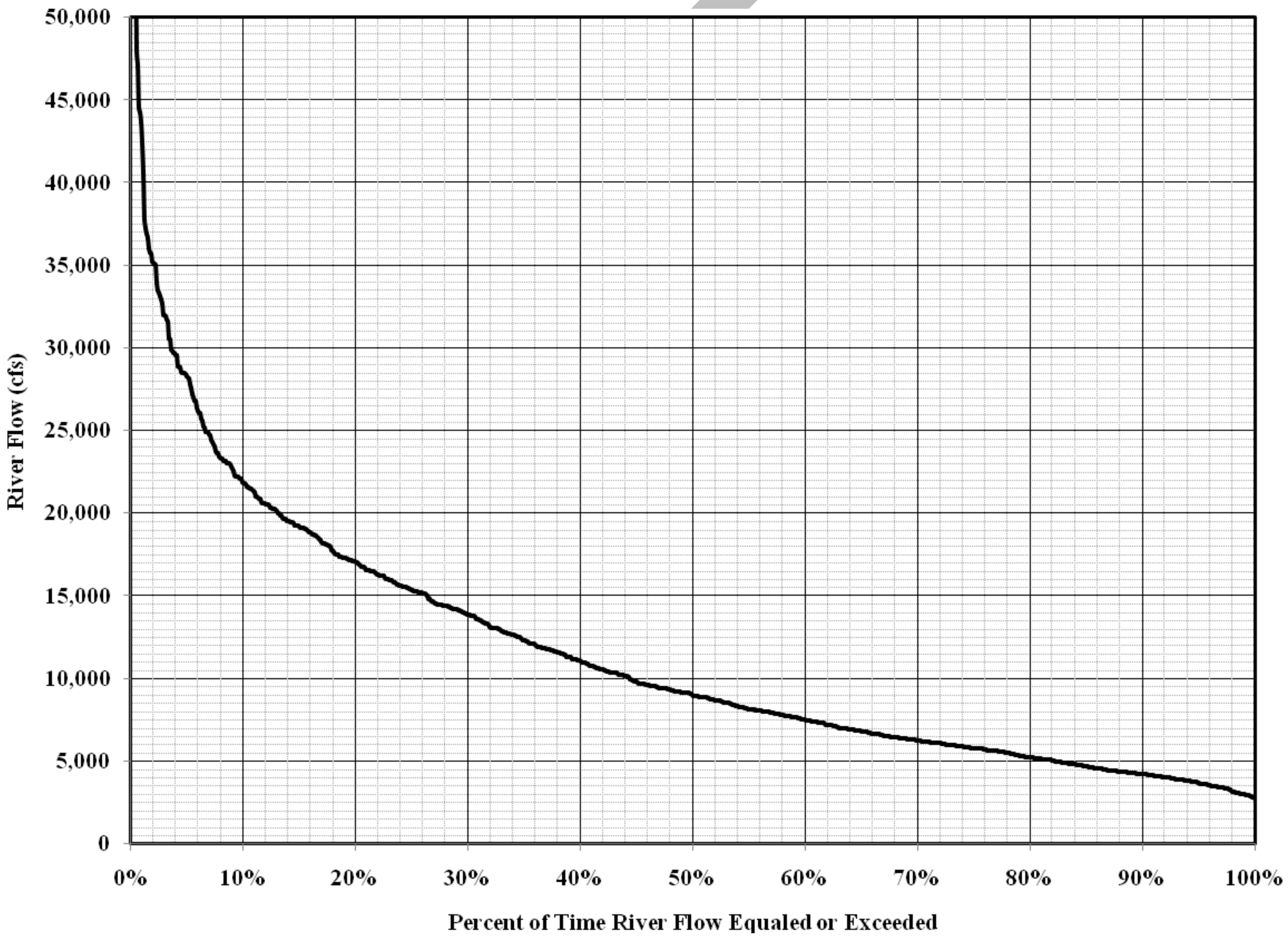


Figure 5. Kennebec River (Shawmut Project) flow duration curve for June.

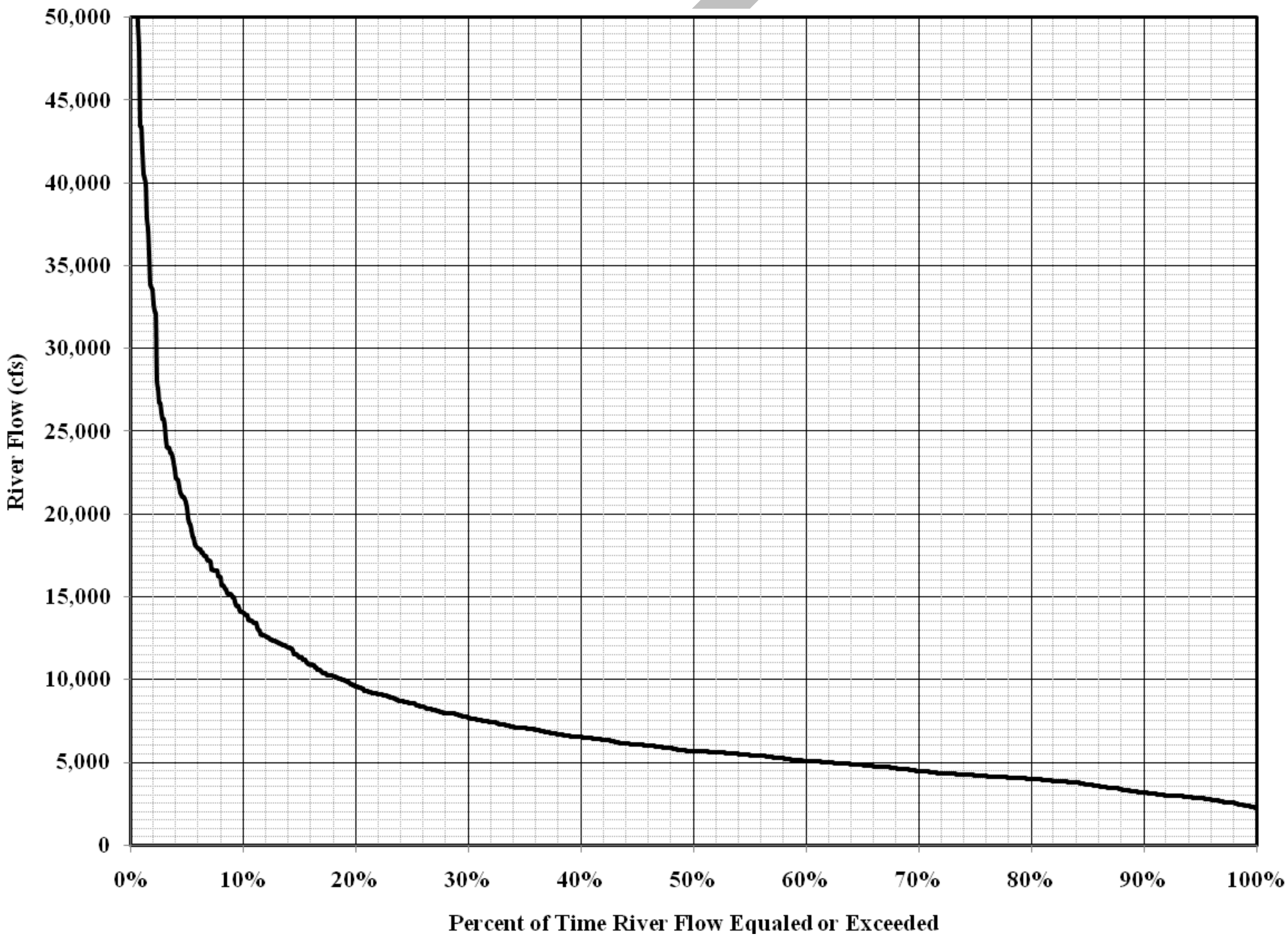


Figure 6. Smolt capture data from 2004 for the Narraguagus, Pleasant and Penobscot Rivers, Maine. Reprinted from USASAC 2005 Annual Report.

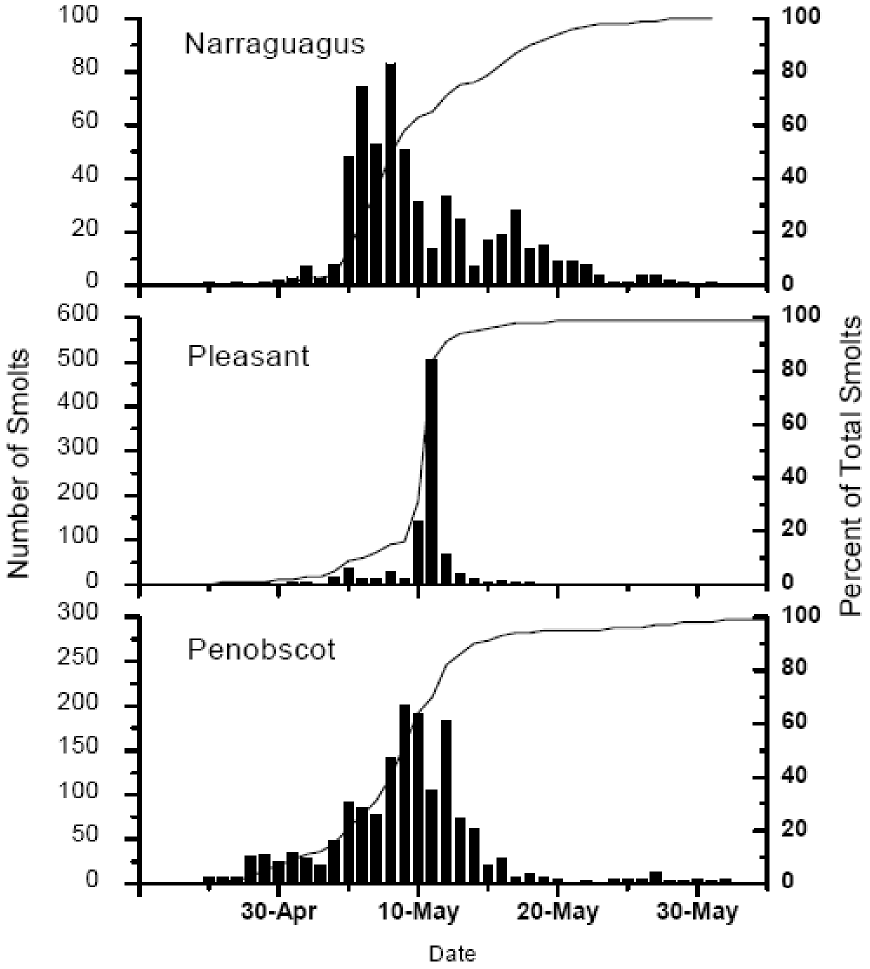


Figure 7. Kennebec River (Shawmut Project) flow duration curves for October.

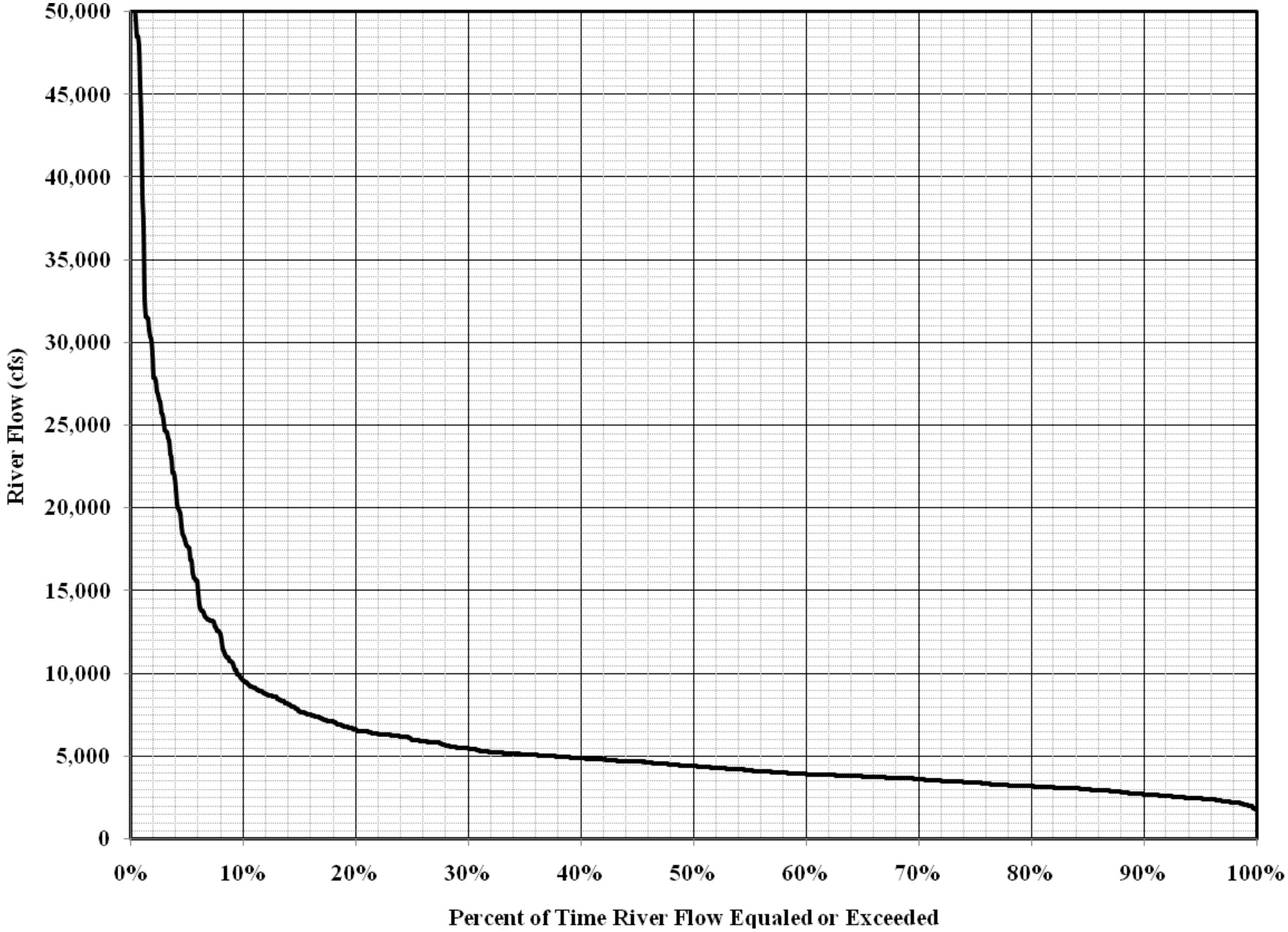


Figure 8. Kennebec River (Shawmut Project) flow duration curves for November.

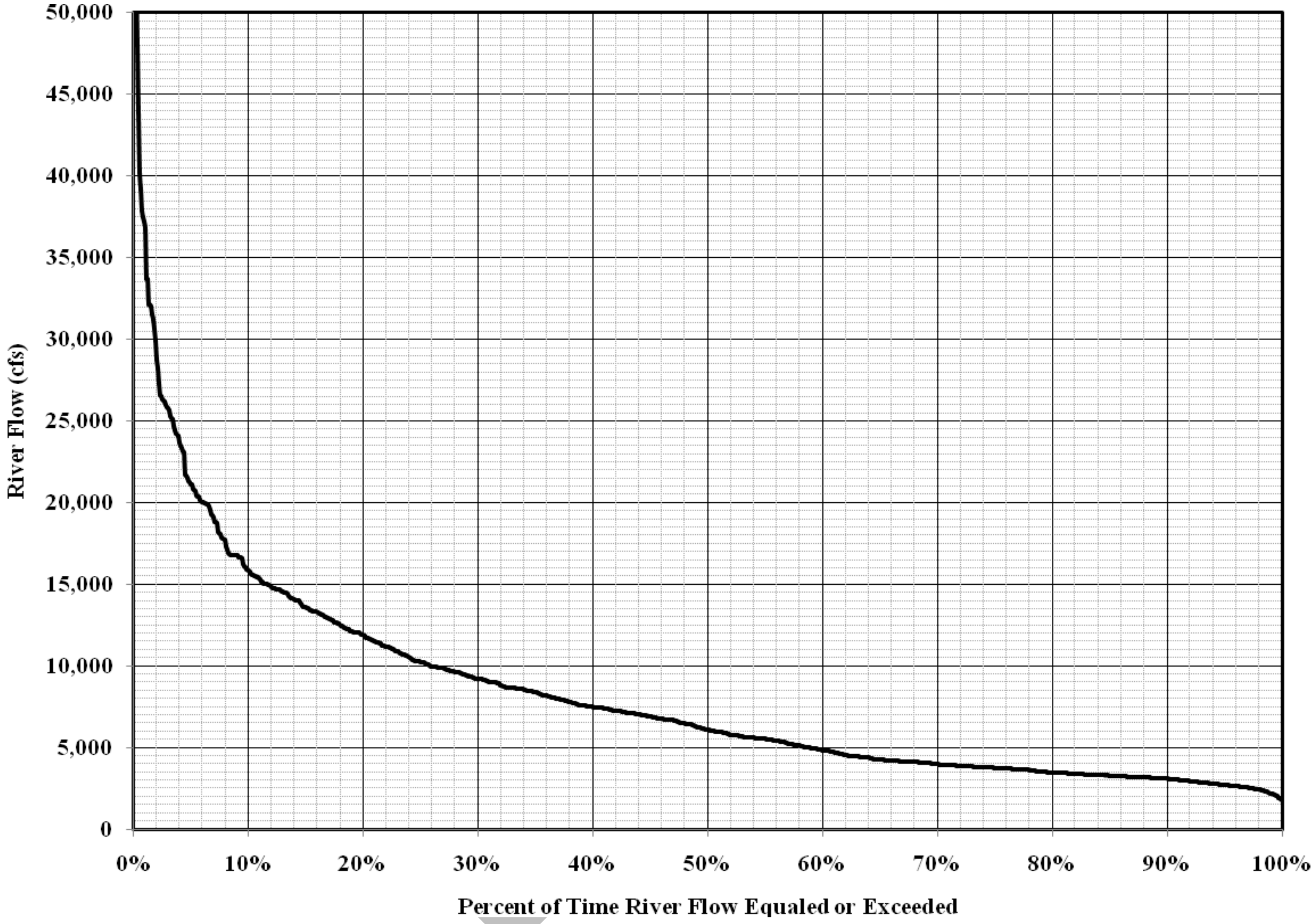
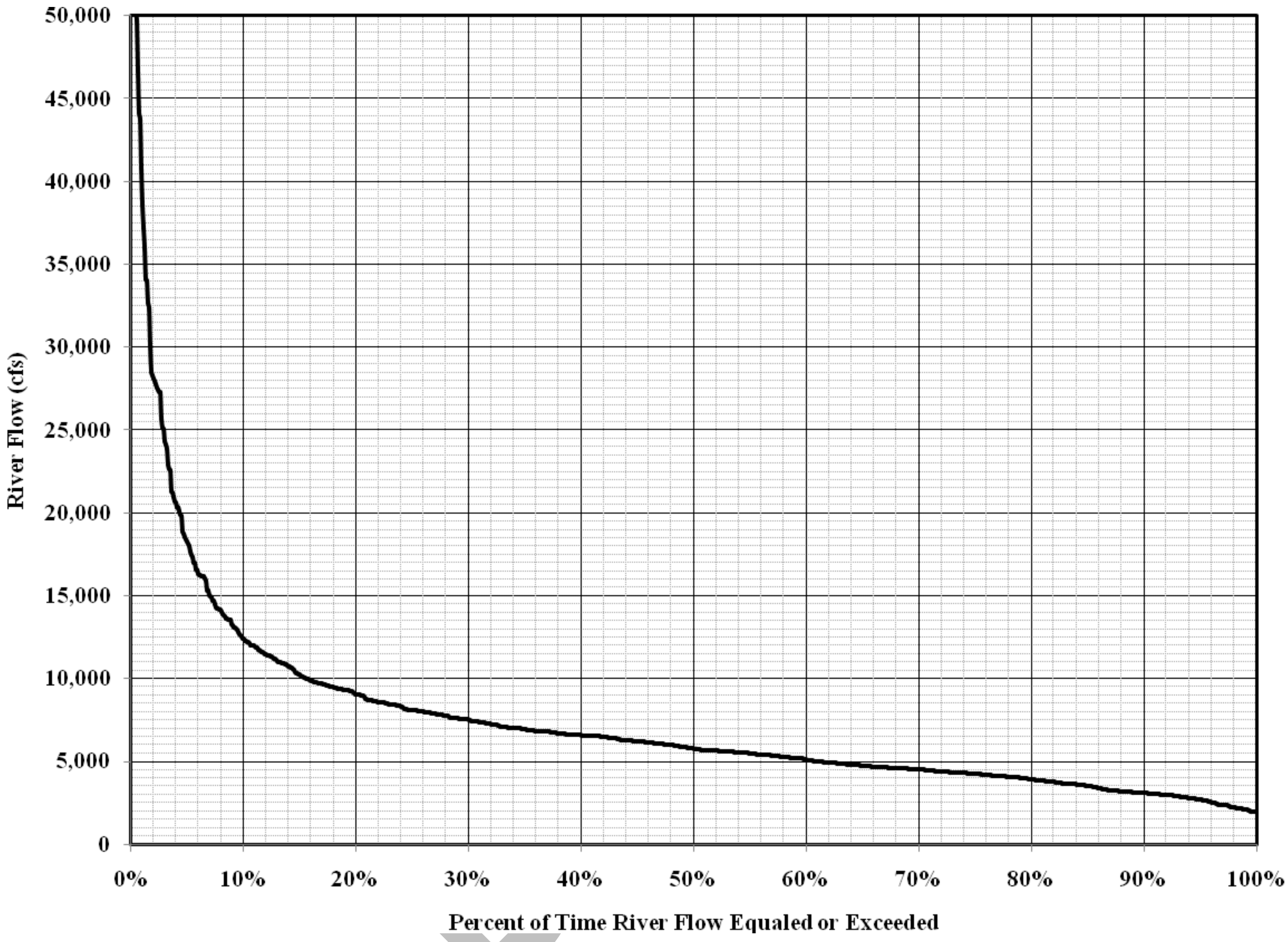


Figure 9. Kennebec River (Shawmut Project) flow duration curves for December.


50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
River Flow (cfs)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time River Flow Equaled or Exceeded

TABLES

Table 1. Number of individuals collected and seasonal timing of downstream migration of Atlantic salmon smolts at the Mattaceunk Project (Weldon Dam) on the Penobscot River. Note: NS = no sample; data is reprinted from GNP 1997.

3-Days Starting	**Sample Year**					
	1995	**1994**	**1993**	**1990**	**1989**	**1988**
1-Apr	NS	0	0	0	NS	0
4-Apr	NS	0	0	0	NS	0
7-Apr	NS	0	0	0	NS	0
10-Apr	NS	0	0	0	NS	0
13-Apr	NS	0	0	0	NS	0
16-Apr	NS	0	0	0	0	0
19-Apr	NS	0	0	0	0	1
22-Apr	NS	0	0	0	0	0
25-Apr	0	0	1	1	0	0
28-Apr	1	0	0	1	0	0
1-May	3	0	0	2	0	0
4-May	15	3	13	1	3	0
7-May	33	1	46	27	9	15
10-May	130	6	189	27	19	43
13-May	238	9	133	33	11	214
16-May	975	7	179	79	38	113
19-May	2,123	32	290	76	267	152
22-May	298	309	699	40	671	262
25-May	264	37	873	25	233	202
28-May	211	620	642	33	294	529
31-May	172	517	81	14	171	208
3-Jun	108	673	30	44	357	106
6-Jun	51	256	38	15	192	16
9-Jun	21	126	16	3	109	12
12-Jun	16	61	25	4	559	21
15-Jun	15	31	5	7	89	9
18-Jun	8	5	3	4	68	NS
21-Jun	9	0	2	1	33	NS
24-Jun	NS	1	0	NS	NS	NS
27-Jun	NS	0	0	NS	NS	NS
30-Jun	NS	1	0	NS	NS	NS

Table 2. **Seasonal distributions for smolt downstream migration used for assessment of whole station survival at the Shawmut Project.**

River System	Year	Percent of Migration			Reference
		April	May	June	
Penobscot	1988	0.1	80.4	19.5	GNP 1997
Penobscot	1989	0.0	49.5	50.5	GNP 1997
Penobscot	1990	0.5	78.5	21.1	GNP 1997
Penobscot	1993	0.0	93.8	6.1	GNP 1997
Penobscot	1994	0.0	38.0	62.0	GNP 1997
Penobscot	1995	0.0	91.5	8.5	GNP 1997
Penobscot	2004	10.0	88.0	2.0	USASAC 2005
Narraguagus	2004	4.0	96.0	0.0	USASAC 2006
Average		**1.8**	**77.0**	**21.2**	

Table 3. Estimated percentage of smolts entering the Shawmut Project forebay canal or passing via spillway.

	Discharge (cfs)			Percent of River Discharge			Project Smolt Distribution[5]	
Month	**River Discharge[1]**	**Shawmut [2]**	**Calculated Spill [3]**	**Spill**	**Forebay Canal**	**Smolt Run Distribution[4]**	**Spill**	**Forebay Canal**
April	13,000	6,700	6,300	48.5%	51.5%	1.8%	0.9%	0.9%
May	9,000	6,700	2,300	25.6%	74.4%	77.0%	19.7%	57.3%
June	5,750	5,750	0	0.0%	100.0%	21.2%	0.0%	21.2%
TOTAL	-	-	-	-	-	-	**20.6%**	**79.4%**

1 - Monthly average condition as obtained from Project flow duration curves (50% occurrence)

2 - Project capacity or total inflow

3 - Equal to River discharge - Project capacity

4 - Monthly distribution of Atlantic salmon smolt run for the Penobscot River (GNP 1997; USASAC2005) and Narraguagus River (USASAC 2005)

5 - Based on 1:1 assumption of spill effectiveness

Table 4. **Survival and associated test parameters for Atlantic salmon smolts passed through spillways and sluices at various hydroelectric projects. All tests conducted using the Hi-Z Turb'N Tag.**

Site Name	Normal head (ft)	Test Discharge (cfs)	Water Temperature (^oC)	Test Fish Size (mm)			Control Fish Size (mm)			No. of Fish Released		Immediate Survival (1-hr)	48-hr Survival	Reference
				Min.	Max.	Avg.	Min.	Max.	Avg.	T	C			
Garvins Falls, NH	30	80	13.0	174	208	190	155	203	185	30	20	100.0	100.0	Normandeau 2005
Amoskeag, NH	46	149	14.0	176	226	207.8	178	229	203.8	30	30	100.0	100.0	Normandeau 2006a
Bellows Falls, VT	59	275-340	10.0-11.5	145	358	-	-	-	-	100	100	96.0	96.0	RMC 1991
Wilder, VT	52	200	8.5-15.5	180	245	212	185	240	211.4	245	145	99.0	97.0	RMC 1992
Wilder, VT	52	300	8.5-15.6	180	245	212	185	240	211.4	245	145	93.3	91.1	RMC 1992
Wilder, VT	52	500	8.5-15.7	180	245	212	185	240	211.4	245	145	98.0	97.0	RMC 1992
Vernon, VT	27	40	16.0-17.5	115	216	156	119	200	149	75	25	93.3	93.3	Normandeau 1995

Table 5. Summary of injury types and frequency of occurrence (among injured and all smolts examined) for Atlantic salmon smolts passed through spillways and sluices at various hydroelectric projects. All tests conducted using the Hi-Z Turb'N Tag.

				Injury Type			
Interval	**Site Name**	**# of Individuals Examined**	**# of Individuals with Injuries**	**Minor scale loss, <25%**	**Major scale loss, >25%**	**Laceration(s), tear(s)**	**Hemorrhaging, bruised**
Initial (1hr)	Garvins Falls, NH	30	0	0	0	0	0
	Amoskeag, NH	30	1	0	0	0	1
	Bellows Falls, VT	95	3	1	0	0	2
	Wilder, VT	100	59	22	20	7	24
	Wilder, VT	44	16	9	0	2	10
	Wilder, VT	99	26	11	4	0	14
	Vernon, VT	70	2	2	0	0	0
	All Projects	468	107	45	24	9	51
	Percent Occurrence for Smolts with Injuries			**42.1%**	**22.4%**	**8.4%**	**47.7%**
	Percent Occurrence for All Smolts Examined			**9.6%**	**5.1%**	**1.9%**	**10.9%**
Delayed (48 hr)	Garvins Falls, NH	30	0	0	0	0	0
	Amoskeag, NH	30	0	0	0	0	0
	Bellows Falls, VT	38	7	6	0	0	1
	All Projects	98	7	6	0	0	1
	Percent Occurrence for Smolts with Injuries			**85.7%**	**0.0%**	**0.0%**	**14.3%**
	Percent Occurrence for All Smolts Examined			**6.1%**	**0.0%**	**0.0%**	**1.0%**

Table 6. Survival and associated test parameters for Atlantic salmon smolts passed through spillways and sluices at various hydroelectric projects. All tests conducted using the Hi-Z Turb'N Tag.

Site Name	Normal head (ft)	Test Discharge (cfs)	Water Temperature (^{o}C)	Test Fish Size (mm)			Control Fish Size (mm)			No. of Fish Released		Immediate Survival (1-hr)	48-hr Survival	Reference
				Min.	Max.	Avg.	Min.	Max.	Avg.	T	C			
Garvins Falls, NH	30	80	13.0	174	208	190	155	203	185	30	20	100.0	100.0	Normandeau 2005
Amoskeag, NH	46	149	14.0	176	226	207.8	178	229	203.8	30	30	100.0	100.0	Normandeau 2006a
Bellows Falls, VT	59	275-340	10.0-11.5	145	358	-	-	-	-	100	100	96.0	96.0	RMC 1991
Wilder, VT	52	200	8.5-15.5	180	245	212	185	240	211.4	245	145	99.0	97.0	RMC 1992
Wilder, VT	52	300	8.5-15.6	180	245	212	185	240	211.4	245	145	93.3	91.1	RMC 1992
Wilder, VT	52	500	8.5-15.7	180	245	212	185	240	211.4	245	145	98.0	97.0	RMC 1992
Vernon, VT	27	40	16.0-17.5	115	216	156	119	200	149	75	25	93.3	93.3	Normandeau 1995

Table 7. Turbine characteristics for Units 1 through 8 at the Shawmut Project.

Parameter	Shawmut Turbines							
	Unit 1	**Unit 2**	**Unit 3**	**Unit 4**	**Unit 5**	**Unit 6**	**Unit 7**	**Unit 8**
Turbine Type	Horizontal Francis	Horizontal Francis	Horizontal Francis	Horizontal Francis	Horizontal Francis	Horizontal Francis	Horizontal Propeller	Horizontal Propeller
Number blades/buckets	10	10	10	13	10	13	3	3
Max turbine discharge (cfs)	648	645	641	672	742	667	[a]	[a]
Efficiency at max discharge	0.74	0.76	0.78	0.67	0.67	0.74	[a]	[a]
Peak turbine discharge (cfs)*	581	583	581	539	520	575	1,312	1,347
Efficiency at peak discharge	0.79	0.8	0.8	0.77	0.88	0.79	0.74	0.75
Runner diameter (ft)	-	-	-	-	-	-	9.0	9.0
Runner Diameter at inlet (ft)	2.8	2.8	2.8	2.8	2.8	2.8	-	-
Runner diameter at discharge (ft)	4.5	4.5	4.5	4.5	4.5	4.5	-	-
Runner height at inlet (ft)	2.8	2.8	2.8	2.8	2.8	2.8	-	-
RPM	200	200	200	200	200	200	160	160
Rated head (ft)	23	23	23	23	23	23	23	23

*Peak turbine discharge is the maximum efficiency for a particular unit.

[a] - value not available

Table 8. **Initial (1-hr) injury/scale loss rates for Atlantic salmon smolts passed through Kaplan, propeller and Francis units at various hydroelectric projects. All tests conducted using the Hi-Z Turb'N Tag.**

Site Name	Unit Type	Normal head (ft)	RPM	Unit Flow (cfs)	No. of Blades or Buckets	Runner Diameter (ft)	Test Fish Injury Rates (%)	Control Fish Injury Rates (%)	Reference
Briar Rolfe, NH	Kaplan	35	150	-	5	9.84	7.1	0.0	Normandeau 2004
Bar Mills, ME [1]	Propeller	19.5	120	960 & 1,560	5	11.2	6.3, 12.2	0.0	Normandeau and FPL 2002
Lairg, Scotland	Kaplan	-	167	-	4	8.5	3.2	-	Normandeau and Fishtrack 1998
Cliff, Ireland	Kaplan	32.8	115.3	-	5	14.1	4.0	2.0	Normandeau and Fishtrack 2002
Cathleens Falls, Ireland	Kaplan	93.5	187.5	-	5	12.6	7.0	0.0	Normandeau and Fishtrack 2002
Ardnacrusha, Ireland [1]	Kaplan	93	167	-	5	16.4	10.6, 8.8	0.0	Normandeau and Fishtrack 2004
Wilder, VT-NH	Kaplan	51	112.5	-	5	9.0	4.8	0.0	Normandeau 1994
Vernon, VT [1]	Kaplan	34	144	1,250 & 1,600	5	10.2	9.4, 11.5	0.1	Normandeau 2009
West Buxton, ME	Propeller	26.8	120	1,360 & 1,800	6	11.1	13.7	-	Normandeau 1999
McIndoes, NH [1]	Propeller	26	150	800 & 1,600	4	10.0	0.6, 6.4	1.0	Normandeau 2006b
West Buxton, ME	Francis	26.8	150	611	16	4.0	30.8	-	Normandeau 1999
Vernon, VT	Francis	34	133.3	1,280	14	5.2	16.7	0.0	Normandeau 1996

1 - Tested two different settings

Table 9. Summary of injury types and frequency of occurrence for Atlantic salmon smolts passed through Kaplan, propeller and Francis units at various hydroelectric projects. All tests conducted using the Hi-Z Turb'N Tag.

					Injury Type									
Unit Type	**Site Name**	**Unit Type**	**# of Individuals Examined**	**# of Individuals with Injuries**	**Loss of Equilibrium**	**Minor scale loss, <25%**	**Major scale loss, >25%**	**Operculum/gill damage**	**Severed body/ back bone**	**Ruptured/ hemorrhaged eye**	**Bruised head or body**	**Cut/tear on head or body**	**Internal Injuries**	**Other**
Kaplan Units	Briar Rolfe, NH	Kaplan	70	5	2		2		1					
	Bar Mills, ME	Propeller	96	9	1			2	5				1	
	Lairg, Scotland	Kaplan	94	3					1	1		1	1	
	Cliff, Ireland	Kaplan	75	3					3					
	Cathleens Falls, Ireland	Kaplan	71	5				1	4					1
	Ardnacrusha, Ireland	Kaplan	185	18	10			4	4	2				
	Wilder, VT-NH	Kaplan	120	6	1		1		2		2	2		
	Vernon, VT	Kaplan	259	27	4		4	6	3	2	11	1	4	
	West Buxton, ME	Propeller	73	10	4	1					6	3		
	McIndoes, NH	Propeller	310	11	3			2	5	2	1	1		
	All Projects		1353	97	25	1	7	15	28	7	20	8	6	1
	Percent Occurrence for Smolts with Injuries				**25.8%**	**1.0%**	**7.2%**	**15.5%**	**28.9%**	**7.2%**	**20.6%**	**8.2%**	**6.2%**	**1.0%**
	Percent Occurrence for All Smolts Examined				**1.8%**	**0.1%**	**0.5%**	**1.1%**	**2.1%**	**0.5%**	**1.5%**	**0.6%**	**0.4%**	**0.1%**
Francis Units	West Buxton, ME	Francis	39	12	6	2	1		2		2	2		
	Vernon, VT	Francis	24	4	1	1			3					
	All Projects		63	16	7	3	1	0	5	0	2	2	0	0
	Percent Occurrence for Smolts with Injuries				**43.8%**	**18.8%**	**6.3%**	**0.0%**	**31.3%**	**0.0%**	**12.5%**	**12.5%**	**0.0%**	**0.0%**
	Percent Occurrence for All Smolts Examined				**11.1%**	**4.8%**	**1.6%**	**0.0%**	**7.9%**	**0.0%**	**3.2%**	**3.2%**	**0.0%**	**0.0%**

Table 10. **Immediate (1 hr) and delayed (48 hr) survival for Atlantic salmon smolts passed through Francis turbines at various hydroelectric projects. Note: All studies conducted using the Hi-Z Turb'N Tag.**

Site Name	Unit Type	Normal head (ft)	RPM	Unit Flow (cfs)	No. of Blades or Buckets	Runner Diameter (ft)	Immediate Survival (1-hr)	Delayed Survival (48-hr)	Reference
West Buxton, ME	Francis	26.8	150	611	16	4.0	85.0	85.0 [1]	Normandeau 1999
Vernon, VT	Francis	34	133.3	1,280	14	5.2	85.1	85.1	Normandeau 1996

1 - This value represents 24-hr survival

Table 11. **Immediate (1 hr) and delayed (48 hr) survival for Atlantic salmon smolts passed through Kaplan/propeller turbines at various hydroelectric projects. Note: All studies conducted using the Hi-Z Turb'N Tag.**

Site Name	Unit Type	Normal head (ft)	RPM	Unit Flow (cfs)	No. of Blades or Buckets	Runner Diameter (ft)	Immediate Survival (1-hr)	Delayed Survival (48-hr)	Reference
Briar Rolfe, NH	Kaplan	35	150	-	5	9.84	95.7	95.7	Normandeau 2004
Bar Mills, ME [1]	Propeller	19.5	120	960 & 1,560	5	11.2	88.0 & 94.0	88.0 & 88.0 [2]	Normandeau and FPL 2002
Lairg, Scotland	Kaplan	-	167	-	4	8.5	91.0	91.0	Normandeau and Fishtrack 1998
Cliff, Ireland	Kaplan	32.8	115.3	-	5	14.1	92.3	92.2	Normandeau and Fishtrack 2002
Cathleens Falls, Ireland	Kaplan	93.5	187.5	-	5	12.6	89.3	88.0	Normandeau and Fishtrack 2002
Ardnacrusha, Ireland [1]	Kaplan	93	167	-	5	16.4	96.3 & 95.2	96.3 & 87.5	Normandeau and Fishtrack 2004
Wilder, VT-NH	Kaplan	51	112.5	-	5	9.0	96.0	94.3	Normandeau 1994
Vernon, VT [1]	Kaplan	34	120	1,250 & 1,600	5	10.2	94.7 & 98.5	92.3 & 89.3	Normandeau 2009
West Buxton, ME [1]	Propeller	26.8	120	1,360 & 1,800	6	11.1	100.0 & 94.0	100.0 & 94.0 [3]	Normandeau 1999
McIndoes, NH [1]	Propeller	26	150	800 & 1,600	4	10.0	100.0 & 96.1	100.0 & 94.8	Normandeau 2006b

1 - Tested two different settings

2 - These values represent 24 hour survival

3 - These values represent 72 hour survival

Table 12. Predicted survival rates for salmon smolts passed through horizontal Francis Units 1-6 at the Shawmut Project under maximum turbine operating conditions.

Unit	Turbine Type	Maximum Discharge (cfs)	Efficiency at Max. Discharge (%)	Correlation Factor	Predicted Survival (%) by Smolt Length (in)						Unit Average
					5	6	7	8	9	Range	
1	Horizontal Francis	648	0.74	0.1	93.0	91.6	90.2	88.8	87.4	87.4 - 93.0	85.3
				0.2	86.0	83.2	80.4	77.6	74.8	74.8 - 86.0	
2	Horizontal Francis	645	0.76	0.1	93.0	91.6	90.2	88.7	87.3	87.3 - 93.0	85.2
				0.2	85.9	83.1	80.3	77.5	74.7	74.7 - 85.9	
3	Horizontal Francis	641	0.78	0.1	92.9	91.5	90.1	88.7	87.3	87.3 - 92.9	85.1
				0.2	85.9	83.0	80.2	77.4	74.5	74.5 - 85.9	
4	Horizontal Francis	675	0.67	0.1	91.6	89.9	88.2	86.5	84.8	84.8 - 91.6	82.3
				0.2	83.1	79.7	76.3	73.0	69.6	69.6 - 83.1	
5	Horizontal Francis	742	0.67	0.1	94.6	93.6	92.5	91.4	90.4	90.4 - 94.6	88.8
				0.2	89.3	87.1	85.0	82.9	80.7	80.7 - 89.3	
6	Horizontal Francis	667	0.74	0.1	91.2	89.4	87.6	85.9	84.1	84.1 - 91.2	81.4
				0.2	82.3	78.8	75.2	71.7	68.2	68.2 - 82.3	

Table 13. **Predicted survival rates for salmon smolts passed through horizontal propeller Units 7 and 8 at the Shawmut Project under peak turbine operating conditions.**

Unit	Peak Efficiency (%)	Discharge (cfs) at Peak Efficiency	Correlation Factor	Fish Entry Point (ft)	Predicted Survival (%) by Smolt Length (in) 5	6	7	8	9	Range	Unit Average
7	0.74	1,312	0.1	blade tip	95.3	94.4	93.4	92.5	91.6	91.6 - 95.3	94.3
				mid-blade	98.2	97.8	97.4	97.1	96.7	96.7 - 98.2	
				near hub	98.3	98.0	97.6	97.3	97.0	97.0 - 98.3	
			0.2	blade tip	90.6	88.7	86.9	85.0	83.1	83.1 - 90.6	
				mid-blade	96.3	95.6	94.9	94.1	93.4	93.4 - 96.3	
				near hub	96.6	96.0	95.3	94.6	93.9	93.9 - 96.6	
8	75	1,347	0.1	blade tip	95.3	94.4	93.4	92.5	91.6	91.6 - 95.3	94.3
				mid-blade	98.2	97.8	97.5	97.1	96.8	96.8 - 98.2	
				near hub	98.4	98.0	97.7	97.4	97.0	97.0 - 98.4	
			0.2	blade tip	90.6	88.8	86.9	85.0	83.1	83.1 - 90.6	
				mid-blade	96.4	95.7	95.0	94.2	93.5	93.5 - 96.4	
				near hub	96.7	96.1	95.4	94.7	94.1	94.1 - 96.7	

Table 14. Initial Survival Rate Model (Model A) for whole station survival of Atlantic salmon smolts passing the Shawmut Project under median (50% occurrence) river conditions.

		BASE MODEL
Theoretical Number of Smolts		1,000
Proportion of Smolts to Spillway		0.206
Number of Smolts Passed via Spillway		206
Spillway/Bypass Survival Rate		0.971
Total Number Smolts Surviving Spill		**200**
Proportion of Smolts to Forebay Canal		0.794
Total Number of Smolts to Powerhouse		794
Number of Smolts to Forebay Canal by Month	April	14
	May	611
	June	168
Bypass Effectiveness Rate	April	0.005
	May	0.005
	June	0.006
Number of Smolts Passed via Bypass	April	0
	May	3
	June	1
Total Number of Smolts Passed via Bypass		4
Number of Smolts Surviving Bypass	April	0
	May	3
	June	1
Total Number of Smolts Surviving Bypass		**4**
Proportion of Smolts to Turbine Units	April	0.995
	May	0.995
	June	0.994
Total Number of Smolts To Turbine Units		790
Proportion of Smolts Passed via Francis		0.600
Proportion of Smolts Passed via Propeller		0.400
Number of Smolts Passed via Francis	Total	474
	April	9
	May	365
	June	100
Number of Smolts Passed via Propeller	Total	316
	April	6
	May	243
	June	67
Francis Turbine Survival Rate		0.851
Propeller Turbine Survival Rate		0.947
Number of Smolts Surviving Francis	April	7
	May	310
	June	85
Total Number of Smolts Surviving Francis		**403**

(continued)

Table 14. (Continued)

		BASE MODEL
Number of Smolts Surviving Propeller	April	5
	May	230
	June	63
Total Number of Smolts Surviving Propeller		**299**
TOTAL SMOLT SURVIVAL		**907**
WHOLE STATION ESTIMATE		**91%**

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 15. Impacts to the whole station smolt survival estimate obtained using the Initial Survival Rate Model (Model A) for theoretical downstream bypass effectiveness rates.

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.206*	0.206	0.206	0.206	0.206	0.206
Number of Smolts Passed via Spillway		*206*	206	206	206	206	206
Spillway/Bypass Survival Rate		*0.971*	0.971	0.971	0.971	0.971	0.971
Total Number Smolts Surviving Spill		***200***	**200**	**200**	**200**	**200**	**200**
Proportion of Smolts to Forebay Canal		*0.794*	0.794	0.794	0.794	0.794	0.794
Total Number of Smolts to Powerhouse		*794*	794	794	794	794	794
Number of Smolts to Forebay Canal by Month	April	*14*	14	14	14	14	14
	May	*611*	611	611	611	611	611
	June	*168*	168	168	168	168	168
Bypass Effectiveness Rate	April	*0.005*	0.250	0.450	0.650	0.850	1.000
	May	*0.005*	0.250	0.450	0.650	0.850	1.000
	June	*0.006*	0.250	0.450	0.650	0.850	1.000
Number of Smolts Passed via Bypass	April	*0*	4	6	9	12	14
	May	*3*	153	275	397	520	611
	June	*1*	42	76	109	143	168
Total Number of Smolts Passed via Bypass		*4*	199	357	516	675	794
Number of Smolts Surviving Bypass	April	*0*	3	6	9	12	14
	May	*3*	148	267	386	505	594
	June	*1*	41	74	106	139	163
Total Number of Smolts Surviving Bypass		***4***	**193**	**347**	**501**	**655**	**771**
Proportion of Smolts to Turbine Units	April	*0.995*	0.750	0.550	0.350	0.150	0.000
	May	*0.995*	0.750	0.550	0.350	0.150	0.000
	June	*0.994*	0.750	0.550	0.350	0.150	0.000
Total Number of Smolts To Turbine Units		*790*	596	437	278	119	0
Proportion of Smolts Passed via Francis		*0.600*	0.600	0.600	0.600	0.600	0.600
Proportion of Smolts Passed via Propeller		*0.400*	0.400	0.400	0.400	0.400	0.400
Number of Smolts Passed via Francis	Total	*474*	357	262	167	71	0
	April	*9*	6	5	3	1	0
	May	*365*	275	202	128	55	0
	June	*100*	76	56	35	15	0
Number of Smolts Passed via Propeller	Total	*316*	238	175	111	48	0
	April	*6*	4	3	2	1	0
	May	*243*	183	135	86	37	0
	June	*67*	50	37	24	10	0
Francis Turbine Survival Rate		*0.851*	0.851	0.851	0.851	0.851	0.851
Propeller Turbine Survival Rate		*0.947*	0.947	0.947	0.947	0.947	0.947
Number of Smolts Surviving Francis	April	*7*	5	4	3	1	0
	May	*310*	234	172	109	47	0
	June	*85*	64	47	30	13	0
Total Number of Smolts Surviving Francis		***403***	**304**	**223**	**142**	**61**	**0**

(continued)

Table 15. (Continued)

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Number of Smolts Surviving Propeller	April	*5*	4	3	2	1	0
	May	*230*	174	127	81	35	0
	June	*63*	48	35	22	10	0
Total Number of Smolts Surviving Propeller		***299***	**226**	**165**	**105**	**45**	**0**
TOTAL SMOLT SURVIVAL		***907***	**922**	**935**	**948**	**961**	**971**
WHOLE STATION ESTIMATE		***91%***	**92%**	**94%**	**95%**	**96%**	**97%**

Italics indicates the base model constructed using median flow conditions in the Kennebec River
Shading indicates the variable assessed in this sensitivity
analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 16. Impacts to the whole station smolt survival estimate obtained using the Initial Survival Rate Model (Model A) for theoretical spill effectiveness rates.

		Evaluated Spill Effectiveness Rates					
		1:1	**0.2:1**	**1.5:1**	**2.4:1**	**3.4:1**	**4.4:1**
		0.206	**0.05**	**0.3**	**0.5**	**0.7**	**0.9**
Proportion of River Flow to Spillway		*0.206*	0.206	0.206	0.206	0.206	0.206
Proportion of River Flow to Powerhouse		*0.794*	0.794	0.794	0.794	0.794	0.794
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.206*	0.05	0.3	0.5	0.7	0.9
Number of Smolts Passed via Spillway		*206*	50	300	500	700	900
Spillway/Bypass Survival Rate		*0.971*	0.971	0.971	0.971	0.971	0.971
Total Number Smolts Surviving Spill		***200***	**49**	**291**	**486**	**680**	**874**
Proportion of Smolts to Forebay Canal		*0.794*	0.95	0.7	0.5	0.3	0.1
Total Number of Smolts to Powerhouse		*794*	950	700	500	300	100
Number of Smolts to Forebay Canal by Month	April	*14*	17	13	9	5	2
	May	*611*	732	539	385	231	77
	June	*168*	201	148	106	64	21
Bypass Effectiveness Rate	April	*0.005*	0.005	0.005	0.005	0.005	0.005
	May	*0.005*	0.005	0.005	0.005	0.005	0.005
	June	*0.006*	0.006	0.006	0.006	0.006	0.006
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0	0
	May	*3*	4	3	2	1	0
	June	*1*	1	1	1	0	0
Total Number of Smolts Passed via Bypass		*4*	5	4	3	2	1
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0	0
	May	*3*	4	3	2	1	0
	June	*1*	1	1	1	0	0
Total Number of Smolts Surviving Bypass		***4***	**5**	**4**	**3**	**2**	**1**
Proportion of Smolts to Turbine Units	April	*0.995*	0.995	0.995	0.995	0.995	0.995
	May	*0.995*	0.995	0.995	0.995	0.995	0.995
	June	*0.994*	0.994	0.994	0.994	0.994	0.994
Total Number of Smolts To Turbine Units		*790*	945	696	497	298	99
Proportion of Smolts Passed via Francis		*0.600*	0.600	0.600	0.600	0.600	0.600
Proportion of Smolts Passed via Propeller		*0.400*	0.400	0.400	0.400	0.400	0.400
Number of Smolts Passed via Francis	Total	*474*	567	418	298	179	60
	April	*9*	10	8	5	3	1
	May	*365*	437	322	230	138	46
	June	*100*	120	89	63	38	13
Number of Smolts Passed via Propeller	Total	*316*	378	278	199	119	40
	April	*6*	7	5	4	2	1
	May	*243*	291	214	153	92	31
	June	*67*	80	59	42	25	8
Francis Turbine Survival Rate		*0.851*	0.851	0.851	0.851	0.851	0.851
Propeller Turbine Survival Rate		*0.947*	0.947	0.947	0.947	0.947	0.947
Number of Smolts Surviving Francis	April	*7*	9	6	5	3	1
	May	*310*	371	274	196	117	39
	June	*85*	102	75	54	32	11
Total Number of Smolts Surviving Francis		***403***	**482**	**355**	**254**	**152**	**51**

(continued)

Table 16. (Continued)

		Evaluated Spill Effectiveness Rates					
		1:1	**0.2:1**	**1.5:1**	**2.4:1**	**3.4:1**	**4.4:1**
		0.206	**0.05**	**0.3**	**0.5**	**0.7**	**0.9**
Number of Smolts Surviving Propeller	April	*5*	6	5	3	2	1
	May	*230*	276	203	145	87	29
	June	*63*	76	56	40	24	8
Total Number of Smolts Surviving Propeller		***299***	**358**	**264**	**188**	**113**	**38**
TOTAL SMOLT SURVIVAL		***907***	**894**	**914**	**930**	**947**	**963**
WHOLE STATION ESTIMATE		***91%***	**89%**	**91%**	**93%**	**95%**	**96%**

Italics indicates the base model constructed using median flow conditions in the Kennebec River
Shading indicates the variable assessed in this sensitivity analysis
*Monthly smolt run distribution is presented in Table 3 of this report.

Table 17. Approximate river discharge (cfs) for Kennebec River at Shawmut during April, May and June for low (i.e. 75 and 90% exceedence) and high (10 and 25% exceedence) flow conditions.

Percent of Time Flow is Exceeded	River Discharge (cfs)		
	April	May	June
10	31,750	21,750	14,000
25	20,500	15,250	8,000
50	*13,000*	*9,000*	*5,750*
75	9,000	5,750	4,250
90	6,500	4,250	3,000

Italics indicate values used for primary model

Table 18. Impacts to the whole station smolt survival estimate obtained using the Initial Survival Rate Model (Model A) for theoretical seasonal flow conditions

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.206*	0.658	0.478	0.005	0.000
Number of Smolts Passed via Spillway		*206*	658	478	5	0
Spillway/Bypass Survival Rate		*0.971*	0.971	0.971	0.971	0.971
Total Number Smolts Surviving Spill		***200***	**638**	**464**	**4**	**0**
Proportion of Smolts to Forebay Canal		*0.794*	0.342	0.522	0.995	1.000
Total Number of Smolts to Powerhouse		*794*	342	522	995	1000
Number of Smolts to Forebay Canal by Month	April	*14*	6	9	18	18
	May	*612*	264	402	766	770
	June	*168*	73	111	211	212
Bypass Effectiveness Rate	April	*0.005*	0.005	0.005	0.005	0.005
	May	*0.005*	0.005	0.005	0.006	0.008
	June	*0.006*	0.005	0.005	0.008	0.012
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0
	May	*3*	1	2	5	6
	June	*1*	0	1	2	2
Total Number of Smolts Passed via Bypass		*4*	2	3	6	9
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0
	May	*3*	1	2	5	6
	June	*1*	0	1	2	2
Total Number of Smolts Surviving Bypass		***4***	**2**	**3**	**6**	**9**
Proportion of Smolts to Turbine Units	April	*0.995*	0.995	0.995	0.995	0.995
	May	*0.995*	0.995	0.995	0.994	0.992
	June	*0.994*	0.995	0.995	0.992	0.988
Total Number of Smolts To Turbine Units		*790*	341	519	989	991
Proportion of Smolts Passed via Francis		*0.600*	0.600	0.600	0.600	0.600
Proportion of Smolts Passed via Propeller		*0.400*	0.400	0.400	0.400	0.400
Number of Smolts Passed via Francis	Total	*474*	204	311	593	595
	April	*9*	4	6	11	11
	May	*365*	157	240	457	458
	June	*101*	43	66	126	126
Number of Smolts Passed via Propeller	Total	*316*	136	208	396	396
	April	*6*	2	4	7	7
	May	*243*	105	160	305	305
	June	*67*	29	44	84	84
Francis Turbine Survival Rate		*0.851*	0.851	0.851	0.851	0.851
Propeller Turbine Survival Rate		*0.947*	0.947	0.947	0.947	0.947
Number of Smolts Surviving Francis	April	*7*	3	5	9	9
	May	*311*	134	204	389	390
	June	*86*	37	56	107	107
Total Number of Smolts Surviving Francis		***403***	**174**	**265**	**505**	**506**

(continued)

Table 18. (Continued)

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Number of Smolts Surviving Propeller	April	*5*	2	4	7	7
	May	*230*	99	151	288	289
	June	*63*	27	42	79	80
Total Number of Smolts Surviving Propeller		***299***	**129**	**197**	**375**	**375**
TOTAL SMOLT SURVIVAL		***907***	**943**	**929**	**890**	**890**
WHOLE STATION ESTIMATE		***91%***	**94%**	**93%**	**89%**	**89%**

Italics indicates the base model constructed using median flow conditions in the Kennebec River

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 19. Delayed Survival Rate Model (Model B) for whole station survival of Atlantic salmon smolts passing the Shawmut Project under median (50% occurrence) river conditions.

		BASE MODEL
Theoretical Number of Smolts		1,000
Proportion of Smolts to Spillway		0.206
Number of Smolts Passed via Spillway		206
Spillway/Bypass Survival Rate		0.963
Total Number Smolts Surviving Spill		**198**
Proportion of Smolts to Forebay Canal		0.794
Total Number of Smolts to Powerhouse		794
Number of Smolts to Forebay Canal by Month	April	14
	May	611
	June	168
Bypass Effectiveness Rate	April	0.005
	May	0.005
	June	0.006
Number of Smolts Passed via Bypass	April	0
	May	3
	June	1
Total Number of Smolts Passed via Bypass		4
Number of Smolts Surviving Bypass	April	0
	May	3
	June	1
Total Number of Smolts Surviving Bypass		**4**
Proportion of Smolts to Turbine Units	April	0.995
	May	0.995
	June	0.994
Total Number of Smolts To Turbine Units		790
Proportion of Smolts Passed via Francis		0.600
Proportion of Smolts Passed via Propeller		0.400
Number of Smolts Passed via Francis	Total	474
	April	9
	May	365
	June	100
Number of Smolts Passed via Propeller	Total	316
	April	6
	May	243
	June	67
Francis Turbine Survival Rate		0.851
Propeller Turbine Survival Rate		0.928
Number of Smolts Surviving Francis	April	7
	May	310
	June	85
Total Number of Smolts Surviving Francis		**403**

(continued)

Table 19. (Continued)

		BASE MODEL
Number of Smolts Surviving Propeller	April	5
	May	226
	June	62
Total Number of Smolts Surviving Propeller		**293**
TOTAL SMOLT SURVIVAL		**899**
WHOLE STATION ESTIMATE		**90%**

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 20. Impacts to the whole station smolt survival estimate obtained using the Delayed Survival Rate Model (Model B) for theoretical downstream bypass effectiveness rates.

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.206*	0.206	0.206	0.206	0.206	0.206
Number of Smolts Passed via Spillway		*206*	206	206	206	206	206
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963	0.963
Total Number Smolts Surviving Spill		***198***	**198**	**198**	**198**	**198**	**198**
Proportion of Smolts to Forebay Canal		*0.794*	0.794	0.794	0.794	0.794	0.794
Total Number of Smolts to Powerhouse		*794*	794	794	794	794	794
Number of Smolts to Forebay Canal by Month	April	*14*	14	14	14	14	14
	May	*611*	611	611	611	611	611
	June	*168*	168	168	168	168	168
Bypass Effectiveness Rate	April	*0.005*	0.250	0.450	0.650	0.850	1.000
	May	*0.005*	0.250	0.450	0.650	0.850	1.000
	June	*0.006*	0.250	0.450	0.650	0.850	1.000
Number of Smolts Passed via Bypass	April	*0*	4	6	9	12	14
	May	*3*	153	275	397	520	611
	June	*1*	42	76	109	143	168
Total Number of Smolts Passed via Bypass		*4*	199	357	516	675	794
Number of Smolts Surviving Bypass	April	*0*	3	6	9	12	14
	May	*3*	147	265	383	500	589
	June	*1*	41	73	105	138	162
Total Number of Smolts Surviving Bypass		***4***	**191**	**344**	**497**	**650**	**765**
Proportion of Smolts to Turbine Units	April	*0.995*	0.750	0.550	0.350	0.150	0.000
	May	*0.995*	0.750	0.550	0.350	0.150	0.000
	June	*0.994*	0.750	0.550	0.350	0.150	0.000
Total Number of Smolts To Turbine Units		*790*	596	437	278	119	0
Proportion of Smolts Passed via Francis		*0.600*	0.600	0.600	0.600	0.600	0.600
Proportion of Smolts Passed via Propeller		*0.400*	0.400	0.400	0.400	0.400	0.400
Number of Smolts Passed via Francis	Total	*474*	357	262	167	71	0
	April	*9*	6	5	3	1	0
	May	*365*	275	202	128	55	0
	June	*100*	76	56	35	15	0
Number of Smolts Passed via Propeller	Total	*316*	238	175	111	48	0
	April	*6*	4	3	2	1	0
	May	*243*	183	135	86	37	0
	June	*67*	50	37	24	10	0
Francis Turbine Survival Rate		*0.851*	0.851	0.851	0.851	0.851	0.851
Propeller Turbine Survival Rate		*0.928*	0.928	0.928	0.928	0.928	0.928
Number of Smolts Surviving Francis	April	*7*	5	4	3	1	0
	May	*310*	234	172	109	47	0
	June	*85*	64	47	30	13	0
Total Number of Smolts Surviving Francis		***403***	**304**	**223**	**142**	**61**	**0**

(continued)

Table 20. (Continued)

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Number of Smolts Surviving Propeller	April	*5*	4	3	2	1	0
	May	*226*	170	125	79	34	0
	June	*62*	47	34	22	9	0
Total Number of Smolts Surviving Propeller		***293***	**221**	**162**	**103**	**44**	**0**
TOTAL SMOLT SURVIVAL		***899***	**915**	**928**	**940**	**953**	**963**
WHOLE STATION ESTIMATE		***90%***	**91%**	**93%**	**94%**	**95%**	**96%**

Italics indicates the base model constructed using median flow conditions in the Kennebec River
Shading indicates the variable assessed in this sensitivity
analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 21. Impacts to the whole station smolt survival estimate obtained using the Delayed Survival Rate Model (Model B) for theoretical spill effectiveness rates.

		Evaluated Spill Effectiveness Rates					
		1:1	**0.2:1**	**1.5:1**	**2.4:1**	**3.4:1**	**4.4:1**
		0.206	**0.05**	**0.3**	**0.5**	**0.7**	**0.9**
Proportion of River Flow to Spillway		*0.206*	0.206	0.206	0.206	0.206	0.206
Proportion of River Flow to Powerhouse		*0.794*	0.794	0.794	0.794	0.794	0.794
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.206*	0.05	0.3	0.5	0.7	0.9
Number of Smolts Passed via Spillway		*206*	50	300	500	700	900
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963	0.963
Total Number Smolts Surviving Spill		***198***	**48**	**289**	**482**	**674**	**867**
Proportion of Smolts to Forebay Canal		*0.794*	0.95	0.7	0.5	0.3	0.1
Total Number of Smolts to Powerhouse		*794*	950	700	500	300	100
Number of Smolts to Forebay Canal by Month	April	*14*	17	13	9	5	2
	May	*611*	732	539	385	231	77
	June	*168*	201	148	106	64	21
Bypass Effectiveness Rate	April	*0.005*	0.005	0.005	0.005	0.005	0.005
	May	*0.005*	0.005	0.005	0.005	0.005	0.005
	June	*0.006*	0.006	0.006	0.006	0.006	0.006
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0	0
	May	*3*	4	3	2	1	0
	June	*1*	1	1	1	0	0
Total Number of Smolts Passed via Bypass		*4*	5	4	3	2	1
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0	0
	May	*3*	4	3	2	1	0
	June	*1*	1	1	1	0	0
Total Number of Smolts Surviving Bypass		***4***	**5**	**4**	**3**	**2**	**1**
Proportion of Smolts to Turbine Units	April	*0.995*	0.995	0.995	0.995	0.995	0.995
	May	*0.995*	0.995	0.995	0.995	0.995	0.995
	June	*0.994*	0.994	0.994	0.994	0.994	0.994
Total Number of Smolts To Turbine Units		*790*	945	696	497	298	99
Proportion of Smolts Passed via Francis		*0.600*	0.600	0.600	0.600	0.600	0.600
Proportion of Smolts Passed via Propeller		*0.400*	0.400	0.400	0.400	0.400	0.400
Number of Smolts Passed via Francis	Total	*474*	567	418	298	179	60
	April	*9*	10	8	5	3	1
	May	*365*	437	322	230	138	46
	June	*100*	120	89	63	38	13
Number of Smolts Passed via Propeller	Total	*316*	378	278	199	119	40
	April	*6*	7	5	4	2	1
	May	*243*	291	214	153	92	31
	June	*67*	80	59	42	25	8
Francis Turbine Survival Rate		*0.851*	0.851	0.851	0.851	0.851	0.851
Propeller Turbine Survival Rate		*0.928*	0.928	0.928	0.928	0.928	0.928
Number of Smolts Surviving Francis	April	*7*	9	6	5	3	1
	May	*310*	371	274	196	117	39
	June	*85*	102	75	54	32	11

(continued)

Table 21. (Continued)

		Evaluated Spill Effectiveness Rates					
		1:1	**0.2:1**	**1.5:1**	**2.4:1**	**3.4:1**	**4.4:1**
		0.206	**0.05**	**0.3**	**0.5**	**0.7**	**0.9**
Total Number of Smolts Surviving Francis		***403***	**482**	**355**	**254**	**152**	**51**
Number of Smolts Surviving Propeller	April	*5*	6	5	3	2	1
	May	*226*	270	199	142	85	28
	June	*62*	74	55	39	23	8
Total Number of Smolts Surviving Propeller		***293***	**351**	**258**	**185**	**111**	**37**
TOTAL SMOLT SURVIVAL		***899***	**886**	**906**	**923**	**939**	**955**
WHOLE STATION ESTIMATE		***90%***	**89%**	**91%**	**92%**	**94%**	**95%**

Italics indicates the base model constructed using median flow conditions in the Kennebec River

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 22. Impacts to the whole station smolt survival estimate obtained using the Delayed Survival Rate Model (Model B) for theoretical seasonal flow conditions.

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.206*	0.658	0.478	0.005	0.000
Number of Smolts Passed via Spillway		*206*	658	478	5	0
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963
Total Number Smolts Surviving Spill		***198***	**633**	**461**	**4**	**0**
Proportion of Smolts to Forebay Canal		*0.794*	0.342	0.522	0.995	1.000
Total Number of Smolts to Powerhouse		*794*	342	522	995	1000
Number of Smolts to Forebay Canal by Month	April	*14*	6	9	18	18
	May	*612*	264	402	766	770
	June	*168*	73	111	211	212
Bypass Effectiveness Rate	April	*0.005*	0.005	0.005	0.005	0.005
	May	*0.005*	0.005	0.005	0.006	0.008
	June	*0.006*	0.005	0.005	0.008	0.012
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0
	May	*3*	1	2	5	6
	June	*1*	0	1	2	2
Total Number of Smolts Passed via Bypass		*4*	2	3	6	9
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0
	May	*3*	1	2	4	6
	June	*1*	0	1	2	2
Total Number of Smolts Surviving Bypass		***4***	**2**	**3**	**6**	**9**
Proportion of Smolts to Turbine Units	April	*0.995*	0.995	0.995	0.995	0.995
	May	*0.995*	0.995	0.995	0.994	0.992
	June	*0.994*	0.995	0.995	0.992	0.988
Total Number of Smolts To Turbine Units		*790*	341	519	989	991
Proportion of Smolts Passed via Francis		*0.600*	0.600	0.600	0.600	0.600
Proportion of Smolts Passed via Propeller		*0.400*	0.400	0.400	0.400	0.400
Number of Smolts Passed via Francis	Total	*474*	204	311	593	595
	April	*9*	4	6	11	11
	May	*365*	157	240	457	458
	June	*101*	43	66	126	126
Number of Smolts Passed via Propeller	Total	*316*	136	208	396	396
	April	*6*	2	4	7	7
	May	*243*	105	160	305	305
	June	*67*	29	44	84	84
Francis Turbine Survival Rate		*0.851*	0.851	0.851	0.851	0.851
Propeller Turbine Survival Rate		*0.928*	0.928	0.928	0.928	0.928
Number of Smolts Surviving Francis	April	*7*	3	5	9	9
	May	*311*	134	204	389	390
	June	*86*	37	56	107	107
Total Number of Smolts Surviving Francis		***403***	**174**	**265**	**505**	**506**

(continued)

Table 22. (Continued)

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Number of Smolts Surviving Propeller	April	*5*	2	3	7	7
	May	*226*	97	148	283	283
	June	*62*	27	41	78	78
Total Number of Smolts Surviving Propeller		***293***	**126**	**193**	**367**	**368**
TOTAL SMOLT SURVIVAL		***899***	**935**	**921**	**883**	**883**
WHOLE STATION ESTIMATE		***90%***	**94%**	**92%**	**88%**	**88%**

Italics indicates the base model constructed using median flow conditions in the Kennebec River

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 23. Delayed/Calculated Survival Rate Model (Model C) for whole station survival of Atlantic salmon smolts passing the Shawmut Project under median (50% occurrence) river conditions.

		BASE MODEL
Theoretical Number of Smolts		1,000
Proportion of Smolts to Spillway		0.206
Number of Smolts Passed via Spillway		206
Spillway/Bypass Survival Rate		0.963
Total Number Smolts Surviving Spill		**198**
Proportion of Smolts to Forebay Canal		0.794
Total Number of Smolts to Powerhouse		794
Number of Smolts to Forebay Canal by Month	April	14
	May	611
	June	168
Bypass Effectiveness Rate	April	0.005
	May	0.005
	June	0.006
Number of Smolts Passed via Bypass	April	0
	May	3
	June	1
Total Number of Smolts Passed via Bypass		4
Number of Smolts Surviving Bypass	April	0
	May	3
	June	1
Total Number of Smolts Surviving Bypass		**4**
Proportion of Smolts to Turbine Units	April	0.995
	May	0.995
	June	0.994
Total Number of Smolts To Turbine Units		790
Proportion of Smolts Passed via Francis		0.600
Proportion of Smolts Passed via Propeller		0.400
Number of Smolts Passed via Francis	Total	474
	April	9
	May	365
	June	100
Number of Smolts Passed via Propeller	Total	316
	April	6
	May	243
	June	67
Francis Turbine Survival Rate		0.847
Propeller Turbine Survival Rate		0.943
Number of Smolts Surviving Francis	April	7
	May	309
	June	85
Total Number of Smolts Surviving Francis		**401**

(continued)

Table 23. (Continued)

		BASE MODEL
Number of Smolts Surviving Propeller	April	5
	May	229
	June	63
Total Number of Smolts Surviving Propeller		**298**
TOTAL SMOLT SURVIVAL		**902**
WHOLE STATION ESTIMATE		**90%**

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 24. Impacts to the whole station smolt survival estimate obtained using the Delayed/Calculated Survival Rate Model (Model C) for theoretical downstream bypass effectiveness rates.

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.206*	0.206	0.206	0.206	0.206	0.206
Number of Smolts Passed via Spillway		*206*	206	206	206	206	206
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963	0.963
Total Number Smolts Surviving Spill		***198***	**198**	**198**	**198**	**198**	**198**
Proportion of Smolts to Forebay Canal		*0.794*	0.794	0.794	0.794	0.794	0.794
Total Number of Smolts to Powerhouse		*794*	794	794	794	794	794
Number of Smolts to Forebay Canal by Month	April	*14*	14	14	14	14	14
	May	*611*	611	611	611	611	611
	June	*168*	168	168	168	168	168
Bypass Effectiveness Rate	April	*0.005*	0.250	0.450	0.650	0.850	1.000
	May	*0.005*	0.250	0.450	0.650	0.850	1.000
	June	*0.006*	0.250	0.450	0.650	0.850	1.000
Number of Smolts Passed via Bypass	April	*0*	4	6	9	12	14
	May	*3*	153	275	397	520	611
	June	*1*	42	76	109	143	168
Total Number of Smolts Passed via Bypass		*4*	199	357	516	675	794
Number of Smolts Surviving Bypass	April	*0*	3	6	9	12	14
	May	*3*	147	265	383	500	589
	June	*1*	41	73	105	138	162
Total Number of Smolts Surviving Bypass		***4***	**191**	**344**	**497**	**650**	**765**
Proportion of Smolts to Turbine Units	April	*0.995*	0.750	0.550	0.350	0.150	0.000
	May	*0.995*	0.750	0.550	0.350	0.150	0.000
	June	*0.994*	0.750	0.550	0.350	0.150	0.000
Total Number of Smolts To Turbine Units		*790*	596	437	278	119	0
Proportion of Smolts Passed via Francis		*0.600*	0.600	0.600	0.600	0.600	0.600
Proportion of Smolts Passed via Propeller		*0.400*	0.400	0.400	0.400	0.400	0.400
Number of Smolts Passed via Francis	Total	*474*	357	262	167	71	0
	April	*9*	6	5	3	1	0
	May	*365*	275	202	128	55	0
	June	*100*	76	56	35	15	0
Number of Smolts Passed via Propeller	Total	*316*	238	175	111	48	0
	April	*6*	4	3	2	1	0
	May	*243*	183	135	86	37	0
	June	*67*	50	37	24	10	0
Francis Turbine Survival Rate		*0.847*	0.847	0.847	0.847	0.847	0.847
Propeller Turbine Survival Rate		*0.943*	0.943	0.943	0.943	0.943	0.943
Number of Smolts Surviving Francis	April	*7*	5	4	3	1	0
	May	*309*	233	171	109	47	0
	June	*85*	64	47	30	13	0
Total Number of Smolts Surviving Francis		***401***	**303**	**222**	**141**	**61**	**0**

(continued)

Table 24. (Continued)

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Number of Smolts Surviving Propeller	April	*5*	4	3	2	1	0
	May	*229*	173	127	81	35	0
	June	*63*	48	35	22	10	0
Total Number of Smolts Surviving Propeller		***298***	**225**	**165**	**105**	**45**	**0**
TOTAL SMOLT SURVIVAL		***902***	**917**	**929**	**941**	**954**	**963**
WHOLE STATION ESTIMATE		***90%***	**92%**	**93%**	**94%**	**95%**	**96%**

Italics indicates the base model constructed using median flow conditions in the Kennebec River
Shading indicates the variable assessed in this sensitivity
analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 25. Impacts to the whole station smolt survival estimate obtained using the Delayed/Calculated Survival Rate Model (Model C) for theoretical spill effectiveness rates.

		Evaluated Spill Effectiveness Rates					
		1:1	**0.2:1**	**1.5:1**	**2.4:1**	**3.4:1**	**4.4:1**
		0.206	**0.05**	**0.3**	**0.5**	**0.7**	**0.9**
Proportion of River Flow to Spillway		*0.206*	0.206	0.206	0.206	0.206	0.206
Proportion of River Flow to Powerhouse		*0.794*	0.794	0.794	0.794	0.794	0.794
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.206*	0.05	0.3	0.5	0.7	0.9
Number of Smolts Passed via Spillway		*206*	50	300	500	700	900
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963	0.963
Total Number Smolts Surviving Spill		***198***	**48**	**289**	**482**	**674**	**867**
Proportion of Smolts to Forebay Canal		*0.794*	0.95	0.7	0.5	0.3	0.1
Total Number of Smolts to Powerhouse		*794*	950	700	500	300	100
Number of Smolts to Forebay Canal by Month	April	*14*	17	13	9	5	2
	May	*611*	732	539	385	231	77
	June	*168*	201	148	106	64	21
Bypass Effectiveness Rate	April	*0.005*	0.005	0.005	0.005	0.005	0.005
	May	*0.005*	0.005	0.005	0.005	0.005	0.005
	June	*0.006*	0.006	0.006	0.006	0.006	0.006
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0	0
	May	*3*	4	3	2	1	0
	June	*1*	1	1	1	0	0
Total Number of Smolts Passed via Bypass		*4*	5	4	3	2	1
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0	0
	May	*3*	4	3	2	1	0
	June	*1*	1	1	1	0	0
Total Number of Smolts Surviving Bypass		***4***	**5**	**4**	**3**	**2**	**1**
Proportion of Smolts to Turbine Units	April	*0.995*	0.995	0.995	0.995	0.995	0.995
	May	*0.995*	0.995	0.995	0.995	0.995	0.995
	June	*0.994*	0.994	0.994	0.994	0.994	0.994
Total Number of Smolts To Turbine Units		*790*	945	696	497	298	99
Proportion of Smolts Passed via Francis		*0.600*	0.600	0.600	0.600	0.600	0.600
Proportion of Smolts Passed via Propeller		*0.400*	0.400	0.400	0.400	0.400	0.400
Number of Smolts Passed via Francis	Total	*474*	567	418	298	179	60
	April	*9*	10	8	5	3	1
	May	*365*	437	322	230	138	46
	June	*100*	120	89	63	38	13
Number of Smolts Passed via Propeller	Total	*316*	378	278	199	119	40
	April	*6*	7	5	4	2	1
	May	*243*	291	214	153	92	31
	June	*67*	80	59	42	25	8
Francis Turbine Survival Rate		*0.847*	0.847	0.847	0.847	0.847	0.847
Propeller Turbine Survival Rate		*0.943*	0.943	0.943	0.943	0.943	0.943

(continued)

Table 25. (Continued)

		Evaluated Spill Effectiveness Rates					
		1:1	**0.2:1**	**1.5:1**	**2.4:1**	**3.4:1**	**4.4:1**
		0.206	**0.05**	**0.3**	**0.5**	**0.7**	**0.9**
Number of Smolts Surviving Francis	April	*7*	9	6	5	3	1
	May	*309*	370	272	195	117	39
	June	*85*	102	75	54	32	11
Total Number of Smolts Surviving Francis		***401***	**480**	**354**	**253**	**152**	**51**
Number of Smolts Surviving Propeller	April	*5*	6	5	3	2	1
	May	*229*	274	202	144	87	29
	June	*63*	76	56	40	24	8
Total Number of Smolts Surviving Propeller		***298***	**356**	**263**	**188**	**113**	**38**
TOTAL SMOLT SURVIVAL		***902***	**890**	**909**	**924**	**940**	**955**
WHOLE STATION ESTIMATE		***90%***	**89%**	**91%**	**92%**	**94%**	**96%**

Italics indicates the base model constructed using median flow conditions in the Kennebec River

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 26. Impacts to the whole station smolt survival estimate obtained using the Delayed/Calculated Survival Rate Model (Model C) for theoretical seasonal flow conditions.

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.206*	0.658	0.478	0.005	0.000
Number of Smolts Passed via Spillway		*206*	658	478	5	0
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963
Total Number Smolts Surviving Spill		***198***	**633**	**461**	**4**	**0**
Proportion of Smolts to Forebay Canal		*0.794*	0.342	0.522	0.995	1.000
Total Number of Smolts to Powerhouse		*794*	342	522	995	1000
Number of Smolts to Forebay Canal by Month	April	*14*	6	9	18	18
	May	*612*	264	402	766	770
	June	*168*	73	111	211	212
Bypass Effectiveness Rate	April	*0.005*	0.005	0.005	0.005	0.005
	May	*0.005*	0.005	0.005	0.006	0.008
	June	*0.006*	0.005	0.005	0.008	0.012
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0
	May	*3*	1	2	5	6
	June	*1*	0	1	2	2
Total Number of Smolts Passed via Bypass		*4*	2	3	6	9
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0
	May	*3*	1	2	4	6
	June	*1*	0	1	2	2
Total Number of Smolts Surviving Bypass		***4***	**2**	**3**	**6**	**9**
Proportion of Smolts to Turbine Units	April	*0.995*	0.995	0.995	0.995	0.995
	May	*0.995*	0.995	0.995	0.994	0.992
	June	*0.994*	0.995	0.995	0.992	0.988
Total Number of Smolts To Turbine Units		*790*	341	519	989	991
Proportion of Smolts Passed via Francis		*0.600*	0.600	0.600	0.600	0.600
Proportion of Smolts Passed via Propeller		*0.400*	0.400	0.400	0.400	0.400
Number of Smolts Passed via Francis	Total	*474*	204	311	593	595
	April	*9*	4	6	11	11
	May	*365*	157	240	457	458
	June	*101*	43	66	126	126
Number of Smolts Passed via Propeller	Total	*316*	136	208	396	396
	April	*6*	2	4	7	7
	May	*243*	105	160	305	305
	June	*67*	29	44	84	84
Francis Turbine Survival Rate		*0.847*	0.847	0.847	0.847	0.847
Propeller Turbine Survival Rate		*0.943*	0.943	0.943	0.943	0.943
Number of Smolts Surviving Francis	April	*7*	3	5	9	9
	May	*309*	133	203	387	388
	June	*85*	37	56	107	107
Total Number of Smolts Surviving Francis		***402***	**173**	**264**	**503**	**504**

(continued)

Table 26. (Continued)

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Number of Smolts Surviving Propeller	April	*5*	2	4	7	7
	May	*230*	99	151	287	288
	June	*63*	27	42	79	79
Total Number of Smolts Surviving Propeller		***298***	**128**	**196**	**373**	**374**
TOTAL SMOLT SURVIVAL		***902***	**937**	**923**	**886**	**886**
WHOLE STATION ESTIMATE		***90%***	**94%**	**92%**	**89%**	**89%**

Italics indicates the base model constructed using median flow conditions in the Kennebec River

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 27. Initial Injury Rate Model (Model D) for whole station survival of Atlantic salmon smolts passing the Shawmut Project under median (50% occurrence) river conditions.

		BASE MODEL
Theoretical Number of Smolts		1,000
Proportion of Smolts to Spillway		0.206
Number of Smolts Passed via Spillway		206
Spillway/Bypass Survival Rate		0.816
Total Number Smolts Surviving Spill		**168**
Proportion of Smolts to Forebay Canal		0.794
Total Number of Smolts to Forebay Canal		794
Number of Smolts to Forebay Canal by Month	April	14
	May	611
	June	168
Bypass Effectiveness Rate	April	0.005
	May	0.005
	June	0.006
Number of Smolts Passed via Bypass	April	0
	May	3
	June	1
Total Number of Smolts Passed via Bypass		4
Number of Smolts Surviving Bypass	April	0
	May	3
	June	1
Total Number of Smolts Surviving Bypass		**4**
Proportion of Smolts to Turbine Units	April	0.995
	May	0.995
	June	0.994
Total Number of Smolts To Turbine Units		790
Proportion of Smolts Passed via Francis		0.600
Proportion of Smolts Passed via Propeller		0.400
Number of Smolts Passed via Francis	Total	474
	April	9
	May	365
	June	100
Number of Smolts Passed via Propeller	Total	316
	April	6
	May	243
	June	67
Francis Turbine Survival Rate		0.762
Propeller Turbine Survival Rate		0.925
Number of Smolts Surviving Francis	April	6
	May	278
	June	77
Total Number of Smolts Surviving Francis		**361**

(continued)

Table 27. (Continued)

		BASE MODEL
Number of Smolts Surviving Propeller	April	5
	May	225
	June	62
Total Number of Smolts Surviving Propeller		**292**
TOTAL SMOLT SURVIVAL		**825**
WHOLE STATION ESTIMATE		**82%**

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 28. Impacts to the whole station smolt survival estimate obtained using the Initial Injury Rate Model (Model D) for theoretical downstream bypass effectiveness rates.

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.206*	0.206	0.206	0.206	0.206	0.206
Number of Smolts Passed via Spillway		*206*	206	206	206	206	206
Spillway/Bypass Survival Rate		*0.816*	0.816	0.816	0.816	0.816	0.816
Total Number Smolts Surviving Spill		***168***	**168**	**168**	**168**	**168**	**168**
Proportion of Smolts to Forebay Canal		*0.794*	0.794	0.794	0.794	0.794	0.794
Total Number of Smolts to Forebay Canal		*794*	794	794	794	794	794
Number of Smolts to Forebay Canal by Month	April	*14*	14	14	14	14	14
	May	*611*	611	611	611	611	611
	June	*168*	168	168	168	168	168
Bypass Effectiveness Rate	April	*0.005*	0.250	0.450	0.650	0.850	1.000
	May	*0.005*	0.250	0.450	0.650	0.850	1.000
	June	*0.006*	0.250	0.450	0.650	0.850	1.000
Number of Smolts Passed via Bypass	April	*0*	4	6	9	12	14
	May	*3*	153	275	397	520	611
	June	*1*	42	76	109	143	168
Total Number of Smolts Passed via Bypass		*4*	199	357	516	675	794
Number of Smolts Surviving Bypass	April	*0*	3	5	8	10	12
	May	*3*	125	224	324	424	499
	June	*1*	34	62	89	117	137
Total Number of Smolts Surviving Bypass		***4***	**162**	**292**	**421**	**551**	**648**
Proportion of Smolts to Turbine Units	April	*0.995*	0.750	0.550	0.350	0.150	0.000
	May	*0.995*	0.750	0.550	0.350	0.150	0.000
	June	*0.994*	0.750	0.550	0.350	0.150	0.000
Total Number of Smolts To Turbine Units		*790*	596	437	278	119	0
Proportion of Smolts Passed via Francis		*0.600*	0.600	0.600	0.600	0.600	0.600
Proportion of Smolts Passed via Propeller		*0.400*	0.400	0.400	0.400	0.400	0.400
Number of Smolts Passed via Francis	Total	*474*	357	262	167	71	0
	April	*9*	6	5	3	1	0
	May	*365*	275	202	128	55	0
	June	*100*	76	56	35	15	0
Number of Smolts Passed via Propeller	Total	*316*	238	175	111	48	0
	April	*6*	4	3	2	1	0
	May	*243*	183	135	86	37	0
	June	*67*	50	37	24	10	0
Francis Turbine Survival Rate		*0.762*	0.762	0.762	0.762	0.762	0.762
Propeller Turbine Survival Rate		*0.925*	0.925	0.925	0.925	0.925	0.925
Number of Smolts Surviving Francis	April	*6*	5	4	2	1	0
	May	*278*	210	154	98	42	0
	June	*77*	58	42	27	12	0
Total Number of Smolts Surviving Francis		***361***	**272**	**200**	**127**	**54**	**0**

(continued)

Table 28. (Continued)

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Number of Smolts Surviving Propeller	April	*5*	4	3	2	1	0
	May	*225*	170	124	79	34	0
	June	*62*	47	34	22	9	0
Total Number of Smolts Surviving Propeller		***292***	**220**	**162**	**103**	**44**	**0**
TOTAL SMOLT SURVIVAL		***825***	**823**	**821**	**819**	**817**	**816**
WHOLE STATION ESTIMATE		***82%***	**82%**	**82%**	**82%**	**82%**	**82%**

Italics indicates the base model constructed using median flow conditions in the Kennebec River
Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 29. Impacts to the whole station smolt survival estimate obtained using the Initial Injury Rate Model (Model D) for theoretical spill effectiveness rates.

		Evaluated Spill Effectiveness Rates					
		1:1	**0.2:1**	**1.5:1**	**2.4:1**	**3.4:1**	**4.4:1**
		0.206	**0.05**	**0.3**	**0.5**	**0.7**	**0.9**
Proportion of River Flow to Spillway		*0.206*	0.206	0.206	0.206	0.206	0.206
Proportion of River Flow to Powerhouse		*0.794*	0.794	0.794	0.794	0.794	0.794
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.206*	0.05	0.3	0.5	0.7	0.9
Number of Smolts Passed via Spillway		*206*	50	300	500	700	900
Spillway/Bypass Survival Rate		*0.816*	0.816	0.816	0.816	0.816	0.816
Total Number Smolts Surviving Spill		***168***	**41**	**245**	**408**	**571**	**734**
Proportion of Smolts to Forebay Canal		*0.794*	0.95	0.7	0.5	0.3	0.1
Total Number of Smolts to Forebay Canal		*794*	950	700	500	300	100
Number of Smolts to Forebay Canal by Month	April	*14*	17	13	9	5	2
	May	*611*	732	539	385	231	77
	June	*168*	201	148	106	64	21
Bypass Effectiveness Rate	April	*0.005*	0.005	0.005	0.005	0.005	0.005
	May	*0.005*	0.005	0.005	0.005	0.005	0.005
	June	*0.006*	0.006	0.006	0.006	0.006	0.006
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0	0
	May	*3*	4	3	2	1	0
	June	*1*	1	1	1	0	0
Total Number of Smolts Passed via Bypass		*4*	5	4	3	2	1
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0	0
	May	*3*	3	2	2	1	0
	June	*1*	1	1	1	0	0
Total Number of Smolts Surviving Bypass		***4***	**4**	**3**	**2**	**1**	**0**
Proportion of Smolts to Turbine Units	April	*0.995*	0.995	0.995	0.995	0.995	0.995
	May	*0.995*	0.995	0.995	0.995	0.995	0.995
	June	*0.994*	0.994	0.994	0.994	0.994	0.994
Total Number of Smolts To Turbine Units		*790*	945	696	497	298	99
Proportion of Smolts Passed via Francis		*0.600*	0.600	0.600	0.600	0.600	0.600
Proportion of Smolts Passed via Propeller		*0.400*	0.400	0.400	0.400	0.400	0.400
Number of Smolts Passed via Francis	Total	*474*	567	418	298	179	60
	April	*9*	10	8	5	3	1
	May	*365*	437	322	230	138	46
	June	*100*	120	89	63	38	13
Number of Smolts Passed via Propeller	Total	*316*	378	278	199	119	40
	April	*6*	7	5	4	2	1
	May	*243*	291	214	153	92	31
	June	*67*	80	59	42	25	8
Francis Turbine Survival Rate		*0.762*	0.762	0.762	0.762	0.762	0.762
Propeller Turbine Survival Rate		*0.925*	0.925	0.925	0.925	0.925	0.925

(continued)

Table 29. (Continued)

		Evaluated Spill Effectiveness Rates					
		1:1	**0.2:1**	**1.5:1**	**2.4:1**	**3.4:1**	**4.4:1**
		0.206	**0.05**	**0.3**	**0.5**	**0.7**	**0.9**
Number of Smolts Surviving Francis	April	*6*	8	6	4	2	1
	May	*278*	333	245	175	105	35
	June	*77*	92	67	48	29	10
Total Number of Smolts Surviving Francis		***361***	**432**	**318**	**227**	**136**	**45**
Number of Smolts Surviving Propeller	April	*5*	6	5	3	2	1
	May	*225*	269	198	142	85	28
	June	*62*	74	55	39	23	8
Total Number of Smolts Surviving Propeller		***292***	**350**	**258**	**184**	**110**	**37**
TOTAL SMOLT SURVIVAL		***825***	**827**	**824**	**822**	**819**	**817**
WHOLE STATION ESTIMATE		***82%***	**83%**	**82%**	**82%**	**82%**	**82%**

Italics indicates the base model constructed using median flow conditions in the Kennebec River

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 30. Impacts to the whole station smolt survival estimate obtained using the Initial Injury Rate Model (Model D)for theoretical seasonal flow conditions.

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.206*	0.658	0.478	0.005	0.000
Number of Smolts Passed via Spillway		*206*	658	478	5	0
Spillway/Bypass Survival Rate		*0.816*	0.816	0.816	0.816	0.816
Total Number Smolts Surviving Spill		***168***	**537**	**390**	**4**	**0**
Proportion of Smolts to Forebay Canal		*0.794*	0.342	0.522	0.995	1.000
Total Number of Smolts to Forebay Canal		*794*	342	522	995	1000
Number of Smolts to Forebay Canal by Month	April	*14*	6	9	18	18
	May	*612*	264	402	766	770
	June	*168*	73	111	211	212
Bypass Effectiveness Rate	April	*0.005*	0.005	0.005	0.005	0.005
	May	*0.005*	0.005	0.005	0.006	0.008
	June	*0.006*	0.005	0.005	0.008	0.012
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0
	May	*3*	1	2	5	6
	June	*1*	0	1	2	2
Total Number of Smolts Passed via Bypass		*4*	2	3	6	9
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0
	May	*3*	1	2	4	5
	June	*1*	0	0	1	2
Total Number of Smolts Surviving Bypass		***4***	**1**	**2**	**5**	**7**
Proportion of Smolts to Turbine Units	April	*0.995*	0.995	0.995	0.995	0.995
	May	*0.995*	0.995	0.995	0.994	0.992
	June	*0.994*	0.995	0.995	0.992	0.988
Total Number of Smolts To Turbine Units		*790*	341	519	989	991
Proportion of Smolts Passed via Francis		*0.600*	0.600	0.600	0.600	0.600
Proportion of Smolts Passed via Propeller		*0.400*	0.400	0.400	0.400	0.400
Number of Smolts Passed via Francis	Total	*474*	204	311	593	595
	April	*9*	4	6	11	11
	May	*365*	157	240	457	458
	June	*101*	43	66	126	126
Number of Smolts Passed via Propeller	Total	*316*	136	208	396	396
	April	*6*	2	4	7	7
	May	*243*	105	160	305	305
	June	*67*	29	44	84	84
Francis Turbine Survival Rate		*0.762*	0.762	0.762	0.762	0.762
Propeller Turbine Survival Rate		*0.925*	0.925	0.925	0.925	0.925
Number of Smolts Surviving Francis	April	*7*	3	4	8	8
	May	*278*	120	183	348	349
	June	*77*	33	50	96	96
Total Number of Smolts Surviving Francis		***361***	**156**	**237**	**452**	**453**

(continued)

Table 30. (Continued)

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Number of Smolts Surviving Propeller	April	*5*	2	3	7	7
	May	*225*	97	148	282	282
	June	*62*	27	41	78	78
Total Number of Smolts Surviving Propeller		***292***	**126**	**192**	**366**	**367**
TOTAL SMOLT SURVIVAL		***825***	**820**	**822**	**827**	**827**
WHOLE STATION ESTIMATE		***82%***	**82%**	**82%**	**83%**	**83%**

Italics indicates the base model constructed using median flow conditions in the Kennebec River

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 31. Summary of upstream passage and associated biological data for adult Atlantic salmon at the Lockwood Project during 2006-2011.

Passage Year	# Individuals	Fork Length (cm)			Sea Age (yrs)	
		Min	Max	Mean	Min	Max
2006	15	50.0	79.0	65.0	1	2
2007[a]	15	53.0	87.0	70.2	1	3
2008	22	55.0	80.0	68.4	1	2
2009[b]	32	58.0	81.0	72.1	1	2
2010	5	50.0	76.0	67.1	1	2
2011	64	53.0	82.0	73.5	1	2

a - length and weight data includes one individual captured in Sebasticook River

b - length and weight data based on 28 individuals

Table 32. Estimated percentage of kelts entering the Shawmut project forebay canal or passing via spill.

Month	Discharge (cfs)			Percent of River Discharge		Kelt Run Distribution[4]	Project Kelt Distribution[5]	
	River Discharge[1]	Shawmut [2]	Calculated Spill [3]	Spill	Forebay Canal		Spill	Forebay Canal
April	13,000	6,700	6,300	48.5%	51.5%	40.0%	19.4%	20.6%
May	9,000	6,700	2,300	25.6%	74.4%	40.0%	10.2%	29.8%
October	4,500	4,500	0	0.0%	100.0%	5.0%	0.0%	5.0%
November	6,000	6,000	0	0.0%	100.0%	10.0%	0.0%	10.0%
December	5,750	5,750	0	0.0%	100.0%	5.0%	0.0%	5.0%
TOTAL	-	-	-	-	-	-	**29.6%**	**70.4%**

1 - Monthly median condition as obtained from Project flow duration curves (50% exceedence)

2 - Project capacity or inflow

3 - Equal to River discharge - Project capacity

4 - Mean monthly distribution of Atlantic salmon kelt migrations based on Baum (1997)

5 - Based on 1:1 assumption of spill effectiveness

Table 33. Predicted survival rates for salmon kelts passed through Propeller Units 7-8 at the Shawmut Project under peak turbine operating conditions.

Unit	Peak Efficiency (%)	Discharge (cfs) at Peak Efficiency	Correlation Factor	Fish Entry Point (ft)	Predicted Survival (%) by Kelt Length (in)						Unit Average
					16	20	24	27	30	Range	
7	0.74	1,312	0.1	blade tip	85.0	81.2	78.4	74.7	71.8	71.8 - 85.0	81.0
				mid-blade	94.1	92.7	91.6	90.1	89.0	89.0 - 94.1	
				near hub	94.6	93.3	92.3	90.9	89.9	89.9 - 94.6	
			0.2	blade tip	70.0	62.4	56.8	49.3	43.7	43.7 - 70.0	
				mid-blade	88.3	85.4	83.2	80.2	78.0	78.0 - 88.3	
				near hub	89.2	86.5	84.5	81.8	79.8	79.8 - 89.2	
8	75	1,347	0.1	blade tip	85.0	81.3	78.5	74.7	71.9	71.9 - 85.0	81.1
				mid-blade	94.2	92.8	91.7	90.3	89.2	89.2 - 94.2	
				near hub	94.7	93.4	92.4	91.1	90.1	90.1 - 94.7	
			0.2	blade tip	70.0	62.5	56.9	49.4	43.8	43.8 - 70.0	
				mid-blade	88.5	85.6	83.5	80.6	78.4	78.4 - 88.5	
				near hub	89.5	86.8	84.9	82.2	80.3	80.3 - 89.5	

Table 34. Model for whole station survival of Atlantic salmon kelts passing the Shawmut Project under median (50% occurrence) river conditions.

		BASE MODEL
Theoretical Number of Kelts		100
Proportion of Kelts to Spillway		0.296
Number of Kelts Passed via Spillway		30
Spillway/Bypass Survival Rate		0.963
Total Number Kelts Surviving Spill		**29**
Proportion of Kelts to Forebay Canal		0.704
Total Number of Kelts to Forebay Canal		70
Number of Kelts to Forebay Canal by Month	April	28
	May	28
	October	4
	November	7
	December	4
Bypass Effectiveness Rate	April	0.005
	May	0.005
	October	0.008
	November	0.006
	December	0.006
Number of Kelts Passed via Bypass	April	0
	May	0
	October	0
	November	0
	December	0
Total Number of Kelts Passed via Bypass		0
Number of Kelts Surviving Bypass	April	0
	May	0
	October	0
	November	0
	December	0
Total Number of Kelts Surviving Bypass		**0**
Proportion of Kelts to Turbine Units	April	0.995
	May	0.995
	October	0.992
	November	0.994
	December	0.994
Total Number of Kelts To Turbine Units		70
Proportion of Kelts Directed Toward Propeller		0.400
Total Number of Kelts Directed to Propeller Unit		28
Proportion of Kelts Through 3.5" Racks (Propeller)		0.709
Proportion of Kelts Screened at 3.5" Racks (Propeller) and to Spill		0.291
Number Kelts Through 3.5" Racks (Propeller)		20
Number Kelts Screened at 3.5" Racks (Propeller) and to Spill		8

(continued)

Table 34. (Continued)

		BASE MODEL
Number Kelts Through 3.5" Racks (Propeller)	April	8
	May	8
	October	1
	November	2
	December	1
Number Kelts Screened at 3.5" Racks (Propeller) and to Spill	April	3
	May	3
	October	0
	November	1
	December	0
Propeller Turbine Survival Rate		0.811
Number of Kelts Surviving Propeller	April	6
	May	6
	October	1
	November	2
	December	1
Total Number of Kelts Surviving Propeller		**16**
Number of Kelts Surviving Spill	April	3
	May	3
	October	0
	November	1
	December	0
Total Number of Kelts Surviving Bypass Spill		**8**
Proportion of Kelts Directed Toward Francis		0.600
Total Number of Kelts Directed to Francis Unit		42
Proportion of Kelts Through 1.5" Racks (Francis)		0.000
Proportion of Kelts Screened at 1.5" Racks (Francis)		1.000
Total Number of Kelts Passing via Francis Unit		0
Proportion of Kelts Directed Towards Propeller from Francis		1.000
Total Number of Kelts Directed Towards Propeller from Francis		42
Proportion of Kelts Screened at 1.5" Racks (Francis) but Through 3.5" Racks (Propeller)		0.709
Number of Kelts Screened at 1.5" Racks (Francis) then Through 3.5" Racks (Propeller)		30
Number of Kelts Screened at 1.5" Racks (Francis) and 3.5" Racks (Propeller) to Spill		12
Number of Kelts Screened at 1.5" Racks (Francis) then Through 3.5" Racks (Propeller)	April	12
	May	12
	October	1
	November	3
	December	1
Number of Kelts Screened at 1.5" Racks (Francis) and 3.5" Racks (Propeller) to Spill	April	5
	May	5
	October	1
	November	1
	December	1

(continued)

Table 34. (Continued)

		BASE MODEL
Number of Kelts Screened at 1.5" Racks (Francis) then Through 3.5" Racks Surviving Propeller	April	10
	May	10
	October	1
	November	2
	December	1
Total Number of Kelts Surviving Propeller		**24**
Number of Kelts Screened at 1.5" Racks (Francis) and 3.5" Racks (Propeller) and Surviving Spill	April	5
	May	5
	October	1
	November	1
	December	1
Total Number of Kelts Surviving Bypass Spill		**12**
TOTAL KELT SURVIVAL		**89**
WHOLE STATION ESTIMATE		**89%**

*Monthly kelt run distribution is presented in Table 32 of this report.

Table 35. Impacts to the whole station kelt survival estimate for theoretical downstream bypass effectiveness rates.

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Theoretical Number of Kelts		*100*	100	100	100	100	100
Proportion of Kelts to Spillway		*0.296*	0.296	0.296	0.296	0.296	0.296
Number of Kelts Passed via Spillway		*30*	30	30	30	30	30
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963	0.963
Total Number Kelts Surviving Spill		***29***	**29**	**29**	**29**	**29**	**29**
Proportion of Kelts to Forebay Canal		*0.704*	0.704	0.704	0.704	0.704	0.704
Total Number of Kelts to Forebay Canal		*70*	70	70	70	70	70
Number of Kelts to Forebay Canal by Month	April	*28*	28	28	28	28	28
	May	*28*	28	28	28	28	28
	October	*4*	4	4	4	4	4
	November	*7*	7	7	7	7	7
	December	*4*	4	4	4	4	4
Bypass Effectiveness Rate	April	*0.005*	0.250	0.450	0.650	0.850	1.000
	May	*0.005*	0.250	0.450	0.650	0.850	1.000
	October	*0.008*	0.250	0.450	0.650	0.850	1.000
	November	*0.006*	0.250	0.450	0.650	0.850	1.000
	December	*0.006*	0.250	0.450	0.650	0.850	1.000
Number of Kelts Passed via Bypass	April	*0*	7	13	18	24	28
	May	*0*	7	13	18	24	28
	October	*0*	1	2	2	3	4
	November	*0*	2	3	5	6	7
	December	*0*	1	2	2	3	4
Total Number of Kelts Passed via Bypass		*0*	18	32	46	60	70
Number of Kelts Surviving Bypass	April	*0*	7	12	18	23	27
	May	*0*	7	12	18	23	27
	October	*0*	1	2	2	3	3
	November	*0*	2	3	4	6	7
	December	*0*	1	2	2	3	3
Total Number of Kelts Surviving Bypass		***0***	**17**	**31**	**44**	**58**	**68**
Proportion of Kelts to Turbine Units	April	*0.995*	0.750	0.550	0.350	0.150	0.000
	May	*0.995*	0.750	0.550	0.350	0.150	0.000
	October	*0.992*	0.750	0.550	0.350	0.150	0.000
	November	*0.994*	0.750	0.550	0.350	0.150	0.000
	December	*0.994*	0.750	0.550	0.350	0.150	0.000
Total Number of Kelts To Turbine Units		*70*	53	39	25	11	0
Proportion of Kelts Directed Toward Propeller		*0.400*	0.400	0.400	0.400	0.400	0.400
Total Number of Kelts Directed to Propeller Unit		*28*	21	15	10	4	0
Proportion of Kelts Through 3.5" Racks (Propeller)		*0.709*	0.709	0.709	0.709	0.709	0.709
Proportion of Kelts Screened at 3.5" Racks (Propeller) and to Spill		*0.291*	0.291	0.291	0.291	0.291	0.291
Number Kelts Through 3.5" Racks (Propeller)		*20*	15	11	7	3	0
Number Kelts Screened at 3.5" Racks (Propeller) and to Spill		*8*	6	5	3	1	0

(continued)

Table 35. (Continued)

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Number Kelts Through 3.5" Racks (Propeller)	April	*8*	6	4	3	1	0
	May	*8*	6	4	3	1	0
	October	*1*	1	1	0	0	0
	November	*2*	1	1	1	0	0
	December	*1*	1	1	0	0	0
Number Kelts Screened at 3.5" Racks (Propeller) and to Spill	April	*3*	2	2	1	0	0
	May	*3*	2	2	1	0	0
	October	*0*	0	0	0	0	0
	November	*1*	1	0	0	0	0
	December	*0*	0	0	0	0	0
Propeller Turbine Survival Rate		*0.811*	0.811	0.811	0.811	0.811	0.811
Number of Kelts Surviving Propeller	April	*6*	5	4	2	1	0
	May	*6*	5	4	2	1	0
	October	*1*	1	0	0	0	0
	November	*2*	1	1	1	0	0
	December	*1*	1	0	0	0	0
Total Number of Kelts Surviving Propeller		***16***	**12**	**9**	**6**	**2**	**0**
Number of Kelts Surviving Spill	April	*3*	2	2	1	0	0
	May	*3*	2	2	1	0	0
	October	*0*	0	0	0	0	0
	November	*1*	1	0	0	0	0
	December	*0*	0	0	0	0	0
Total Number of Kelts Surviving Bypass Spill		***8***	**6**	**4**	**3**	**1**	**0**
Proportion of Kelts Directed Toward Francis		*0.600*	0.600	0.600	0.600	0.600	0.600
Total Number of Kelts Directed to Francis Unit		*42*	32	23	15	6	0
Proportion of Kelts Through 1.5" Racks (Francis)		*0.000*	0.000	0.000	0.000	0.000	0.000
Proportion of Kelts Screened at 1.5" Racks (Francis)		*1.000*	1.000	1.000	1.000	1.000	1.000
Total Number of Kelts Passing via Francis Unit		0	0	0	0	0	0
Proportion of Kelts Directed Towards Propeller from Francis		*1.000*	1.000	1.000	1.000	1.000	1.000
Total Number of Kelts Directed Towards Propeller from Francis		*42*	32	23	15	6	0
Proportion of Kelts Screened at 1.5" Racks (Francis) but Through 3.5" Racks (Propeller)		*0.709*	0.709	0.709	0.709	0.709	0.709
Number of Kelts Screened at 1.5" Racks (Francis) then Through 3.5" Racks (Propeller)		*30*	22	16	10	4	0
Number of Kelts Screened at 1.5" Racks (Francis) and 3.5" Racks (Propeller) to Spill		*12*	9	7	4	2	0
Number of Kelts Screened at 1.5" Racks (Francis) then Through 3.5" Racks (Propeller)	April	*12*	9	7	4	2	0
	May	*12*	9	7	4	2	0
	October	*1*	1	1	1	0	0
	November	*3*	2	2	1	0	0
	December	*1*	1	1	1	0	0

(continued)

Table 35. (Continued)

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Number of Kelts Screened at 1.5" Racks (Francis) and 3.5" Racks (Propeller) to Spill	April	*5*	4	3	2	1	0
	May	*5*	4	3	2	1	0
	October	*1*	0	0	0	0	0
	November	*1*	1	1	0	0	0
	December	*1*	0	0	0	0	0
Number of Kelts Screened at 1.5" Racks (Francis) then Through 3.5" Racks Surviving Propeller	April	*10*	7	5	3	1	0
	May	*10*	7	5	3	1	0
	October	*1*	1	1	0	0	0
	November	*2*	2	1	1	0	0
	December	*1*	1	1	0	0	0
Total Number of Kelts Surviving Propeller		***24***	**18**	**13**	**9**	**4**	**0**
Number of Kelts Screened at 1.5" Racks (Francis) and 3.5" Racks (Propeller) and Surviving Spill	April	*5*	4	3	2	1	0
	May	*5*	4	3	2	1	0
	October	*1*	0	0	0	0	0
	November	*1*	1	1	0	0	0
	December	*1*	0	0	0	0	0
Total Number of Kelts Surviving Bypass Spill		***12***	**9**	**7**	**4**	**2**	**0**
TOTAL KELT SURVIVAL		***89***	**91**	**92**	**94**	**95**	**96**
WHOLE STATION ESTIMATE		***89%***	**91%**	**92%**	**94%**	**95%**	**96%**

Italics indicates the base model constructed using median flow conditions in the Kennebec River

Shading indicates the variable assessed in this sensitivity analysis

*Monthly kelt run distribution is presented in Table 32 of this report.

Table 36. Impacts to the whole station kelt survival estimate for theoretical spill effectiveness rates.

		Evaluated Spill Effectiveness Rates					
		1:1	**0.2:1**	**0.3:1**	**1.7:1**	**2.4:1**	**3:1**
		0.296	**0.05**	**0.1**	**0.5**	**0.7**	**0.9**
Proportion of River Flow to Spillway		*0.296*	0.296	0.296	0.296	0.296	0.296
Proportion of River Flow to Powerhouse		*0.704*	0.704	0.704	0.704	0.704	0.704
Theoretical Number of Kelts		*100*	100	100	100	100	100
Proportion of Kelts to Spillway		*0.296*	0.05	0.1	0.5	0.7	0.9
Number of Kelts Passed via Spillway		*30*	5	10	50	70	90
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963	0.963
Total Number Kelts Surviving Spill		***29***	**5**	**10**	**48**	**67**	**87**
Proportion of Kelts to Forebay Canal		*0.704*	0.95	0.9	0.5	0.3	0.1
Total Number of Kelts to Forebay Canal		*70*	95	90	50	30	10
Number of Kelts to Forebay Canal by Month	April	*28*	28	28	28	28	28
	May	*28*	28	28	28	28	28
	October	*4*	4	4	4	4	4
	November	*7*	7	7	7	7	7
	December	*4*	4	4	4	4	4
Bypass Effectiveness Rate	April	*0.005*	0.005	0.005	0.005	0.005	0.005
	May	*0.005*	0.005	0.005	0.005	0.005	0.005
	October	*0.008*	0.008	0.008	0.008	0.008	0.008
	November	*0.006*	0.006	0.006	0.006	0.006	0.006
	December	*0.006*	0.006	0.006	0.006	0.006	0.006
Number of Kelts Passed via Bypass	April	*0*	0	0	0	0	0
	May	*0*	0	0	0	0	0
	October	*0*	0	0	0	0	0
	November	*0*	0	0	0	0	0
	December	*0*	0	0	0	0	0
Total Number of Kelts Passed via Bypass		*0*	0	0	0	0	0
Number of Kelts Surviving Bypass	April	*0*	0	0	0	0	0
	May	*0*	0	0	0	0	0
	October	*0*	0	0	0	0	0
	November	*0*	0	0	0	0	0
	December	*0*	0	0	0	0	0
Total Number of Kelts Surviving Bypass		***0***	**0**	**0**	**0**	**0**	**0**
Proportion of Kelts to Turbine Units	April	*0.995*	0.995	0.995	0.995	0.995	0.995
	May	*0.995*	0.995	0.995	0.995	0.995	0.995
	October	*0.992*	0.992	0.992	0.992	0.992	0.992
	November	*0.994*	0.994	0.994	0.994	0.994	0.994
	December	*0.994*	0.994	0.994	0.994	0.994	0.994
Total Number of Kelts To Turbine Units		*70*	95	90	50	30	10
Proportion of Kelts Directed Toward Propeller		*0.400*	0.400	0.400	0.400	0.400	0.400
Total Number of Kelts Directed to Propeller Unit		*28*	38	36	20	12	4
Proportion of Kelts Through 3.5" Racks (Propeller)		*0.709*	0.709	0.709	0.709	0.709	0.709
Proportion of Kelts Screened at 3.5" Racks (Propeller) and to Spill		*0.291*	0.291	0.291	0.291	0.291	0.291
Number Kelts Through 3.5" Racks (Propeller)		*20*	27	25	14	8	3

(continued)

Table 36. (Continued)

		Evaluated Spill Effectiveness Rates					
		1:1	**0.2:1**	**0.3:1**	**1.7:1**	**2.4:1**	**3:1**
		0.296	**0.05**	**0.1**	**0.5**	**0.7**	**0.9**
Number Kelts Screened at 3.5" Racks (Propeller) and to Spill		*8*	11	10	6	3	1
Number Kelts Through 3.5" Racks (Propeller)	April	*8*	11	10	6	3	1
	May	*8*	11	10	6	3	1
	October	*1*	1	1	1	0	0
	November	*2*	3	3	1	1	0
	December	*1*	1	1	1	0	0
Number Kelts Screened at 3.5" Racks (Propeller) and to Spill	April	*3*	4	4	2	1	0
	May	*3*	4	4	2	1	0
	October	*0*	1	1	0	0	0
	November	*1*	1	1	1	0	0
	December	*0*	1	1	0	0	0
Propeller Turbine Survival Rate		*0.811*	0.811	0.811	0.811	0.811	0.811
Number of Kelts Surviving Propeller	April	*6*	9	8	5	3	1
	May	*6*	9	8	5	3	1
	October	*1*	1	1	1	0	0
	November	*2*	2	2	1	1	0
	December	*1*	1	1	1	0	0
Total Number of Kelts Surviving Propeller		***16***	**22**	**21**	**11**	**7**	**2**
Number of Kelts Surviving Spill	April	*3*	4	4	2	1	0
	May	*3*	4	4	2	1	0
	October	*0*	1	1	0	0	0
	November	*1*	1	1	1	0	0
	December	*0*	1	1	0	0	0
Total Number of Kelts Surviving Bypass Spill		***8***	**11**	**10**	**6**	**3**	**1**
Proportion of Kelts Directed Toward Francis		*0.600*	0.600	0.600	0.600	0.600	0.600
Total Number of Kelts Directed to Francis Unit		*42*	57	54	30	18	6
Proportion of Kelts Through 1.5" Racks (Francis)		*0.000*	0.000	0.000	0.000	0.000	0.000
Proportion of Kelts Screened at 1.5" Racks (Francis)		*1.000*	1.000	1.000	1.000	1.000	1.000
Total Number of Kelts Passing via Francis Unit		0	0	0	0	0	0
Proportion of Kelts Directed Towards Propeller from Francis		*1.000*	1.000	1.000	1.000	1.000	1.000
Total Number of Kelts Directed Towards Propeller from Francis		*42*	57	54	30	18	6
Proportion of Kelts Screened at 1.5" Racks (Francis) but Through 3.5" Racks (Propeller)		*0.709*	0.709	0.709	0.709	0.709	0.709
Number of Kelts Screened at 1.5" Racks (Francis) then Through 3.5" Racks (Propeller)		*30*	40	38	21	13	4
Number of Kelts Screened at 1.5" Racks (Francis) and 3.5" Racks (Propeller) to Spill		*12*	17	16	9	5	2
Number of Kelts Screened at 1.5" Racks (Francis) then Through 3.5" Racks (Propeller)	April	*12*	16	15	8	5	2
	May	*12*	16	15	8	5	2
	October	*1*	2	2	1	1	0
	November	*3*	4	4	2	1	0
	December	*1*	2	2	1	1	0

(continued)

Table 36. (Continued)

		Evaluated Spill Effectiveness Rates					
		1:1	**0.2:1**	**0.3:1**	**1.7:1**	**2.4:1**	**3:1**
		0.296	**0.05**	**0.1**	**0.5**	**0.7**	**0.9**
Number of Kelts Screened at 1.5" Racks (Francis) and 3.5" Racks (Propeller) to Spill	April	*5*	7	6	3	2	1
	May	*5*	7	6	3	2	1
	October	*1*	1	1	0	0	0
	November	*1*	2	2	1	1	0
	December	*1*	1	1	0	0	0
Number of Kelts Screened at 1.5" Racks (Francis) then Through 3.5" Racks Surviving Propeller	April	*10*	13	12	7	4	1
	May	*10*	13	12	7	4	1
	October	*1*	2	2	1	1	0
	November	*2*	3	3	2	1	0
	December	*1*	2	2	1	1	0
Total Number of Kelts Surviving Propeller		***24***	**33**	**31**	**17**	**10**	**3**
Number of Kelts Screened at 1.5" Racks (Francis) and 3.5" Racks (Propeller) and Surviving Spill	April	*5*	6	6	3	2	1
	May	*5*	6	6	3	2	1
	October	*1*	1	1	0	0	0
	November	*1*	2	2	1	0	0
	December	*1*	1	1	0	0	0
Total Number of Kelts Surviving Bypass Spill		***12***	**16**	**15**	**8**	**5**	**2**
TOTAL KELT SURVIVAL		***89***	**86**	**87**	**91**	**93**	**95**
WHOLE STATION ESTIMATE		***89%***	**86%**	**87%**	**91%**	**93%**	**95%**

Italics indicates the base model constructed using median flow conditions in the Kennebec River

Shading indicates the variable assessed in this sensitivity analysis

*Monthly kelt run distribution is presented in Table 32 of this report.

Table 37. Approximate river discharge (cfs) for the Kennebec River at Shawmut during April, May, October, November, December for low (i.e. 75 and 90% exceedence) and high (10 and 25% exceedence) conditions.

Percent of Time Flow is Exceeded	River Discharge (cfs)				
	April	May	October	November	December
10	31,750	21,750	9,500	15,750	12,500
25	20,500	15,250	6,000	10,250	8,000
50	*13,000*	*9,000*	*4,500*	*6,000*	*5,750*
75	9,000	5,750	3,500	3,750	4,250
90	6,500	4,250	2,750	3,000	3,000

Italics indicates values used for 50% exceedence model

Table 38. Impacts to the whole station kelt survival estimate for seasonal flow conditions.

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Theoretical Number of Kelts		*100*	100	100	100	100
Proportion of Kelts to Spillway		*0.296*	0.688	0.536	0.102	0.000
Number of Kelts Passed via Spillway		*30*	69	54	10	0
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963
Total Number Kelts Surviving Spill		***29***	**66**	**52**	**10**	**0**
Proportion of Kelts to Forebay Canal		*0.704*	0.312	0.464	0.898	1.000
Total Number of Kelts to Forebay Canal		*70*	31	46	90	100
Number of Kelts to Forebay Canal by Month	April	*28*	28	28	28	28
	May	*28*	28	28	28	28
	October	*4*	4	4	4	4
	November	*7*	7	7	7	7
	December	*4*	4	4	4	4
Bypass Effectiveness Rate	April	*0.005*	0.005	0.005	0.005	0.005
	May	*0.005*	0.005	0.005	0.006	0.008
	October	*0.008*	0.005	0.006	0.010	0.013
	November	*0.006*	0.005	0.005	0.009	0.012
	December	*0.006*	0.005	0.005	0.008	0.012
Number of Kelts Passed via Bypass	April	*0*	0	0	0	0
	May	*0*	0	0	0	0
	October	*0*	0	0	0	0
	November	*0*	0	0	0	0
	December	*0*	0	0	0	0
Total Number of Kelts Passed via Bypass		*0*	0	0	0	1
Number of Kelts Surviving Bypass	April	*0*	0	0	0	0
	May	*0*	0	0	0	0
	October	*0*	0	0	0	0
	November	*0*	0	0	0	0
	December	*0*	0	0	0	0
Total Number of Kelts Surviving Bypass		***0***	**0**	**0**	**0**	**1**
Proportion of Kelts to Turbine Units	April	*0.995*	0.995	0.995	0.995	0.995
	May	*0.995*	0.995	0.995	0.994	0.992
	October	*0.992*	0.995	0.994	0.990	0.987
	November	*0.994*	0.995	0.995	0.991	0.988
	December	*0.994*	0.995	0.995	0.992	0.988
Total Number of Kelts To Turbine Units		*70*	31	46	89	99
Proportion of Kelts Directed Toward Propeller		*0.400*	0.400	0.400	0.400	0.400
Total Number of Kelts Directed to Propeller Unit		*28*	12	18	36	40
Proportion of Kelts Through 3.5" Racks (Propeller)		*0.709*	0.709	0.709	0.709	0.709
Proportion of Kelts Screened at 3.5" Racks (Propeller) and to Spill		*0.291*	0.291	0.291	0.291	0.291
Number Kelts Through 3.5" Racks (Propeller)		*20*	9	13	25	28
Number Kelts Screened at 3.5" Racks (Propeller) and to Spill		*8*	4	5	10	12

(continued)

Table 38. (Continued)

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Number Kelts Through 3.5" Racks (Propeller)	April	*8*	4	5	10	11
	May	*8*	4	5	10	11
	October	*1*	0	1	1	1
	November	*2*	1	1	3	3
	December	*1*	0	1	1	1
Number Kelts Screened at 3.5" Racks (Propeller) and to Spill	April	*3*	1	2	4	5
	May	*3*	1	2	4	5
	October	*0*	0	0	1	1
	November	*1*	0	1	1	1
	December	*0*	0	0	1	1
Propeller Turbine Survival Rate		*0.811*	0.811	0.811	0.811	0.811
Number of Kelts Surviving Propeller	April	*6*	3	4	8	9
	May	*6*	3	4	8	9
	October	*1*	0	1	1	1
	November	*2*	1	1	2	2
	December	*1*	0	1	1	1
Total Number of Kelts Surviving Propeller		***16***	**7**	**11**	**21**	**23**
Number of Kelts Surviving Spill	April	*3*	1	2	4	4
	May	*3*	1	2	4	4
	October	*0*	0	0	1	1
	November	*1*	0	1	1	1
	December	*0*	0	0	1	1
Total Number of Kelts Surviving Bypass Spill		***8***	**3**	**5**	**10**	**11**
Proportion of Kelts Directed Toward Francis		*0.600*	0.600	0.600	0.600	0.600
Total Number of Kelts Directed to Francis Unit		*42*	19	28	54	60
Proportion of Kelts Through 1.5" Racks (Francis)		*0.000*	0.000	0.000	0.000	0.000
Proportion of Kelts Screened at 1.5" Racks (Francis)		*1.000*	1.000	1.000	1.000	1.000
Total Number of Kelts Passing via Francis Unit		0	0	0	0	0
Proportion of Kelts Directed Towards Propeller from Francis		*1.000*	1.000	1.000	1.000	1.000
Total Number of Kelts Directed Towards Propeller from Francis		*42*	19	28	54	60
Proportion of Kelts Screened at 1.5" Racks (Francis) but Through 3.5" Racks (Propeller)		*0.709*	0.709	0.709	0.709	0.709
Number of Kelts Screened at 1.5" Racks (Francis) then Through 3.5" Racks (Propeller)		*30*	13	20	38	42
Number of Kelts Screened at 1.5" Racks (Francis) and 3.5" Racks (Propeller) to Spill		*12*	5	8	16	17
Number of Kelts Screened at 1.5" Racks (Francis) then Through 3.5" Racks (Propeller)	April	*12*	5	8	15	17
	May	*12*	5	8	15	17
	October	*1*	1	1	2	2
	November	*3*	1	2	4	4
	December	*1*	1	1	2	2
Number of Kelts Screened at 1.5" Racks (Francis) and 3.5" Racks (Propeller) to Spill	April	*5*	2	3	6	7
	May	*5*	2	3	6	7
	October	*1*	0	0	1	1
	November	*1*	1	1	2	2
	December	*1*	0	0	1	1

(continued)

Table 38. (Continued)

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Number of Kelts Screened at 1.5" Racks (Francis) then Through 3.5" Racks Surviving Propeller	April	*10*	4	6	12	14
	May	*10*	4	6	12	14
	October	*1*	1	1	2	2
	November	*2*	1	2	3	3
	December	*1*	1	1	2	2
Total Number of Kelts Surviving Propeller		***24***	**11**	**16**	**31**	**34**
Number of Kelts Screened at 1.5" Racks (Francis) and 3.5" Racks (Propeller) and Surviving Spill	April	*5*	2	3	6	7
	May	*5*	2	3	6	7
	October	*1*	0	0	1	1
	November	*1*	1	1	2	2
	December	*1*	0	0	1	1
Total Number of Kelts Surviving Bypass Spill		***12***	**5**	**8**	**15**	**17**
TOTAL KELT SURVIVAL		***89***	**93**	**91**	**87**	**86**
WHOLE STATION ESTIMATE		***89%***	**93%**	**91%**	**87%**	**86%**

Italics indicates the base model constructed using median flow conditions in the Kennebec River

Shading indicates the variable assessed in this sensitivity analysis

*Monthly kelt run distribution is presented in Table 32 of this report.

Table 39. Impacts to the whole station kelt survival estimate for behavioral route selection rates.

		Evaluated Behavioral Route Selection Rates						
		1.00	**0.00**	**0.10**	**0.30**	**0.50**	**0.70**	**0.90**
Theoretical Number of Kelts		*100*	100	100	100	100	100	100
Proportion of Kelts to Spillway		*0.296*	0.296	0.296	0.296	0.296	0.296	0.296
Number of Kelts Passed via Spillway		*30*	30	30	30	30	30	30
Spillway/Bypass Survival Rate		*0.96*	0.963	0.963	0.963	0.963	0.963	0.963
Total Number Kelts Surviving Spill		***29***	**29**	**29**	**29**	**29**	**29**	**29**
Proportion of Kelts to Forebay Canal		*0.704*	0.704	0.704	0.704	0.704	0.704	0.704
Total Number of Kelts to Forebay Canal		*70*	70	70	70	70	70	70
Number of Kelts to Forebay Canal by Month	April	*28*	28	28	28	28	28	28
	May	*28*	28	28	28	28	28	28
	October	*4*	4	4	4	4	4	4
	November	*7*	7	7	7	7	7	7
	December	*4*	4	4	4	4	4	4
Bypass Effectiveness Rate	April	*0.005*	0.005	0.005	0.005	0.005	0.005	0.005
	May	*0.005*	0.005	0.005	0.005	0.005	0.005	0.005
	October	*0.008*	0.008	0.008	0.008	0.008	0.008	0.008
	November	*0.006*	0.006	0.006	0.006	0.006	0.006	0.006
	December	*0.006*	0.006	0.006	0.006	0.006	0.006	0.006
Number of Kelts Passed via Bypass	April	*0*	0	0	0	0	0	0
	May	*0*	0	0	0	0	0	0
	October	*0*	0	0	0	0	0	0
	November	*0*	0	0	0	0	0	0
	December	*0*	0	0	0	0	0	0
Total Number of Kelts Passed via Bypass		*0*	0	0	0	0	0	0
Number of Kelts Surviving Bypass	April	*0*	0	0	0	0	0	0
	May	*0*	0	0	0	0	0	0
	October	*0*	0	0	0	0	0	0
	November	*0*	0	0	0	0	0	0
	December	*0*	0	0	0	0	0	0
Total Number of Kelts Surviving Bypass		***0***	**0**	**0**	**0**	**0**	**0**	**0**
Proportion of Kelts to Turbine Units	April	*0.995*	0.995	0.995	0.995	0.995	0.995	0.995
	May	*0.995*	0.995	0.995	0.995	0.995	0.995	0.995
	October	*0.992*	0.992	0.992	0.992	0.992	0.992	0.992
	November	*0.994*	0.994	0.994	0.994	0.994	0.994	0.994
	December	*0.994*	0.994	0.994	0.994	0.994	0.994	0.994
Total Number of Kelts To Turbine Units		*70*	70	70	70	70	70	70

(Continued)

Table 39. (Continued)

		Evaluated Behavioral Route Selection Rates						
		1.00	**0.00**	**0.10**	**0.30**	**0.50**	**0.70**	**0.90**
Proportion of Kelts Directed Toward Propeller		*0.400*	0.400	0.400	0.400	0.400	0.400	0.400
Total Number of Kelts Directed to Propeller Unit		*28*	28	28	28	28	28	28
Proportion of Kelts Through 3.5" Racks (Propeller)		*0.709*	0.709	0.709	0.709	0.709	0.709	0.709
Proportion of Kelts Screened at 3.5" Racks (Propeller) and to Spill		*0.291*	0.291	0.291	0.291	0.291	0.291	0.291
Number Kelts Through 3.5" Racks (Propeller)		*20*	20	20	20	20	20	20
Number Kelts Screened at 3.5" Racks (Propeller) and to Spill		*8*	8	8	8	8	8	8
Number Kelts Through 3.5" Racks (Propeller)	April	*8*	8	8	8	8	8	8
	May	*8*	8	8	8	8	8	8
	October	*1*	1	1	1	1	1	1
	November	*2*	2	2	2	2	2	2
	December	*1*	1	1	1	1	1	1
Number Kelts Screened at 3.5" Racks (Propeller) and to Spill	April	*3*	3	3	3	3	3	3
	May	*3*	3	3	3	3	3	3
	October	*0*	0	0	0	0	0	0
	November	*1*	1	1	1	1	1	1
	December	*0*	0	0	0	0	0	0
Propeller Turbine Survival Rate		*0.81*	0.811	0.811	0.811	0.811	0.811	0.811
Number of Kelts Surviving Propeller	April	*6*	6	6	6	6	6	6
	May	*6*	6	6	6	6	6	6
	October	*1*	1	1	1	1	1	1
	November	*2*	2	2	2	2	2	2
	December	*1*	1	1	1	1	1	1
Total Number of Kelts Surviving Propeller		***16***	**16**	**16**	**16**	**16**	**16**	**16**
Number of Kelts Surviving Spill	April	*3*	3	3	3	3	3	3
	May	*3*	3	3	3	3	3	3
	October	*0*	0	0	0	0	0	0
	November	*1*	1	1	1	1	1	1
	December	*0*	0	0	0	0	0	0
Total Number of Kelts Surviving Bypass Spill		***8***	**8**	**8**	**8**	**8**	**8**	**8**
Proportion of Kelts Directed Toward Francis		*0.600*	0.600	0.600	0.600	0.600	0.600	0.600
Total Number of Kelts Directed to Francis Unit		*42*	42	42	42	42	42	42
Proportion of Kelts Through 1.5" Racks (Francis)		*0.000*	0.000	0.000	0.000	0.000	0.000	0.000
Proportion of Kelts Screened at 1.5" Racks (Francis)		*1.000*	1.000	1.000	1.000	1.000	1.000	1.000
Total Number of Kelts Passing via Francis Unit		*0*	0	0	0	0	0	0
Proportion of Kelts Directed Towards Propeller from Francis		*1.000*	0.00	0.10	0.30	0.50	0.70	0.90
Total Number of Kelts Directed Towards Propeller from Francis		*42*	0	4	13	21	29	38
Proportion of Kelts Screened at 1.5" Racks (Francis) but Through 3.5" Racks (Propeller)		*0.709*	0.709	0.709	0.709	0.709	0.709	0.709
Number of Kelts Screened at 1.5" Racks (Francis) then Through 3.5" Racks (Propeller)		*30*	0	3	9	15	21	27
Number of Kelts Screened at 1.5" Racks (Francis) and 3.5" Racks (Propeller) to Spill		*12*	42	39	33	27	21	15

(Continued)

Table 39. (Continued)

		Evaluated Behavioral Route Selection Rates						
		1.00	**0.00**	**0.10**	**0.30**	**0.50**	**0.70**	**0.90**
Number of Kelts Screened at 1.5" Racks (Francis) then Through 3.5" Racks (Propeller)	April	*12*	0	1	4	6	8	11
	May	*12*	0	1	4	6	8	11
	October	*1*	0	0	0	1	1	1
	November	*3*	0	0	1	1	2	3
	December	*1*	0	0	0	1	1	1
Number of Kelts Screened at 1.5" Racks (Francis) and 3.5" Racks (Propeller) to Spill	April	*5*	17	16	13	11	8	6
	May	*5*	17	16	13	11	8	6
	October	*1*	2	2	2	1	1	1
	November	*1*	4	4	3	3	2	2
	December	*1*	2	2	2	1	1	1
Number of Kelts Screened at 1.5" Racks (Francis) then Through 3.5" Racks Surviving Propeller	April	*10*	0	1	3	5	7	9
	May	*10*	0	1	3	5	7	9
	October	*1*	0	0	0	1	1	1
	November	*2*	0	0	1	1	2	2
	December	*1*	0	0	0	1	1	1
Total Number of Kelts Surviving Propeller		***24***	**0**	**2**	**7**	**12**	**17**	**22**
Number of Kelts Screened at 1.5" Racks (Francis) and 3.5" Racks (Propeller) and Surviving Spill	April	*5*	16	15	13	10	8	6
	May	*5*	16	15	13	10	8	6
	October	*1*	2	2	2	1	1	1
	November	*1*	4	4	3	3	2	1
	December	*1*	2	2	2	1	1	1
Total Number of Kelts Surviving Bypass Spill		***12***	**40**	**38**	**32**	**26**	**20**	**15**
TOTAL KELT SURVIVAL		***89***	**93**	**93**	**92**	**91**	**90**	**89**
WHOLE STATION ESTIMATE		***89%***	**93%**	**93%**	**92%**	**91%**	**90%**	**89%**

Italics indicates the base model constructed using median flow conditions in the Kennebec River

Shading indicates the variable assessed in this sensitivity analysis

*Monthly kelt run distribution is presented in Table 32 of this report.

APPENDIX A

Appendix Table A-1. Site characteristics and study parameters for turbine survival studies conducted using the Hi-Z Turb'N Tag method.

Site Name	Species Tested	Sampling Method	Unit Type	Normal head (ft)	RPM	Wicket Gate (%)	Unit Flow (cfs)	No. of Blades or Buckets	Runner Diameter (ft)	Water Temp. (°C)	Test Season or Month	Test Fish Size (mm)			Control Fish Size (mm)			No. of Fish Released		Immediate Survival (1-hr)	24-hr Survival	48-hr Survival	72-hr Survival	Reference
												Min	Max	Avg	Min	Max	Avg	T	C					
West Buxton, ME	Atlantic salmon	Hi-Z Turb'N Tag	Francis	26.8	150	100	611	16	4.0	15.0	May	192	250	217	192	226	210	73	20	85.0	85.0	-	-	Normandeau 1999
Vernon, VT	Atlantic salmon	Hi-Z Turb'N Tag	Francis	34	133.3	75	1,280	14	5.2	-	May	123	194	-	110	208	-	25	80	85.1	-	85.1	-	Normandeau 1996
Vernon, VT [1]	Atlantic salmon	Hi-Z Turb'N Tag	Francis	34	74	75 & 100	1,350 & 1,800	15	13.0	-	May	120	214	-	110	208	-	105	80	95.9 & 100.0	-	94.9 & 100.0	-	Normandeau 1996
Briar Rolfe, NH	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	35	150	73.3-76.3	-	5	9.84	13.0	May	174	228	192.7	180	219	194.1	70	30	95.7	-	95.7	-	Normandeau 2004
Bar Mills, ME [1]	Atlantic salmon	Hi-Z Turb'N Tag	Propeller	19.5	120	50 & 100	960 & 1,560	5	11.2	14-16.5	May	177	238	204	175	238	205	100	50	88.0 & 94.0	-	-	88.0 & 88.0	Normandeau 2002
Lairg, Scotland	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	-	167	-	-	4	8.5	7.0-8.5	April	90	136	111.4	96	147	112.8	100	75	91.0	-	91.0	-	Normandeau and Fishtrack 1998
Cliff, Ireland	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	32.8	115.3	-	-	5	14.1	-	April	121	155	136	108	150	132	78	50	92.3	-	92.2	-	Normandeau and Fishtrack 2002
Cathleens Falls, Ireland	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	93.5	187.5	-	-	5	12.6	-	April	122	150	136	121	152	136	75	50	89.3	-	88.0	-	Normandeau and Fishtrack 2002
Ardnacrusha, Ireland [1]	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	93	167	-	-	5	16.4	9.5-10.1	April	148	214	181	161	225	189	190	60	96.3 & 95.2	-	96.3 & 87.5	-	Normandeau and Fishtrack 2004
Wilder, VT-NH	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	51	112.5	74-84	-	5	9.0	8.5-10.0	May	163	218	187.9	162	220	186.3	125	125	96.0	-	94.3	-	Normandeau 1994
Vernon, VT [1]	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	34	144	-	1,250 & 1,600	5	10.2	-	May	152	305	223	183	322	224	273	107	94.7 & 98.5	-	92.3 & 89.3	-	Normandeau 2009
West Buxton, ME [1]	Atlantic salmon	Hi-Z Turb'N Tag	Propeller	26.8	120	55 & 80	1,360 & 1,800	6	11.1	15.0	May	190	244	214	192	226	210	40	20	100.0 & 94.0	100.0 & 94.0	-	-	Normandeau 1999
McIndoes, NH [1]	Atlantic salmon	Hi-Z Turb'N Tag	Propeller	26	150	-	800 & 1,600	4	10.0	-	May	133	248	207	141	245	203	310	100	100.0 & 96.1	-	100.0 & 94.8	-	Normandeau 2006

1 - Tested two different settings

APPENDIX B

Shawmut Hydroelectric Project FERC No. 2322-ME - Flow Duration Curves

Prepared by Don Dow, PE, National Marine Fisheries Service, Orono Maine

The flow duration curve is based upon 32 years (1979-2010) of daily stream flow. In order to understand how the flow from various USGS gages was prorated to the site, it is important to understand the locations of the gages and their drainage areas.

The Sebasticook River flows into the Kennebec River downstream of the Shawmut Project. The entire Sebasticook River has a drainage area of 946 mi^2. There is a gage on the Sebasticook River which is USGS Gage No. 01049000 Sebasticook River near Pittsfield, Maine that has a drainage area of 572 mi^2. For the periods of January 1, 1979 to September 30, 1993 and October 1, 2000 to present, USGS Gage No. 01049265 Kennebec River at North Sidney, Maine was operating. This gage is located some distance downstream of the confluence of the Sebasticook and Kennebec Rivers and has a drainage area of 5,403 mi^2. For the period of October 1, 1993 to September 30, 2000, USGS Gage No. 01049205 Kennebec River near Waterville, ME was in operation. This gage is located just downstream of the confluence of the Sebasticook and Kennebec Rivers and has a drainage area of 5,179 mi^2. The drainage area of the Kennebec just above the confluence with the Sebasticook River is 5,179 mi^2 less 946 mi^2 which is 4,233 mi^2. The drainage area at the project which is upstream of the confluence with the Sebasticook is 4,200 mi^2.

Therefore, for the period where the North Sydney gage was in operation, the flow at the site was prorated from the following formula:

$$QShawmut = (Qns \text{ x } (5{,}179\ mi^2 / 5{,}403\ mi^2)^{0.85} - Qseb \text{ x } (946\ mi^2/572\ mi^2)^{0.85}) \text{ x } (4200\ mi^2/4{,}233\ mi^2)^{0.85}$$

Where:

QShawmut = Average Daily Flow at the Project
Qns= Average Daily Flow at the North Sydney Gage
Qseb= Average Daily Flow at the Sebasticook Gage

For the period where the Waterville gage was in operation, the flow at the site was prorated from the following formula:

$$QShawmut = (Qwat - Qseb \text{ x } (946\ mi^2/572\ mi^2)^{0.85}) \text{ x } (4200\ mi^2/4{,}233\ mi^2)^{0.85}$$

Where:

Qwat = Average Daily Flow at the Waterville Gage

A REVIEW OF EFFECTS OF THE WESTON PROJECT ON THE KENNEBEC RIVER, MAINE ON ATLANTIC SALMON (SALMO SALAR) SMOLT AND KELT DOWNSTREAM PASSAGE AND ADULT UPSTREAM PASSAGE

January 20, 2012

A Review of Effects of the Weston Project on the Kennebec River, Maine on Atlantic Salmon (*Salmo salar*) Smolts and Kelt Downstream Passage and Adult Upstream Passage

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January 20, 2012

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1.0 Introduction

In 2009, the Gulf of Maine population of Atlantic salmon was listed as an endangered species under the Endangered Species Act (ESA). The Weston Project located on the Kennebec River is within the designated critical habitat for the species. Consequently, continued operation of the hydropower project will require the Licensee (FPL Energy Maine Hydro LLC (FPLE)) to prepare a habitat conservation plan (HCP) and secure an incidental take permit (ITP). In order to issue an ITP, the HCP must outline measures to be undertaken by the Licensee to avoid, minimize and mitigate Project impacts, so as to assure that there is “no jeopardy" to the species as a result of continued operation of the Project. A first step in considering appropriate performance standards and measures to be included in the HCP is a common understanding of the affect of the Project on Atlantic salmon and its habitat. The purpose of this white paper is to evaluate current Project effects and examine whole station survival on downstream migrating Atlantic salmon smolts and kelts. The whole station survival of downstream migrating Atlantic salmon smolts was modeled based on available environmental, biological and physical data related to or similar to the Weston Project. The construction and output of that modeling process are discussed in Sections 3, 4 and 5 of this paper. Additionally, the whole station survival of downstream migrating Atlantic salmon kelts was also modeled based on available environmental, biological and physical data related to or similar to the Weston Project. The construction and output of that modeling process are discussed in Sections 6 and 7 of this report. Additional considerations such as predation are discussed in Section 8.

This white paper has been revised from the original draft (provided during April, 2011) based on comments received from agencies and other members of the HCP Technical Advisory Committee (TAC). A summary of comments and a description of how comments were addressed in both the August, 2011 and this version (December 2011) of the white paper is provided in Appendix C of the Lockwood white paper.

2.0 Background

2.1 Project Facilities and Operation

The Weston Project, owned by FPL Energy Maine Hydro LLC, is located at river mile 83.5 (approximately 38 miles above head-of-tide in Augusta) in the Town of Skowhegan and is the fourth dam on the mainstem of the Kennebec River. The Weston Project includes a 930-acre impoundment, two dams, and one powerhouse. The normal full pond elevation is 156.0 ft mean sea level (msl). The Project impoundment extends 12.5 miles upstream. The two dams are constructed on the north and south channels of the Kennebec River where the river is divided by Weston Island (Figure 1).

The North Channel dam is a concrete gravity and buttress dam approximately 38 feet high having a crest elevation of 156.0 ft. The dam extends about 529.5 ft from the north bank of the Kennebec River to Weston Island, forming a broad V-shaped structure following the high ledge of a natural falls, and consists of four sections: a 22.5 ft long concrete non-overflow section, a 244 ft long stanchion section, a 160.5 ft long pneumatic gate section, and a 93 ft long gated section (located next to the island). The concrete non-overflow section of the dam has a top elevation of 167.0 ft and extends from the north retaining wall that functions as the north abutment for the North Channel dam. The stanchion section has five 10.5 ft high stanchion bays set on sills at elevation 145.5 ft separated by 3 and 4 ft wide concrete piers. The pneumatic gates are in two sections with lengths of about 81.7 ft and 78.8 ft. The section has a permanent crest at elevation 149.0 ft and 7.5 ft high steel panels, which allow for a 6 in freeboard. The gated section of the North Channel dam includes a concrete pier and two steel Taintor gates, each 28 ft wide by 16 ft high, with sills at elevation 140.0 ft. A concrete retaining wall and earth fill with a concrete core wall comprise the southern abutment of the North Channel dam.

The South Channel dam is a concrete gravity and buttress dam 51 ft high having a crest elevation of 156.0 ft. The dam extends about 391.5 ft between abutment walls from the island to the south riverbank and consists of five sections: a 125 ft long powerhouse/intake section, a 33 ft long concrete spillway section, a 18 ft long sluice section, a 188 ft long stanchion section, and a 21.5 ft long concrete non-overflow section. The northern abutment of the south dam consists of a 3 ft wide concrete retaining wall that extends upstream and forms the forebay wall.

The powerhouse/intake section of the dam, located adjacent to the north abutment and integral to the project dam, includes the headworks and four intake bays that lead to the turbines. Each bay houses three reinforced concrete gates that control flow to the individual turbines. The gates are operated by a track-mounted hoist that travels the length of the intake from a concrete deck at elevation 166.0 ft. The 4.0 inch clear spacing trashracks, which are situated in front of the gate slots, are cleaned using a motor-operated trash rake from a concrete deck at elevation 159.0 ft. The 1920 concrete and steel powerhouse contains four vertical Francis units having a total installed capacity of 14.2 MW and combined flow of approximately 6,000 cfs . The concrete spillway section has a permanent crest elevation of 154.0 ft and is topped by 2 ft high stoplogs.

The existing surface sluice gate and flume (formerly for logs) has a permanent top elevation of 142.0 ft. This gate is located adjacent to Unit 4 and is 18 ft wide by 14 ft high and can pass flows up to 2,250 cfs. This gate discharges to a newly resurfaced concrete flume which extends 69.5 ft downstream to the tailrace. Downstream anadromous fish passage (presently in shakedown and upcoming spring 2012 study phase) is provided via a recently installed 300 ft long by 10 ft deep floating guidance boom leading to the existing sluice gate and concrete flume.

The stanchion section has five stanchion bays, with four bays set on sills at elevation 143.0 ft and one bay set at sill elevation 145.0 ft. The concrete gravity non-overflow section abuts a concrete retaining wall (south abutment) that extends upstream to the U.S. Route 2 bridge. The non-overflow section has a top elevation of 166.0 ft msl. The project's tailrace is excavated riverbed located between the north and south river channels. The normal tailwater elevation of the station is 122.5 ft msl.

The Licensee operates the project in a run-of-river mode to maintain the impoundment water surface elevation within one foot of the normal full pond elevation of 156.0 ft msl, during normal operations. A minimum flow requirement in the existing license requires the project provide an instantaneous minimum flow of 1,947 cfs or inflow, whichever is less, as measured in the project tailrace immediately downstream of Weston dam.

2.2 Target Species: Atlantic salmon

Numerous reviews detailing the life history of Atlantic salmon exist (NRC 2004, Fay et al. 2006, NMFS 2009) and their life cycle is summarized here. Adult Atlantic salmon begin to return to freshwater rivers during the spring. Redds are constructed and fertilized eggs are buried during the late fall. Following the fall spawn, approximately 20% of spent adult salmon (kelts) move back downstream but the majority move back downstream and into the ocean the following spring (Baum 1997). Eggs remain in the gravel until hatching during the early spring. Following a three to six week period, the young salmon emerge from the gravel as fry and begin to actively seek food. As fry begin to feed they develop cryptic vertical stripes and are then known as parr. Atlantic salmon remain in the parr stage for one to three years and remain resident to freshwater during that period. Following that period, each parr undergoes a series of physiological and morphological changes known as smoltification. It is at that time that these fish move downstream through the freshwater river system and into the ocean. This downstream migration takes place during the spring season (April-June) with the majority of Maine smolts entering the ocean during May (NFMS 2009). A review of downstream migration timing data from the Penobscot and Narraguagus Rivers indicates that approximately 2% of smolts depart during April, 77% during May and 21% during June (GNP 1997, USUSUC 2005). Those individuals remain in the ocean for a period of 1-2 years prior to returning as adults and continuing the cycle.

2.3 Fish Passage Operations at the Weston Project

Downstream smolt and kelt passage at Weston currently occurs via unregulated spillage and via a recently installed 300 ft long by 10 ft deep floating guidance boom leading to the existing sluice gate and associated concrete flume. The sluice gate structure is 18 ft wide by 14 ft high, is located next to Unit 4 and can pass flows up to 2,250 cfs. During the spring smolt migration season (April 1 – June 15) and the fall kelt migration season (Oct 15-Dec 15) the sluice is currently opened 1.5 feet. A salmon smolt effectiveness study for the guidance boom and sluice gate is scheduled for the spring of 2012 with a goal of assessing boom guidance effectiveness and identifying an appropriate gate flow. Upstream passage is provided by the trap, lift and transport system located downstream at the Lockwood Project.

Within the Kennebec River, returning adult salmon are collected at the Lockwood fish lift are trucked upstream around the Lockwood, Hydro Kennebec (owned and operated by Brookfield), Shawmut, and Weston Projects and released into the Sandy River. It is assumed that these fish spawn in the Sandy River (approximately 12 river miles upstream from Weston, 25.5 miles upstream from Shawmut and 32.5 miles upstream from Lockwood). Radio-tagged sea run Atlantic salmon transported to the Sandy River during 2007 and 2008 showed a high degree of fidelity to that river with 89% (8 of 9) of tagged fish remaining in the Sandy River through the fall spawning season during both 2007 and 2008 (MDMR 2008, MDMR 2009). The Sandy River has the greatest biological value for both spawning and rearing habitat within the occupied range of the Merrymeeting Bay Salmon Habitat Recovery Unit (NMFS 2009). Given the combination of geographical distance between quality habitat in the Sandy River and the downstream projects and territorial nature of both the fry and parr life stages to that quality rearing habitat (Danie et al. 1984) it is unlikely that either life stage would be significantly impacted by passage through the Weston hydroelectric project. The focus of this assessment is the potential Project impacts to downstream migrating Atlantic salmon smolts (Sections 3, 4, and 5) as well as an initial consideration to the impact on kelts (Sections 6.0 and 7.0).

3.0 Methods: Downstream Migrating Smolt Survival

Outmigrating Atlantic salmon smolts encountering the Weston Project must either pass downstream via the Project spillways or through the powerhouse. Currently, smolts passing downstream through the powerhouse are able to pass via either an interim downstream bypass (existing sluice gate adjacent to Unit 4) or one of the four Project turbines. Those three potential routes of passage were considered and incorporated into the model of whole station survival at the Weston Project (Figure 2). Information from the primary literature, reports and literature reviews on fish passage through turbines and non-turbine exit routes was assembled for examination and analysis for application to the Weston Project. Necessary components for assessing the impact of safe fish passage at the Weston Project included: smolt run timing, prevailing river flows, proportion diverted to Project spillways and the associated survival rate, proportion passed downstream via the interim downstream bypass and the associated survival, and the proportion transported through the four Francis turbines and the associated survival. Francis turbines contain a runner which has water passages through it formed by curved vanes.

3.1 Smolt Downstream Bypass Efficiency

There is no site-specific data for the effectiveness rate of the interim downstream bypass located adjacent to Unit 4 at the Weston Project for downstream passage of smolts. For the purposes of estimating the downstream bypass efficiency component of whole station survival, smolts passing through the powerhouse and associated interim downstream bypass were partitioned by assuming an equal distribution to that of outflow.

The Licensee has installed a downstream fishway and associated guidance device during 2011. This utilizes the existing sluice adjacent to Unit 4 in conjunction with a 10-ft deep guidance boom to direct outmigrating salmon smolts past the turbines. Estimated impacts of the downstream bypass to the whole station survival estimate for the Weston Project are evaluated in Section 5.1 of this report.

3.2 Spillway and Downstream Bypass Passage Smolt Survival Assessment

Due to the lack of site-specific field-test information, estimates for passage survival of Atlantic salmon smolts through the Weston spillway and downstream bypass were developed based on existing empirical studies conducted at other hydroelectric projects with similar characteristics. The principal causes of injury and mortality for fish passed through either a spillway or bypass sluice are shear forces, turbulence, rapid deceleration, terminal velocity, impact against the base of the spillway, scraping against the rough concrete face of the spillway and rapid pressure changes (Heisey et al. 1996). Empirical studies related to spillway and bypass survival were pooled into a single data set. Existing studies described in the peer-reviewed primary literature and gray literature reports were pulled together and reviewed for potential application to the Weston Project. Professional judgment was used to sort through the existing studies and select those appropriate for and similar to Weston. Selection criteria used for this assessment included physical characteristics of the spillways/sluices at those projects, fish species tested, and geographical location.

Acceptability criteria for spillway and bypass survival studies were as follows:

- Completeness of the reported data on the important spill characteristics known to affect fish survival, information on the tested species, and other relevant information such as environmental conditions.
- Ensure control group survival >75% and sample size >25. The use of a control group allows for the isolation of effects due to the experimental treatment from those associated with the experimental procedure (e.g., handling stress or scale loss injury due to netting). Low control group survival may mask treatment effects or indicate that the experimental design and/or implementation were flawed to an extent that the results may not be reliable. Adequate sample size is important to achieve reasonable precision levels and to reduce the importance of each individual fish in a given test. For example, if 100 fish are used in a treatment group, each fish represents 1% of the sample. However, if 10 fish are used, each fish represents 10% of the sample. As control group survival decreases or the recapture rate of treatment and control fish decreases, the sample size must increase to achieve a particular level of precision.

3.3 Turbine Passage Smolt Survival Assessment

Due to the lack of site-specific information, estimates of turbine passage survival of Atlantic salmon smolts at Weston were developed using a combination of existing empirical studies and modeled calculations. Existing studies described in the peer-reviewed primary literature, gray literature reports, review documents and databases were collected and reviewed for potential application to the Weston Project. Professional judgment was used to sort through the existing studies and select those appropriate for Weston estimates. Selection criteria used for this assessment included physical characteristics of the projects, characteristics of the turbines at those projects, fish species tested, and geographical location. In addition to existing empirical data from similar hydroelectric projects, established models for determination of blade strike probabilities for fish passing Francis turbines were constructed for Units 1 through 4 at Weston.

An examination of the results of recent studies indicate that turbine passage survival is largely a function of fish size relative to size of the water passageway (as indexed by runner diameter), clearance between structural components (*e.g.*, spacing between runner blades or buckets, wicket gates, and turbine housing), flow, angle of flow, and the number of buckets/blades, though other non-mechanical factors (*e.g.*, hydraulic) may also contribute to fish injury/mortality. Thus, species *per se* is not as important as fish size (Heisey et al. 1996; Franke et al. 1997) in safe passage through turbines.

3.3.1 Empirical Estimates of Smolt Turbine Passage Survival

Acceptance criteria were established prior to the review of existing empirical data for turbine survival studies. Acceptability criteria were as follows:

- Completeness of the reported data on the important turbine characteristics known to affect fish survival and information on the tested species, fish size, and other relevant information such as station discharge or environmental conditions.
- Ensure control group survival >75% and sample size >25. The use of a control group allows for the isolation of effects due to the experimental treatment from those associated with the experimental procedure (e.g., handling stress or scale loss injury due to netting). Low control group survival may mask treatment effects and indicates that the experimental design and/or implementation were flawed to an extent that the results may not be reliable. Adequate sample size is important to achieve reasonable

precision levels and to reduce the importance of each individual fish in a given test. For example, if 100 fish are used in a treatment group, each fish represents 1% of the sample. However, if 10 fish are used, each fish represents 10% of the sample. As control group survival decreases or the recapture rate of treatment and control fish decreases, the sample size must increase to achieve a particular level of precision.

3.3.2 Modeled Estimates of Smolt Turbine Passage Survival

Franke et al. (1997) defined the three primary risks to outmigrating fish passing through the turbine environment as 1) mechanical mechanisms, 2) fluid mechanisms, and 3) pressure mechanisms. Mechanical mechanisms were primarily defined as forces on fish body resulting from direct contact with turbine structural components (e.g. rotating runner blades, wicket gates, stay vanes, discharge ring, draft tube, passage through gaps between the blades and hub or at the distal end of blades or other structures placed into the water passageway). The probability of that contact is dependent on distance between blades, number of blades and fish body length. Additional sources of mechanical injury may include gap grinding, abrasion, wall strike and mechanical chop. Fluid mechanisms were defined as shear-turbulence (the effect on fish of encountering hydraulic forces due to rapidly changing water velocities) and cavitation (injury resulting from forces on fish body due to vapor pockets imploding near fish tissue). Impacts to fish from pressure resulted from the inability of fish to adjust from the regions of high pressure immediately upstream of turbine to regions of low pressure immediately downstream of turbines. Results from most studies indicate that mechanical related injuries are the dominant source of mortality for fish in the turbine environment at low head (< 30 m or 100 ft) projects (Franke et al. 1997). Blade strike is considered the primary mechanism of mortality when fish pass through turbines (Eicher Associates Inc. 1987; Cada 2001). Franke et al. (1997) noted that pressure related injuries appear to be of minor secondary importance when working at low head (< 30 m or 100 ft) hydroelectric projects. In addition, Franke et al. (1997) noted that tolerance to pressure reduction is greater for physostomous fish species, such as salmonids. Physostomous fish species are defined by having a pneumatic duct connecting the air bladder to the esophagus so that gasses from the air bladder can quickly dissipate through the mouth to accommodate changing pressures. Franke et al. (1997) noted that although evidence of injuries due to fluid shear forces does exist, relative to other injury types, they are not a dominant source of mortality during turbine passage.

Given that mechanical related injuries comprise the dominant source of mortality for fish passing through low head (< 30 m or 100 ft) hydroelectric projects, blade strike probabilities and turbine passage survival at Units 1 through 4 of the Weston Project was estimated for outmigrating Atlantic salmon smolts using the Advanced Hydro Turbine model developed by Franke et al. (1997). The Franke et al. (1997) blade strike model was developed as part of the U.S. Department of Energy program to develop more "fish friendly" turbines and is a modified form of the equation originally proposed by VonRaben (Bell 1981). Franke et al. (1997) refined the VonRaben model to consider tangential projection of the fish length and calculation of flow angles based on overall operating head and discharge parameters because most turbine passage mortality is likely caused by fish striking a blade or other component of the turbine unit. The Franke blade strike model predicts the probabilities of leading edge strikes (a possible mechanical injury source). Those strikes could result from contact between a fish body and a blade, a gap between blade and an adjacent structure, stay vane leading edge, wicket gate leading edge, or leading edge to any support pieces in the intake or draft tube.

The probability (*P*) of direct contact between a fish and a leading edge depends on a number of factors including the number of turbine blades (or buckets; N), fish length (L), runner blade speed (rpm), turbine type, runner diameter (D), and total discharge. Additionally, a correlation function (λ) is added to the equations to account for several factors (Franke et al. 1997). Among these are that an individual fish may not lie entirely in the plane of revolution due either to internal forces within the turbine or the physical movement of the individual fish. Additionally, a length-related fraction could be applied to account for the fact that an impact on a sensitive portion of the fish body (i.e. the head) may be more damaging than an impact to a less sensitive portion (i.e. the tail) of the fish (Franke et al. 1997). The use of the correlation factor also extends the applicability for the blade strike equations to all injury mechanisms related to the variable NL/D (number of blades*body length / runner diameter). These include both mechanical (leading edge strikes and gap grinding) and fluid mechanisms (Franke et al. 1997). As used in this analysis, the equation assumes that any strike results in immediate mortality whether the fish actually died, was injured, or not. The probability of survival predicted by this model will provide a useful perspective for fish sizes where site-specific data is not available.

Turbine passage survival was calculated for a range of fish body lengths (5-9 inches) considered to be representative of outmigrating salmon smolts in Maine rivers (NRC 2004; Fay et al. 2006). The blade strike probability for Francis units was calculated using Equation 1:

$$P = \lambda \frac{N \cdot L}{D} \cdot \left[\frac{\dfrac{\sin \alpha_t \cdot \dfrac{B}{D_1}}{2\, Q_{\omega d}} + \cos \alpha_t}{\pi} \right] \qquad \text{(Equation 1)}$$

where Equation 2 was used to calculate the value of α_t:

$$\tan(90 - \alpha_t) = \frac{2\pi E_{\omega d} \cdot \eta}{Q_{\omega d}} \cdot \frac{B}{D_1} + \frac{\pi \cdot 0.707^2}{2 Q_{\omega d}} \frac{B}{D_1} \left(\frac{D_2}{D_1}\right)^2 - 4 \cdot 0.707 \cdot \tan\beta \frac{B}{D_1} \frac{D_1}{D_2} \qquad \text{(Equation 2)}$$

and Equation 3 was used to calculate the value of tan β.

$$\tan\beta = \frac{0.707 \frac{\pi}{8}}{\xi \cdot Q_{\omega d} opt \left(\frac{D_1}{D_2}\right)^3} \qquad \text{(Equation 3)}$$

Input parameters for Equations 1 through 3 were defined as:

B = Runner height at inlet

D = Diameter of runner

D_1 = Diameter of runner at the inlet

D_2 = Diameter of runner at the discharge

g = Acceleration due to gravity

H = Turbine head

L = Length of fish

N = Number of turbine blades or buckets

P = Predicted strike probability
Q = Turbine discharge
Q_{opt} = Turbine discharge at best efficiency
R = Radius
RPM = Revolutions per minute
α_t = Angle to tangential of absolute flow upstream of runner (for Francis units)
β = Relative flow angle at runner discharge
ξ = Ratio between Q with no exit swirl and Q_{opt} (typical value = 1.1)
λ = Strike mortality correlation factor
η = Turbine efficiency
ω = Rotational speed (calculated as $\omega = RPM \cdot \frac{2\pi}{60}$)
$E_{\omega d}$ = Energy coefficient (calculated as $E_{\omega \mathbf{d}} = \frac{gH}{(\omega \mathbf{d})^2}$)
$Q_{\omega d}$ = Discharge coefficient (calculated as $Q_{\omega \mathbf{d}} = \frac{Q}{\omega \mathbf{D}^3}$)

Calculated blade strike probabilities (P) generated by leading edge strike equations for Francis turbines were converted into a percent survival (S) using equation 4.

S = 100 – P (Equation 4)

4.0 Results: Downstream Migrating Smolt Survival

4.1 Smolt Run Timing

In order to model whole station survival for Atlantic salmon smolts passing the Weston Project, it is necessary to know the timing and seasonal distribution of smolts moving downstream. Seasonal distribution data for smolt downstream migration on the Kennebec River is unavailable. As a result, distribution data collected from the smolt downstream migration on other Maine rivers was used as a surrogate. Seasonal run timing data was collected from seven different sampling years and two Maine rivers. Smolt passage was assessed during the months of April, May and June during 1988, 1989, 1990, 1993, 1994, and 1995 at the Mattaceunk Project (Weldon Dam) on the Penobscot River (Table 1; GNP 1997). During those six sampling years, a total of 16,114 Atlantic salmon smolts were collected. The average seasonal distribution for smolts during those six years was 0.09% during April (range = 0-0.46%), 71.94 during May (range = 38.0-93.84%) and 27.96 during June (range = 6.13-62.0%) (Table 2). Additional sampling was conducted and data was available related to smolt outmigration in the Penobscot River during 2004 (USASAC 2005). Total catch of Atlantic salmon smolts within Penobscot River rotary screw traps during spring 2004 is presented in Figure 6 (Note – this figure is reprinted from USASAC 2005). Based on visual assessment of Penobscot River data in Figure 6, it was estimated that approximately 10% of the Atlantic salmon smolt run took place during April, approximately 88% of the run took place during May and the remaining approximately 2% of the run took place during June. Rotary screw trap data from the Narraguagus River was also collected during 2004 (USASAC 2005). Based on visual assessment of Narraguagus River data in Figure 6, it was estimated that approximately 4% of the Atlantic salmon smolt run took place during April, approximately 96% of the run took place during May and 0% took place during June.

For the purposes of estimating whole station survival for downstream migrating Atlantic salmon smolts moving past the Weston Project it was assumed the average smolt distribution from the seven years of available data on seasonal smolt distribution from the Penobscot and Narraguagus Rivers would account for annual variation and be representative of patterns observed within the Kennebec River. Patterns in mean daily discharge for the three rivers were examined for the years 2006-2010 and similar trends in the timing of spring run-off events were observed. Although not readily available, it is likely that spring water temperatures are also similar among the three rivers. Similarity in spring water temperatures and run-off timing for the three rivers supports the extrapolation of smolt run timing from those systems for application to the Kennebec River. As a result, the model presented here is based on a seasonal distribution of Atlantic salmon smolts of 1.8% during April, 77.0% during May and 21.2% during June (Table 2). Variations in this seasonal distribution and their impacts to whole station survival are examined in Section 5.1 of this report.

4.1.1 Additional Considerations Related to Smolt Run Timing

There are additional ecological and anthropogenic factors that may influence smolt run timing in the Kennebec River on an annual basis. Potential sources of variation to the seasonal distribution of Atlantic salmon smolts used in the model presented in this report could include smolt origin (hatchery-reared vs. wild) as well as differences in river temperature between upstream smolt rearing areas and the downstream hydroelectric Projects.

Smolt Origin:

Differences in the timing and seasonal distribution for smolts moving downstream may vary depending on the origin of the individuals (hatchery-reared vs. wild). Holbrook (2007) observed hatchery-reared smolts released during April (2005 and 2006) to exhibit downstream migratory behavior earlier than wild smolts within the Penobscot River. It was theorized that premature smolting of hatchery-reared individuals may potentially cause them to miss the natural environmental "window of opportunity" for successful outmigration. This "window of opportunity" (McCormick et al. 1998) is defined by impacts to smolt survival based on a number of physiological and ecological factors. The impact of potential differences in the timing and seasonal distribution of hatchery-reared and wild smolts is complicated by the long history of hatchery supplementation for the species (Holbrook 2007). Collections of outmigrating smolts during the studies used in this white paper assessment (and the resulting models for the NextEra Projects) did not distinguish between hatchery-reared or wild individuals.

Source Water Temperatures:

It has been suggested that rising spring water temperatures may be the key environmental trigger for initiation of outmigration of Atlantic salmon smolts from freshwater systems with the peak of migration occurring at water temperatures of approximately 10^{o}C (Ruggles 1980). Currently, Kennebec River smolts originate in the upper reaches of the Sandy River. Water temperature data recorded by MDMR at three locations (upper Orbeton spawning shoals, Route 4 Bridge, and Old Sandy River dam site) in the Sandy River during 2007 was examined in an attempt to provide support for the seasonal distribution of smolts used in this report (G. Wippelhauser, MDMR, personal communication). Daily average water temperatures (based on 24-hour records) were calculated for the period 23 April – 27 May 2007 at the most upstream (upper Orbeton spawning shoals) and most downstream (Old Sandy River dam site) water temperature sampling sites. Those two sampling sites are separated by approximately 60 miles of river. During 2007, Sandy River water temperatures first hit 10^{o}C in the upper reaches of the river on 24 May. Given the literature-reported peak of smolt migration (10^{o}C; Ruggles 1980) and the temporal occurrence of that peak temperature within the upper reaches of the Sandy River during 2007 , the seasonal distribution of Atlantic salmon smolts at the NextEra Projects of 1.8% during April, 77.0% during May and 21.2% during June seems reasonable. Given the lack of smolt outmigration data from the Sandy and Kennebec Rivers, the models for smolt outmigration presented in this report will rely on the data acquired from other Maine Rivers and described in Section 4.1.

4.2 Kennebec River Flows

Flow duration curves were obtained for the Kennebec River at the Weston Project during the months of April, May and June (D. Dow, NOAA, personal communication)[1]. Weston Project flow duration curves were based on the flow record for the period 1979 through 2010. A description of the methodology used in the development of these curves can be found in Appendix B of this report. For the purposes of modeling project survival of Atlantic salmon smolts migrating past the Weston Project, the median monthly flow condition (i.e. the value with 50% flow exceedence) was used. It is likely that the use of the 50% flow exceedence value will provide a conservative estimate of the percentage of smolts passing via spill (as well as a conservative estimate of whole station survival).

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[1] The 1979-2010 flow duration curves provided by Don Dow (NOAA) replace the Lockwood Project 1978-1998 curves (Merimil 2002) that were used in the April 2011 draft of this paper.

Once environmental cues thought to initiate the smolt outmigration period (such as water temperature) are triggered and the smolt migration is underway, it is likely that during years with seasonal pulses of flow greater than the 50% flow exceedence value will pass a greater number of smolts via spill. The median flow condition at the Weston Project during April was approximately 12,250 cfs (Figure 3), during May was approximately 8,500 cfs (Figure 4) and during June was approximately 5,500 cfs (Figure 5). Impacts to the model of whole station smolt survival during years of high flow (10 and 25% flow exceedence) and low flow (75 and 90% flow exceedence) are examined in Section 5.1 of this report.

4.3 Smolt Downstream Route Determination

River discharge during the spring migration period will dictate the proportion of Atlantic salmon smolts passed downstream of the Weston Project though the spillway (and conversely, through the powerhouse or downstream passage facility). Determination of the spill effectiveness, defined as the proportion of smolts passed through spill relative to the total number passing the project, is the first step in assessing whole station survival (Figure 2). Spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (i.e., spilling 50% of total river flow results in 50% of smolts passing via the spillway). Although a number of site specific factors may impact spill effectiveness (i.e. project configuration and operations, forebay bathymetry, fish behavior, etc) the 1:1 spill effectiveness assumption has been validated at other hydroelectric projects (Normandeau 2010) and serves as a good initial value for this model. To date, no studies have been conducted to provide any empirical evidence to confirm the 1:1 assumption for spill effectiveness at the Weston Project.

An overall spill effectiveness for the period April through June of 23.6% was used for the assessment of whole station survival at Weston. This value was calculated using a Project turbine capacity of 6,000 cfs, the monthly distribution of Atlantic salmon smolt outmigration for the nearby Penobscot and Narraguagus Rivers (Section 4.1), monthly median Kennebec River flow conditions (Section 4.2) and the assumption of 1:1 spill effectiveness. Table 3 provides a summary of that calculation as well as the monthly values used for the assessment of Weston Project spill effectiveness.

4.4 Smolt Downstream Bypass Efficiency

Interim downstream passage for Atlantic salmon smolts at Weston currently includes an existing sluice gate and associated concrete flume which discharges into a plunge pool in the river. The sluice gate structure is 18 ft wide by 14 ft high and is located next to Unit 4. During the spring operating season (April 1 – June 15) the sluice is opened 1.5 ft and passes 120 cfs. Given the lack of site specific data related to movement patterns through the powerhouse area at Weston Station, it was assumed (for modeling purposes) that the distribution of smolt passage was equal to the distribution of outflow. The downstream bypass efficiency rate was allowed to vary by month to account for occasions when river discharge was less than the Project operating flow. For example, as presented in Table 3, the monthly median Kennebec discharge (cfs) values during April and May were greater than the Project operating flow of 6,000 cfs. In those instances, the downstream bypass efficiency rate (assuming passage distribution of smolts through the powerhouse is equal to the distribution of outflow through the powerhouse and downstream bypass) was calculated as 2.0% ((120 cfs/6,000 cfs)*100 = 2.0%). However, during June, the monthly median Kennebec discharge (cfs) value was 5,500 cfs. For that month, the downstream bypass efficiency rate (assuming passage distribution of smolts through the powerhouse is equal to the distribution of outflow through the powerhouse and downstream bypass) was calculated as 2.2% ((120 cfs/5,500 cfs)*100 = 2.2%). The remainder of the powerhouse area flow passes via the turbine units.

The smolt whole station survival models presented in this white paper represent the Weston Project as it operated prior to the installation of the new floating boom and downstream passage facility. Following field evaluation of that system during spring 2012, this model can be updated with the site-specific data.

4.5 Smolt Spillway and Downstream Bypass Passage Survival Assessment

The Weston Project spillway sections dam the river on either side of a small island. The North channel dam consists of an Obermeyer inflatable dam section and two taintor gates (28 ft wide by 16 ft high). The South channel dam has a single taintor gate (18 ft wide by 14 ft high) at the sluiceway.

As the principal causes of injury and mortality for fish passed through either a spillway or bypass sluice are similar (Heisey et al. 1996) empirical studies related to spillway and bypass survival were pooled into a single data set. Injury/scale loss rates for Atlantic salmon smolt test and control fish released through sluices and bypasses at five different hydroelectric projects are presented in Table 4. Initial (1-hr) injury rates were available at all five projects and for test fish varied widely from 0% to 59% (average 18.4%) while those for control fish ranged from 0% to 4%. When initial (1-hr) test fish injuries from each of the five locations were pooled (Table 5), bruising/hemorrhaging had the greatest frequency of occurrence, being noted on 47.7% of individual smolts with injuries (10.9% of all individuals examined). Minor scale loss (<25% of body), major scale loss (>25% scale loss) and lacerations/tears were noted on 42.1%, 22.4%, and 8.4%, respectively of the individual smolts with injuries (9.6%, 5.1%, and 1.9%, respectively, of all individuals examined). Delayed (48-hr) injury rates were available at three of the five projects and for both test and control fish varied from 0% to 18% (average 6.0%). When delayed (48-hr) test fish injuries from each of the three locations were pooled (Table 5), minor scale loss (<25% of body) had the greatest frequency of occurrence, being noted on 85.7% of individual smolts with injuries (6.1% of all individuals examined). Bruising/hemorrhaging was noted on 14.3% of the individual smolts with injuries (1.0% of all individuals examined). Note that multiple injury types could be assigned to a single individual during each of the studies included in Tables 4 and 5.

Table 6 presents the measured initial (1-hr) and delayed (48-hr) survival for Atlantic salmon smolts passed through sluices and bypasses at five different hydroelectric projects. Selection of studies was limited to only those using the Hi-Z balloon tag method so that survival estimates were based solely on direct impacts from passage through the spill and not from indirect effects such as predation. Survival data collected from efficiency or fish movement studies do not represent actual Project survival and as a result, were not used in this analysis. Immediate survival (1-hr) estimates for Atlantic salmon smolts following passage through sluiceways and bypasses ranged from 93.3 to 100.0%, resulting in a mean overall spill survival of 97.1%. Delayed survival (48-hr) estimates for Atlantic salmon smolts following passage through sluiceways and bypasses ranged from 91.1 to 100.0%, resulting in a mean overall spill survival of 96.3%.

A review of 17 different spillway and sluice Hi-Z balloon tag studies conducted by Franke et al. (1997) reported an average immediate survival (1-hr) of 97.2%. That review included studies conducted for Atlantic salmon, Chinook salmon, American shad and blueback herring. Additionally, observations of post-passage movements for a limited number (N=18) of radio-tagged Atlantic salmon smolts which passed the nearby Lockwood Project via the spillway or surface sluice during 2007 (Normandeau 2008) were determined to have survived passage.

4.6 Smolt Entrainment Rates and Turbine Passage Survival Assessment

The Weston powerhouse contains a total of four vertical Francis units and has a total Project generating capacity of 13.2 MW. Maximum capacity (cfs) ranges from 1,822-1,498 cfs for the four vertical Francis units (Table 7). Total unit flow for the Project is approximately 6,000 cfs. Normal operating head for the Weston Project is approximately 34 ft. The trash racks screening the intakes in front of Units 1-4 are 4 in clear spacing. Additional turbine characteristics for Weston Units 1-4 are provided in Table 7.

4.6.1 Turbine Entrainment Rates

Given the lack of site-specific data related to movement patterns through the South channel powerhouse area at the Weston Project, it was assumed (for modeling purposes) that the distribution of smolt passage is equal to the distribution of outflow. Turbine entrainment rates at the Weston Project were calculated on a monthly basis as 100% minus the downstream bypass efficiency rate.

4.6.2 Empirical Estimates of Turbine Passage Survival

Although existing information for turbine passage survival for Kaplan, propeller and Francis turbines is extensive (e.g. Franke et al. 1997, EPRI 1997), studies specific to the passage of Atlantic salmon are not as plentiful. Injury/scale loss rates for Atlantic salmon smolt test and control fish having passed through Francis turbines at two different hydroelectric projects are presented in Table 8. Smolts recaptured during Normandeau turbine tag studies were assessed for scale loss and injuries following their initial recapture. Individuals were then held for a 48-hr period after which any incidence of latent mortality was recorded. Initial (1-hr) injury rates for test fish varied widely from 1.0% to 30.8% (Francis average = 16.2%) while those for control fish were 0%.

When initial (1-hr) test fish injuries from each of the studies involving Francis units were pooled (Table 9), incidences of severed body/back bone and minor scale loss (<25%) had the highest frequency of occurrence, being noted on 29.4%, and 17.6% of individual smolts with injuries (3.1%, and 1.8%, respectively, of all individuals examined) having passed through a Francis unit. Smolts displaying a loss of equilibrium (i.e. dazed) had a 47.1% frequency of occurrence in smolts injured passing through Francis units (4.9% of all individuals examined following Francis passage). Note that multiple injury types could be assigned to a single individual during each of the studies included in Tables 8 and 9.

Table 10 presents the initial (1-hr) and delayed (48-hr) survival rates and basic Project characteristics for turbine passage survival studies conducted to evaluate turbine survival for Atlantic salmon smolts passing though Francis units. Selection of studies was limited to only those using the Hi-Z balloon tag method so that estimates were based solely on direct impacts from passage through a turbine unit. Survival data collected from efficiency or fish movement studies do not represent actual Project survival and as a result, were not used in this analysis. Additional study-specific information related to each study presented in Table 10 is presented in Appendix A of this report.

4.6.3 Modeled Estimates of Turbine Passage Survival

Survival estimates for turbine passage were generated for the four Francis units in operation at Weston. Estimates were calculated for five body lengths considered representative of the range of total length for outmigrating Atlantic salmon smolts (5, 6, 7, 8, and 9 inches). Two correlation factors (λ) were used in this analysis (0.1 and 0.2). Franke et al. (1997) recommended the value for the correlation factor be within the range of 0.1 to 0.2 based on a review of empirical results associated with a substantial number of salmonid survival studies. Survival estimates for Weston units1-4 were modeled using the maximum turbine discharge (cfs) and the associated efficiency. The maximum turbine discharges were selected for use in the model under the assumption that the Project would be in full operation during the spring period of high seasonal river flow.

Model runs for five body lengths and two correlation factors resulted in a total of 10 survival estimates which are likely to bracket the actual survival for salmon smolts passing through Francis units 1-4 at the Weston Project. Predicted survival values for salmon smolts passing through the Weston Francis units ranged from a high value of 95.4% for a five inch smolt to a low value of 75.5% for a nine inch smolt (Table 11). The range of survival estimates were similar for Francis units 1-4 and the predicted survival probability increased as smolt body length decreased. The average survival of salmon smolts passing through the Francis units at Weston was determined by averaging the 10 modeled survival estimates for each unit. Those values ranged from a high of 90.3% at Unit 3 to a low of 85.7% at Unit 2 with an overall calculated mean survival of 88.2% for all Weston Francis units combined.

4.6.4 Comparison of Modeled and Empirical Passage Survival

Survival estimates for Francis turbines obtained from empirical data collected at other hydroelectric projects were compared with the predictive models developed specifically for the Weston Project Units 1-4. As expected, the average modeled survival rate for Weston Francis units (88.2%) was most similar to empirical data collected from other smaller-sized Francis units (as indicated by runner diameter) than empirical data collected from larger Francis units. Turbines characterized by wider water passage areas (as defined by larger runner diameter and/or fewer runner blades) relative to fish size pose lower risks associated with mechanical damage to a fish (Franke et al. 1997).

5.0 Estimated Project Impact on Outmigrating Atlantic salmon Smolts

5.1 Modeled Estimate of Whole Station Survival for Smolts

Whole station survival for the Weston Project was estimated by integrating Kennebec River flows, Project operating flows, the proportion of smolts diverted towards the spillway and powerhouse, spillway survival rate (as estimated from empirical data), turbine passage survival rate (as estimated through a combination of empirical and modeled data), interim downstream bypass efficiency, and fish bypass passage survival rate (as estimated from empirical data). Four models intended to estimate whole station survival of smolts passing the Weston Project were constructed using the available empirical and modeled survival estimates for both spill and turbine passage. The four individual models were:

1) Initial Survival Rate Model (Model A): Spill survival based on 1-hr empirical survival data and Kaplan and Francis turbine survival based on 1-hr empirical survival data
2) Delayed Survival Rate Model (Model B): Spill survival based on 48-hr empirical survival data and Kaplan and Francis turbine survival based on 48-hr empirical survival data
3) Delayed/Calculated Survival Rate Model (Model C): Spill survival based on 48-hr empirical survival data and Kaplan and Francis turbine survival based Franke estimates
4) Initial Injury Rate Model (Model D): survival based on 1-hr empirical injury data and Kaplan and Francis turbine survival based on 1-hr empirical injury data

5.1.1 Whole Station Smolt Survival Modeled Using Initial Survival Rates

The Model A whole station smolt survival estimate was generated using initial (1-hr) survival rates for spill and turbine passed fish obtained from empirical data collected at other hydroelectric projects. The following values for each of the necessary model parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in this calculation of whole station survival for salmon smolts at the Weston Project:

- Kennebec River Flow – monthly medians of 12,250 cfs (April), 8,500 cfs (May), and 5,500 cfs (June) (Merimil 2002);
- Project operating flow – 6,000 cfs;
- Proportion of salmonid smolts diverted – utilized a ratio of 1:1 fish to river flow;
- Project spillway survival – 97.1% (based on review of initial (1-hr) empirical survival data from other hydroelectric projects)
- Fish bypass guidance efficiency – as determined on a monthly basis based on the relationship of bypass discharge (120 cfs) and Project operating flow;
  - April: (120 cfs / 6,000 cfs)*100 = 2.0%
  - May: (120 cfs / 6,000 cfs)*100 = 2.0%
  - June: (120 cfs / 5,500 cfs)*100 = 2.2%

- Entrainment rate through turbines – as determined on a monthly basis as 100% - fish bypass guidance efficiency;
  - April: 100%-2.0% - 98.0%
  - May: 100%-2.0% - 98.0%
  - June: 100%-2.2% - 97.8%
- Francis turbine passage survival – 91.5% (based on review of initial (1-hr) empirical survival data from other hydroelectric projects);
- Fish bypass system survival – 97.1% (based on review of initial (1-hr) empirical survival data from other hydroelectric projects).

The integration of the above values is provided in Table 12 for a hypothetical case of 1,000 Atlantic salmon smolts approaching the Weston Project during the spring migration period (April-June). The whole station survival estimate for Atlantic salmon smolts passing the Weston Project generated using initial (1-hr) empirical data for spillway and turbine survival estimates is 93%[2].

5.1.1.1 Impacts to Estimated Smolt Survival Associated with Bypass Efficiency Assumption

The Initial Survival Rate Model (Model A) for Weston can be easily manipulated to provide insight into impacts to whole station survival based on modifying the various input parameters. The Licensee has installed a new downstream bypass facility and guidance device during 2011. The new guidance device consists of a 10 ft deep floating guidance boom leading outmigrating smolts to the existing sluice adjacent to Unit 4. The floating guidance boom at the Weston Project should lead to increased effectiveness of the downstream bypass and reduced impact of turbine passage on outmigrating smolts. Table 13 provides whole station survival estimates for a range of theoretical bypass efficiency rates. Theoretical bypass effectiveness rates between 25 and 100% were modeled and produced a range of whole station survival estimates for outmigrating Atlantic salmon smolts between 94% and 97%.

5.1.1.2 Impacts to Estimated Smolt Survival Associated with Seasonal Distribution Assumption

In cases with no site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (e.g., spilling 50% of total river flow results in 50% of smolts passing via the spillway). A basic implication of the deviation from the 1:1 assumption is that if a proportionally smaller percentage of smolts relative to the river flow enter the Project powerhouse area then the calculated station-related smolt survival would be higher. Under these conditions, a greater percentage of smolts would pass the project via spill and would avoid impacts associated with turbine passage. Alternatively, if a proportionally higher percentage of smolts are entering the Project powerhouse area than the calculated station related smolt survival would be lower. Under these conditions, a lower percentage of smolts would pass the project via spill and a greater number would be entrained through the Project turbines.

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[2] Whole station survival estimates are reported to the nearest whole percentage so as to not overstate the accuracy of these models. This was done following comments made at the Technical Advisory Committee meeting held on 7 September 2011.

The sensitivity of the Initial Survival Rate Model (Model A) associated with deviation from the assumed 1:1 ratio of fish to flow at the Weston Project is presented in Table 14. A range of spill effectiveness rates for Atlantic salmon smolts from 5% (0.2:1) to 90% (3.8:1) was evaluated. For conditions where a proportionately lower percentage of smolts relative to river flow entered the powerhouse area (i.e. spill effectiveness rates of 50% and greater), the estimates for whole station survival were greater than that observed under the assumption of 1:1 spill effectiveness and ranged from 94% to 97%. For conditions where a proportionately higher percentage of smolts relative to river flow entered the powerhouse area (i.e. spill effectiveness rates of 5 or 10%), the estimate for whole station survival was lower than or equal to that observed under the assumption of 1:1 spill effectiveness.

5.1.1.3 Impacts to Estimated Smolt Survival Associated with Seasonal Flow Assumption

The Initial Survival Rate Model (Model A) for Weston was constructed using the assumption of median Kennebec River flows (i.e. 50% exceedence) during the months of April, May and June. Two "low flow" conditions (75 and 90% exceedence) and two "high flow" conditions (10 and 25% exceedence) were also examined. Estimated monthly Kennebec River flows for the months of April, May and June under the 10, 25, 75, and 90% exceedence conditions are presented in Table 15. Table 16 presents the modeled whole station survival estimates for downstream migrating Atlantic salmon smolts under the additional low and high flow conditions. Under the low flow conditions (i.e. those exceeded 75 and 90 % of the time) the estimated whole station survival for salmon smolts at the Weston Project decreased to 91% and 92%, respectively. Under the high flow conditions (i.e. those exceeded only 10 or 25% of the time) the estimated whole station survival for salmon smolts at the Weston Project increased to 95% and 94%, respectively.

5.1.2 Whole Station Smolt Survival Modeled Using Delayed Survival Rates

The Model B whole station smolt survival estimate was generated using delayed (48-hr) survival rates for spill and turbine passed fish obtained from empirical data collected at other hydroelectric projects. The following values for each of the necessary model parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in this calculation of whole station survival for salmon smolts at the Weston Project:

- Kennebec River Flow – monthly medians of 12,250 cfs (April), 8,500 cfs (May) and 5,500 cfs (June);
- Project operating flow – 6,000 cfs;
- Proportion of salmonid smolts diverted – utilized a ratio of 1:1 fish to river flow;
- Project spillway survival – 96.3% (based on review of delayed (48-hr) empirical survival data from other hydroelectric projects);
- Fish bypass guidance efficiency – as determined on a monthly basis based on the relationship of bypass discharge (120 cfs) and Project operating flow;
  - April: (120 cfs / 6,000 cfs)*100 = 2.0%
  - May: (120 cfs / 6,000 cfs)*100 = 2.0%
  - June: (120 cfs / 5,500 cfs)*100 = 2.2%
- Entrainment rate through turbines – as determined on a monthly basis as 100% - fish bypass guidance efficiency;

  - April: 100%-2.0% - 98.0%
  - May: 100%-2.0% - 98.0%
  - June: 100%-2.2% - 97.8%
- Francis turbine passage survival – 91.3% (based on review of delayed (48-hr) empirical survival data from other hydroelectric projects);
- Fish bypass system survival – 96.3% (based on review of delayed (48-hr) empirical survival data from other hydroelectric projects).

The integration of the above values is provided in Table 17 for a hypothetical case of 1,000 Atlantic salmon smolts approaching the Weston Project during the spring migration period (April-June). The Model B whole station survival estimate for Atlantic salmon smolts passing the Weston Project generated using delayed (48-hr) empirical data for spillway and turbine survival estimates is 92%.

5.1.2.1 Impacts to Estimated Smolt Survival Associated with Bypass Efficiency Assumption

The Delayed Survival Model (Model B) for Weston can be manipulated to provide insight into potential impacts to whole station survival based on modifying the various input parameters. The Licensee has installed a new downstream bypass facility and guidance device during 2011. The new guidance device consists of a 10 ft deep floating guidance boom leading outmigrating smolts to the existing sluice adjacent to Unit 4. Installation of the floating guidance boom at the Weston Project should increase effectiveness of the downstream bypass and reduced impact of turbine passage on outmigrating smolts. Table 18 provides whole station survival estimates for a range of theoretical bypass efficiency rates. Theoretical bypass effectiveness rates between 25 and 100% were modeled and produced a range of whole station survival estimates for outmigrating Atlantic salmon smolts between 93% and 96%.

5.1.2.2 Impacts to Estimated Smolt Survival Associated with Seasonal Distribution Assumption

In cases with no site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (e.g., spilling 50% of total river flow results in 50% of smolts passing via the spillway). A basic implication of the deviation from the 1:1 assumption is that if a proportionally smaller percentage of smolts relative to the river flow enter the Project powerhouse area then the calculated station-related smolt survival would be higher. Under these conditions, a greater percentage of smolts would pass the project via spill and would avoid impacts associated with turbine passage. Alternatively, if a proportionally higher percentage of smolts are entering the Project powerhouse area than the calculated station related smolt survival would be lower. Under these conditions, a lower percentage of smolts would pass the project via spill and a greater number would be entrained through the Project turbines.

The sensitivity of Delayed Survival Model (Model B) associated with deviation from the assumed 1:1 ratio of fish to flow at the Weston Project is presented in Table 19. A range of spill effectiveness rates for Atlantic salmon smolts from 5% (0.2:1) to 90% (3.8:1) was evaluated. For conditions where a proportionately lower percentage of smolts relative to river flow entered the powerhouse area (i.e. spill effectiveness rates of 30% and greater), the estimates for whole station survival were higher than that observed under the assumption of 1:1 spill effectiveness and ranged from 93% to 96%. For conditions where a proportionately higher percentage of smolts relative to river flow entered the powerhouse area (i.e. a spill effectiveness rate of 5%), the estimate for whole station survival (91%) was lower than that observed under the assumption of 1:1 spill effectiveness.

5.1.2.3 Impacts to Estimated Smolt Survival Associated with Seasonal Flow Assumption

The Delayed Survival Model (Model B) for Weston was constructed using the assumption of median Kennebec River flows (i.e. 50% exceedence) during the months of April, May and June. Two "low flow" conditions (75 and 90% exceedence) and two "high flow" conditions (10 and 25% exceedence) were also examined. Estimated monthly Kennebec River flows for the months of April, May and June under the 10, 25, 75, and 90% exceedence conditions are presented in Table 15. Table 20 presents the modeled whole station survival estimates for downstream migrating Atlantic salmon smolts under the additional low and high flow conditions. Under the low flow conditions (i.e. those exceeded 75 and 90 % of the time) the estimated whole station survival for salmon smolts at the Weston Project decreased to 91% and 92%, respectively. Under the high flow conditions (i.e. those exceeded only 10 or 25% of the time) the estimated whole station survival for salmon smolts at the Weston Project increased to 95% and 94%, respectively.

5.1.3 Whole Station Smolt Survival Modeled Using Delayed/Calculated Survival Rates

The Model C whole station smolt survival estimate was generated using delayed (48-hr) survival rates for spill obtained from empirical data collected at other hydroelectric projects in conjunction with modeled estimates of turbine passed fish obtained using the Franke (Franke et al. 1997) formula. The following values for each of the necessary model parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in this calculation of whole station survival for salmon smolts at the Weston Project:

- Kennebec River Flow – monthly medians of 12,250 cfs (April), 8,500 cfs (May) and 5,500 cfs (June);
- Project operating flow – 6,000 cfs;
- Proportion of salmonid smolts diverted – utilized a ratio of 1:1 fish to river flow;
- Project spillway survival – 96.3% (based on review of delayed (48-hr) empirical survival data from other hydroelectric projects);
- Fish bypass guidance efficiency – as determined on a monthly basis based on the relationship of bypass discharge (120 cfs) and Project operating flow;
    - April: (120 cfs / 6,000 cfs)*100 = 2.0%
    - May: (120 cfs / 6,000 cfs)*100 = 2.0%
    - June: (120 cfs / 5,500 cfs)*100 = 2.2%
- Entrainment rate through turbines – as determined on a monthly basis as 100% - fish bypass guidance efficiency;
    - April: 100%-2.0% - 98.0%
    - May: 100%-2.0% - 98.0%
    - June: 100%-2.2% - 97.8%
- Francis turbine passage survival – 88.2% (based on modeled values generated using site-specific turbine parameters);

- Fish bypass system survival – 96.3% (based on review of delayed (48-hr) empirical survival data from other hydroelectric projects).

The integration of the above values is provided in Table 21 for a hypothetical case of 1,000 Atlantic salmon smolts approaching the Weston Project during the spring migration period (April-June). The Model C whole station survival estimate for Atlantic salmon smolts passing the Weston Project generated using delayed (48-hr) empirical data for spill and site-specific modeled values for turbine survival estimates is 90%.

5.1.3.1 Impacts to Estimated Smolt Survival Associated with Bypass Efficiency Assumption

The Delayed/Calculated Survival Model (Model C) for Weston can be manipulated to provide insight into potential impacts to whole station survival based on modifying the various input parameters. The Licensee has installed a new downstream bypass facility and guidance device during 2011 that has not yet been tested for effectiveness. The new guidance device consists of a 10 ft deep floating guidance boom leading outmigrating smolts to the existing sluice adjacent to Unit 4. The floating guidance boom at the Weston Project should lead to increased effectiveness of the downstream bypass and reduced impact of turbine passage on outmigrating smolts. Table 22 provides whole station survival estimates for a range of theoretical bypass efficiency rates. Theoretical bypass effectiveness rates between 25 and 100% were modeled and produced a range of whole station survival estimates for outmigrating Atlantic salmon smolts between 92% and 96%.

5.1.3.2 Impacts to Estimated Smolt Survival Associated with Seasonal Distribution Assumption

In cases with no site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (e.g., spilling 50% of total river flow results in 50% of smolts passing via the spillway). A basic implication of the deviation from the 1:1 assumption is that if a proportionally smaller percentage of smolts relative to the river flow enter the Project powerhouse area then the calculated station-related smolt survival would be higher. Under these conditions, a greater percentage of smolts would pass the project via spill and would avoid impacts associated with turbine passage. Alternatively, if a proportionally higher percentage of smolts are entering the Project powerhouse area than the calculated station related smolt survival would be lower. Under these conditions, a lower percentage of smolts would pass the project via spill and a greater number would be entrained through the Project turbines.

The sensitivity of the Delayed/Calculated Survival Model (Model C) associated with deviation from the assumed 1:1 ratio of fish to flow at the Weston Project is presented in Table 23. A range of spill effectiveness rates for Atlantic salmon smolts from 5% (0.2:1) to 90% (3.8:1) was evaluated. For conditions where a proportionately lower percentage of smolts relative to river flow entered the powerhouse area (i.e. spill effectiveness rates of 30% and greater), the estimates for whole station survival were higher than that observed under the assumption of 1:1 spill effectiveness and ranged from 91% to 95%. For conditions where a proportionately higher percentage of smolts relative to river flow entered the powerhouse area (i.e. a spill effectiveness rate of 5%), the estimate for whole station survival (89%) was lower than that observed under the assumption of 1:1 spill effectiveness.

5.1.3.3 Impacts to Estimated Smolt Survival Associated with Seasonal Flow Assumption

The Delayed/Calculated Survival Model (Model C) for Weston was constructed using the assumption of median Kennebec River flows (i.e. 50% exceedence) during the months of April, May and June. Two "low flow" conditions (75 and 90% exceedence) and two "high flow" conditions (10 and 25%

exceedence) were also examined. Estimated monthly Kennebec River flows for the months of April, May and June under the 10, 25, 75, and 90% exceedence conditions are presented in Table 15. Table 24 presents the modeled whole station survival estimates for downstream migrating Atlantic salmon smolts under the additional low and high flow conditions. Under the low flow conditions (i.e. those exceeded 75 and 90 % of the time) the estimated whole station survival for salmon smolts at the Weston Project decreased to 88%. Under the high flow conditions (i.e. those exceeded only 10 or 25% of the time) the estimated whole station survival for salmon smolts at the Weston Project increased to 94% and 93%, respectively.

5.1.4 Whole Station Smolt Survival Modeled Using Initial Injury Rates

The Model D whole station smolt survival estimate was generated using initial (1-hr) injury rates for spill and turbine passed fish obtained from empirical data collected at other hydroelectric projects. Comparisons of initial injury assessment and delayed survival rates for Atlantic salmon smolts subjected to mark-recapture spill and turbine passage studies suggest that not all injuries sustained by smolts during dam passage will result in mortality. However, for the purposes of this analysis, it was assumed that any fish subjected to an injury (regardless of the magnitude of that injury) suffered mortality. This model was intended to provide a “worst case” scenario for Atlantic salmon smolts passing the Weston Project. The following values for each of the necessary model parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in this calculation of whole station survival for salmon smolts at the Weston Project:

- Kennebec River Flow – monthly medians of 12,250 cfs (April), 8,500 cfs (May) and 5,500 cfs (June);
- Project operating flow – 6,000 cfs;
- Proportion of salmonid smolts diverted – utilized a ratio of 1:1 fish to river flow;
- Project spillway survival – 81.6% (based on review of initial (1-hr) empirical injury data from other hydroelectric projects used as a surrogate for survival);
- Fish bypass guidance efficiency – as determined on a monthly basis based on the relationship of bypass discharge (120 cfs) and Project operating flow;
    - April: (120 cfs / 6,000 cfs)*100 = 2.0%
    - May: (120 cfs / 6,000 cfs)*100 = 2.0%
    - June: (120 cfs / 5,500 cfs)*100 = 2.2%
- Entrainment rate through turbines – as determined on a monthly basis as 100% - fish bypass guidance efficiency;
    - April: 100%-2.0% - 98.0%
    - May: 100%-2.0% - 98.0%
    - June: 100%-2.2% - 97.8%
- Francis turbine passage survival – 83.8% (based on review of initial (1-hr) empirical injury data from other hydroelectric projects used as a surrogate for survival);
- Fish bypass system survival – 81.6% (based on review of initial (1-hr) empirical injury data from other hydroelectric projects used as a surrogate for survival).

The integration of the above values is provided in Table 25 for a hypothetical case of 1,000 Atlantic salmon smolts approaching the Weston Project during the spring migration period (April-June). The Model D whole station survival estimate for Atlantic salmon smolts passing the Weston Project generated using initial (1-hr) empirical injury data as a surrogate for spillway and turbine survival estimates is 83%.

5.1.4.1 Impacts to Estimated Smolt Survival Associated with Bypass Efficiency Assumption

The Initial Injury Rate Model (Model D) for Weston can be manipulated to provide insight into potential impacts to whole station survival based on modifying the various input parameters. The Licensee has installed a new downstream bypass facility and guidance device during 2011. The new guidance device consists of a 10 ft deep floating guidance boom leading outmigrating smolts to the existing sluice adjacent to Unit 4. The floating guidance boom at the Weston Project should lead to increased effectiveness of the downstream bypass and reduced impact of turbine passage on outmigrating smolts. Table 26 provides whole station survival estimates for a range of theoretical bypass efficiency rates. Theoretical bypass effectiveness rates between 25 and 100% were modeled and produced whole station survival estimates for outmigrating Atlantic salmon smolts of 83% and 82%.

5.1.4.2 Impacts to Estimated Smolt Survival Associated with Seasonal Distribution Assumption

In cases with no site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (e.g., spilling 50% of total river flow results in 50% of smolts passing via the spillway). A basic implication of the deviation from the 1:1 assumption is that if a proportionally smaller percentage of smolts relative to the river flow enter the Project powerhouse area then the calculated station-related smolt survival would be higher. Under these conditions, a greater percentage of smolts would pass the project via spill and would avoid impacts associated with turbine passage. Alternatively, if a proportionally higher percentage of smolts are entering the Project powerhouse area than the calculated station related smolt survival would be lower. Under these conditions, a lower percentage of smolts would pass the project via spill and a greater number would be entrained through the Project turbines.

The sensitivity of the Initial Injury Rate Model (Model D) associated with deviation from the assumed 1:1 ratio of fish to flow at the Weston Project is presented in Table 27. A range of spill effectiveness rates for Atlantic salmon smolts from 5% (0.2:1) to 90% (3.8:1) was evaluated. For conditions where a proportionately lower percentage of smolts relative to river flow entered the powerhouse area (i.e. spill effectiveness rates of 30% and greater), the estimates for whole station survival were equal to or lower than that observed under the assumption of 1:1 spill effectiveness. For conditions where a proportionately higher percentage of smolts relative to river flow entered the powerhouse area (i.e. a spill effectiveness rate of 5%), the estimate for whole station survival was the same as that observed under the assumption of 1:1 spill effectiveness.

5.1.4.3 Impacts to Estimated Smolt Survival Associated with Seasonal Flow Assumption

The Initial Injury Rate Model (Model D) for Weston was constructed using the assumption of median Kennebec River flows (i.e. 50% exceedence) during the months of April, May and June. Two “low flow” conditions (75 and 90% exceedence) and two “high flow” conditions (10 and 25% exceedence) were also examined. Estimated monthly Kennebec River flows for the months of April, May and June under the 10, 25, 75, and 90% exceedence conditions are presented in Table 15. Table 28 presents the modeled whole station survival estimates for downstream migrating Atlantic salmon smolts under the additional low and high flow conditions. Under the low flow conditions (i.e. those exceeded 75 and 90 % of the time) the estimated whole station survival for salmon smolts at the Weston Project increased to 84%. Under the high flow conditions (i.e. those exceeded only 10 or 25% of the time) the estimated whole station survival for salmon smolts at the Weston Project decreased or was equal to median flows with estimates of 82% and 83%, respectively.

5.2 Summary of Modeled Estimate of Whole Station Survival for Smolts

Four models of whole station survival of Atlantic salmon smolts at the Weston Project were constructed using available empirical and modeled survival rates for passage via spill and through turbine units. The primary estimates of whole station survival generated by those models ranged from 93% to 83% with modifications during the various sensitivity analyses expanding those bounds to 97% and 82%. Model A (Initial Survival Rate Model) yielded the highest estimate of whole station smolt survival (93%). Model D, the Initial Injury Rate Model (using 1-hr empirical spill and turbine injury rates as a surrogate for survival) produced the lowest estimate of whole station smolt survival. The Initial Injury Rate Model (Model D) was constructed under the assumption that any fish subjected to an injury (regardless of the magnitude of that injury) suffered mortality. It should be noted that comparisons of initial injury assessment and delayed survival rates for Atlantic salmon smolts subjected to mark-recapture spill and turbine passage studies suggest that not all injuries sustained by smolts during dam passage will result in mortality. In addition, the sensitivity analyses for Model D showed an increase in whole station survival as a greater proportion of smolts were passed via turbine units. This was due to the relatively low survival rate (81.6%) when empirical injury data collected at other hydroelectric projects for spill passed salmon smolts was used as a surrogate for survival. The majority of injuries observed for Atlantic salmon smolts passed via spill (Table 5) were minor scale loss and bruising/hemorrhaging. Although some studies have suggested that descaling of smolts may reduce performance and decrease survival during migration (Gadomski et al. 1994; Zydlewski et al. 2010), another study has suggested that the required time (in freshwater) for a smolt to to recover from a loss of scales that would be lethal in saltwater is within one day (Bouck and Smith 1979). While injuries to smolts passed via spill and turbines will lead to mortality for a percentage of individuals, it is likely that the Initial Injury Rate Model (using 1-hr injury rates as a surrogate for survival) underestimates whole station smolt survival at Weston. Model C, the Delayed/Calculated Survival Rate Model provides the most conservative and reliable estimate of whole station smolt survival at Weston (90%).

6.0 Atlantic Salmon Adults and Kelts

6.1 Adult Upstream Migration

6.1.1 Kennebec River Returns

Within the Kennebec River, returning adult salmon are collected at the Lockwood fish lift and are trucked upstream around the Lockwood, Hydro Kennebec, Shawmut, and Weston Projects and are released into the Sandy River. There are no upstream passage facilities at the Weston Project. Collection totals for the previous six years (2006-2011) at Lockwood have ranged from a low of five individuals during 2010 to a high of 64 individuals during 2011 (Table 29). The average adult fork length for years 2006-2011 has ranged between 65.0-73.5 cm and the majority of individuals were aged at 1 or 2 years at sea.

6.1.2 Upstream Migration Delays

Delays to the upstream migration of Atlantic salmon have been observed below hydroelectric facilities. Fay et al. (2006) provided a review of available literature (Dube 1988; Shepard 1989; Shepard and Hall 1991; Shepard 1995) related to the observed passage delays at a number of hydroelectric projects on the Penobscot River. Results from these radio-telemetry studies indicate that the duration of delay varies widely among year and hydroelectric facility. Yearly pooled median passage times for adult Atlantic salmon at Veazie ranged from 4.7 to 33.2 days over five years of study. Yearly pooled median passage times for adult Atlantic salmon at Great Works ranged from 1.4 to 2.7 days over four years of study. Yearly pooled median passage times for adult Atlantic salmon at Milford Dam ranged from 1.0 to 5.3 days over five years of study. A recent (2005/2006) radio-telemetry assessment of upstream passage for Atlantic salmon adults at Penobscot River projects reported individual passage times (defined as interval between first tailrace detection and first upstream detection) for a limited number of fish at Veazie, Great Works and Milford Dams (Holbrook et al. 2009). Individual passage times (2005) for adult salmon approaching Veazie from Penobscot Bay were 2.0 and 3.3 days (for 2 of 4 individuals detected in tailrace) and for salmon approaching Great Works were 1.9, 13.1, and 25.4 days (for 3 of 6 individuals detected in tailrace). Individual passage times for all adult salmon having passed Great Works were 0.1, 2.9, and 3.7 days at Milford. Individual passage times (2006) for adult salmon reapproaching Veazie (following passage over the dam) were 2.1, 6.8 and 58.4 days (for 3 of 7 individuals detected in tailrace) and for salmon approaching Great Works were 8.6, 8.7, and 12.5 days (for 3 of 25 individuals detected in tailrace).

There are no delays to the upstream migration of adult salmon caused by the Weston Project due to the current Kennebec River management practice of trap and truck for returning sea-run Atlantic salmon at the Lockwood Project upstream to the Sandy River.

6.2 Kelt Downstream Migration

Following the fall season spawning period, Atlantic salmon kelts either outmigrate during the fall or remain in the freshwater portion of the river before outmigrating during the following spring. Baum (1997) indicated that following the fall spawn, approximately 20% of kelts move back downstream with the remainder (80%) moving downstream and the following spring. Quantitative data obtained from studies regarding timing, duration and survival of Atlantic salmon kelts during their downstream migration in the Kennebec River and through the Weston Project are unavailable.

Although sample size and information related to passage routes are limited, successful downstream passage through four hydroelectric projects on the lower Kennebec River was observed for a single kelt radio tagged as part of a study on the Sandy River (MDMR 2009). A total of 18 sea-run Atlantic salmon were captured at the Lockwood Project, radio tagged and trucked to the Sandy River during the spring seasons of 2007 and 2008 (MDMR 2008, MDMR 2009). The majority (8 of 9) of those fish were determined to have remained in the Sandy River through the spawning season during both years. A single individual released in the Sandy River during early June 2008 successfully passed downstream of the Weston Project and was located in the mainstem of the Kennebec River during August and September of 2008. That same individual was next detected downstream of Lockwood during January 2009. Detection of that fish below Lockwood demonstrates that it successfully passed downstream past the Weston, Shawmut, and Lockwood projects as well as Hydro Kennebec (owned and operated by Brookfield Power).

6.3 Modeled Downstream Migrating Kelt Survival

Limited data for Atlantic salmon kelts make it difficult to assess the specific effects of the Weston Project on kelt survival. Observations on the Penobscot and other river systems in the Northeast suggest that kelts tend to linger in spawning areas and in parts of the freshwater river system, including hydropower impoundments and facilities. Similar to the behavior recorded on the Penobscot River, anecdotal observations by Normandeau personnel working on the Merrimack River, NH have noted adult salmon to remain within the forebay canal of the Garvins Falls Project and individuals are often visible within the upper portion of the water column at that site. Kelts are not thought to sound frequently and that notion is supported through the reduction in turbine passage at Weldon following the installation of tightly spaced 1 in trashracks over the upper 16 feet of the intakes. In addition, adult salmon are strong swimmers and have the ability to avoid turbine intakes. Observed burst speeds for adult salmon range between 14.1 to 19.7 ft/s with a maximum sustained swim speed of 3.4 f/s (Beamish 1978). These behaviors suggest that salmon could be successful at locating and using surface bypasses. Similar to the whole station survival estimate generated for outmigrating Atlantic salmon smolts in Sections 4.0 and 5.0 of this report, this section will attempt to predict kelt survival at the Weston Project. Where passage related data is unavailable for the kelt life stage, it will be assumed that outmigration behaviors are similar to those of the smolt life stage.

6.3.1 Kelt Run Timing

In order to model whole station survival for Atlantic salmon kelts passing the Weston Project, it is necessary to know the timing and seasonal distribution of their downstream migration. Seasonal distribution data for kelt downstream migration specific to the Kennebec River is unavailable. Baum (1997) indicated that following the fall spawn, approximately 20% of kelts move back downstream and into the ocean but the majority move back downstream and into the ocean the following spring. Based on observations during MDMR redd surveys, outmigration of kelts immediately following the fall spawn occurs during the latter half of October, November, and the first half of December (N. Dube, MDMR, personal communication). For the purposes of estimating whole station kelt survival at Weston, it was assumed that the percentage of the total kelt outmigration occurring during the fall (20%) would be partitioned among the known salmon outmigration months of October (5%), November (10%), and December (5%). Likewise, the percentage of the total kelt outmigration occurring during the spring (80%) would be divided between the known salmon outmigration months of April (40%) and May (40%). Variations in this seasonal distribution and their impacts to whole station survival are examined in Section 7.1.1.2 of this report.

6.3.2 Kennebec River Flows

Flow duration curves were obtained for the Kennebec River at the Weston Project during the months of April, May, October, November, and December (D. Dow, NOAA, personal communication). Weston Project flow duration curves were based on the flow record for the period 1979 through 2010. A description of the methodology used in the development of these curves can be found in Appendix B of this report. For the purposes of modeling project survival of Atlantic salmon kelts migrating past the Weston Project, the median monthly flow condition (i.e. the value with 50% flow exceedence) was used. Median flow conditions at the Weston Project used to estimate whole station survival for outmigrating kelts were the same as those used for smolts during the spring months of April and May (Section 4.2). The median monthly condition for April was approximately 12,250 cfs (Figure 3), during May was approximately 8,500 cfs (Figure 4), during October was approximately 4,250 cfs (Figure 7), during November was approximately 5,750 cfs (Figure 8), and during December was approximately 5,500 cfs (Figure 9). Impacts to the model of whole station kelt survival during years of high flow (10 and 25% flow exceedence) and low flow (75 and 90% flow exceedence) are examined in Section 7.1.1.3 of this report.

6.3.3 Kelt Downstream Route Determination

Similar to the assumption for outmigrating smolts, it was assumed that river discharge during the months of October, November, December, April and May will dictate the proportion of Atlantic salmon kelts passed downstream of the Weston Project though the spillway (and conversely, through the powerhouse or downstream passage facility). This is likely a conservative estimate given the strong swimming ability of adult salmon and their behavioral reluctance to sound. Determination of the spill effectiveness, defined as the proportion of kelts passed through spill relative to the total number passing the project, is the first step in assessing whole station survival. As was done for smolts, it was assumed that the Project spillway has a 1:1 ratio of percent total fish to percent total river flow passed (i.e., spilling 50% of total river flow results in 50% of kelts passing via the spillway). An overall spill effectiveness for the outmigration months of October, November, December, April and May of 32.2% was used for the assessment of whole station kelt survival at Weston. This value was calculated using a Project capacity of 6,000 cfs, the monthly distribution of Atlantic salmon kelt outmigration (Section 6.3.1), monthly median Kennebec River flow conditions (Section 6.3.2) and the assumption of 1:1 spill effectiveness. Table 30 provides a summary of that calculation as well as the monthly values used for the assessment of Weston Project spill effectiveness for kelts.

6.3.4 Kelt Downstream Bypass Efficiency

Given the lack of downstream bypass efficiency studies for Atlantic salmon kelts at the NextEra Projects on the Kennebec River the guidance efficiency rate used for the smolt model (Section 4.4) was used as a surrogate value for estimation of whole station survival for kelts. That efficiency rate was based on the assumption that the distribution of smolt passage was equal to the distribution of outflow. Sluice capacity for the current downstream passage system at the Weston Project is 120 cfs. The downstream bypass efficiency rate was allowed to vary by month to account for occasions when river discharge was less than the Project operating flow. For example, as presented in Table 30, the monthly median Kennebec discharge (cfs) values during April and May were greater than the Project operating flow of 6,000 cfs. In those instances, the downstream bypass efficiency rate (assuming passage distribution of smolts through the powerhouse is equal to the distribution of outflow through the powerhouse and downstream bypass) was calculated as 2.0% ((120 cfs/6,000 cfs)*100 = 2.0%). However, during October, the monthly median Kennebec discharge (cfs) value was 4,250 cfs. For that month, the downstream bypass efficiency rate (assuming passage distribution of kelts through the powerhouse is equal to the distribution of outflow through the powerhouse and downstream bypass) was calculated as 2.8% ((120 cfs/4,250 cfs)*100 = 2.8%). The remainder of the powerhouse area flow passes via the turbine units. Variations in bypass efficiency and their impacts to whole station survival for kelts are examined in Section 7.1.1.1 of this report.

6.3.5 Kelt Spillway and Downstream Bypass Passage Survival Assessment

The Weston Project spillway sections dam the river on either side of a small island. The North channel dam consists of an Obermeyer inflatable dam section and two taintor gates (28 ft wide by 16 ft high). The South channel dam has a single taintor gate (18 ft wide by 14 ft high) at the sluiceway.

Based on the lack of survival studies conducted for Atlantic salmon kelts at the NextEra and other hydroelectric projects, it was assumed that survival for Atlantic salmon kelts passing the Project via the downstream bypass or spillway was 96.3%. That value was based on a review of empirical studies conducted for Atlantic salmon smolts passed through sluices and bypasses at five different hydroelectric projects (See Section 4.5). Delayed survival (48-hr) estimates for Atlantic salmon smolts following passage through sluiceways and bypasses ranged from 91.1 to 100.0%, resulting in a mean overall spill survival of 96.3%.

6.3.6 Kelt Entrainment Rates and Turbine Passage Survival

The Weston powerhouse contains a total of four vertical Francis units and has a total Project generating capacity of 13.2 MW. Maximum capacity (cfs) ranges from 1,822-1,498 cfs for the four vertical Francis units (Table 7). Total unit flow for the Project is approximately 6,000 cfs. Normal operating head for the Weston Project is approximately 34 ft. The trash racks screening the intakes in front of Units 1-4 are 4 in clear spacing. Additional turbine characteristics for Weston Units 1-4 are provided in Table 7.

Turbine Entrainment Rates

Empirical data related to the route selection of Atlantic salmon kelts using the Weston turbine units to move downstream of the project does not exist. As a result, it was assumed (for modeling purposes) that the distribution of kelt passage is equal to the distribution of outflow. Turbine entrainment rates at the Weston Project were calculated on a monthly basis as 100% minus the downstream bypass efficiency rate.

Ten records of adult Atlantic salmon total lengths (762 – 821mm) and maximum body widths (79-100mm) were obtained from sea-run returns to the Deerfield River during spring 2011 (B. Hanson, Normandeau, personal communication). Total lengths from that data set were converted to fork lengths using the equation FL = 0.9173TL (Carlander 1969) where FL = fork length and TL = total length. The linear relationship for the log-transformed (ln) fork length and body width was determined to be ln(width) = 1.3113(lnFL) – 4.1717. Although the relationship was weak (r^2 = 0.155), it was used to predict body widths for theoretical salmon fork lengths to determine the longest fork length that would fit through the 4 in trash rack spacing in front of Units 1-4 . Based on that relationship, it was determined that adult Atlantic salmon with a fork length of greater than 32.5

inches would have achieved a body width greater than the 4 in trash rack spacing at Weston Units 1-4.

Fork length data was obtained for sea-run Atlantic salmon returns collected within the Kennebec and Sebasticook Rivers during the years 2006-2010 (P. Christman, MDMR, personal communication) as well as at the Veazie fishway trap on the Penobscot River for the years 1978-2009 (J. Murphy, NMFS, personal communication). Fork lengths recorded for returning Atlantic salmon (86 individuals) to the Kennebec drainage had a mean fork length of 27.3 in (range 19.7-34.3 in). Fork lengths recorded for 25,721 individual Atlantic salmon to the Penobscot River ranged from 15.7-40.9 in (mean 27.5in).

The length-frequency distribution for sea run returns to the Penobscot River was used as a surrogate for outmigrating kelts on the Kennebec due to the robust nature of the data set. It was assumed that fork lengths of kelts approaching the Francis units at Weston would be of a similar length-frequency distribution to that of the Penobscot River data set. For Atlantic salmon kelts approaching the Francis units, 97.6% of individuals were predicted to pass through the 4 in trash racks and be subjected to turbine passage. The remaining 2.4% would be excluded from turbine passage and were assumed to pass via bypass spill.

Turbine Passage Survival

Kelt survival estimates for turbine passage were generated for the four Francis units in operation at Weston using the same equations (Franke et al. 1997) as used for smolts and detailed in Section 3.3.2 of this report. Estimates for Atlantic salmon kelts passing through the Francis units were calculated for five body lengths considered representative of individuals capable of passing through 4 in trash racks (16, 20, 24, 28, and 32 inches). Two correlation factors (λ) were used in this analysis (0.1 and 0.2). Survival estimates for Weston units 1-4 were modeled using the maximum turbine discharge (cfs) and the associated efficiency.

Model runs for five body lengths and two correlation factors resulted in a total of 10 survival estimates which are likely to bracket the actual survival for Atlantic salmon kelts passing through Francis units 1-4 at the Weston Project. Predicted survival values for salmon kelts capable of passing through the 4 in trash racks screening the Weston Francis units ranged from a high value of 85.2% for a 16 inch kelt to a low value of 13.0% for a 32 inch kelt (Table 31). The range of survival estimates were somewhat similar for Francis Units 1-4 and the predicted survival probability increased as kelt body length decreased. The average survival of salmon kelts passing through the Francis units at Weston was determined by averaging the 10 modeled survival estimates for each unit. Those values ranged from a high of 66.6% at Unit 3 to a low of 51.1% at Unit 2 with an overall calculated mean survival of 59.6% for Atlantic salmon kelts passing through the Weston Francis units.

7.0 Estimated Project Impact on Outmigrating Atlantic Salmon Kelts

7.1 Modeled Estimate of Whole Station Survival for Kelts

Whole station survival for outmigrating kelts at the Weston Project was estimated by integrating Kennebec River flows, Project operating flows, the proportion of kelts diverted towards the spillway and powerhouse, spillway survival rate (as estimated from empirical data for smolts), screening effectiveness of turbine trash racks, turbine passage survival rates (as estimated by modeled data), bypass guidance efficiency, and fish bypass passage survival rate (as estimated from empirical data for smolts). The following values for each of the above parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in the calculations of whole station survival for salmon kelts at Weston Project:

7.1.1 Modeled Estimate of Whole Station Survival for Kelts

Whole station kelt survival was modeled using delayed (48-hr) smolt survival rates for spill obtained from empirical data collected at other hydroelectric projects and model derived estimates for turbine passed fish. The following values for each of the necessary model parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in this calculation of whole station survival for salmon kelts at Weston Project:

- Kennebec River Flow – monthly medians of 12,250 cfs (April), 8,500 cfs (May), 4,250 cfs (October), 5,750 cfs (November), and 5,500 (December);
- Project operating flow – 6,000 cfs;
- Proportion of kelts diverted – utilized a ratio of 1:1 fish to river flow;
- Project spillway survival – 96.3% (based on review of delayed (48-hr) empirical survival data for smolts from other hydroelectric projects);
- Fish bypass guidance efficiency – as determined on a monthly basis based on the relationship of bypass discharge (60 cfs) and Project operating flow;
    - April: (120 cfs / 7,800 cfs)*100 = 0.8%
    - May: (120 cfs / 7,800 cfs)*100 = 0.8%
    - October: (120 cfs / 3,820 cfs)*100 = 1.6%
    - November: (120 cfs / 6,670 cfs)*100 = 0.9%
    - December: (120 cfs / 6,400 cfs)*100 = 0.9%
- Entrainment rate through turbines – as determined on a monthly basis as 100% - fish bypass guidance efficiency
    - April: 100% - 0.8% = 99.2%
    - May: 100% - 0.8% = 99.2%
    - October: 100% - 1.6% = 98.4%
    - November: 100% - 0.9% = 99.1%
    - December: 100% - 0.9% = 99.1%
- Proportion of kelts screened from passage through turbines – based on Penobscot River length-frequency data and derived FL-width relationship

- Francis turbine passage survival – 59.6% (based on modeled values generated using site-specific turbine parameters);
- Fish bypass system survival – 96.3% (based on review of delayed (48-hr) empirical survival data for smolts from other hydroelectric projects).

The integration of the above values is provided in Table 32 for a hypothetical case of 100 Atlantic salmon kelts approaching the Weston Project during the outmigration period (April-May, October-December). The whole station survival estimate for Atlantic salmon kelts passing the Weston Project generated using delayed (48-hr) empirical data for spillway and modeled turbine survival estimates is 73%.

7.1.1.1 Impacts to Estimated Kelt Survival Associated with Bypass Efficiency Assumption

The model for estimating whole station survival for outmigrating kelts at Weston can be manipulated to provide insight into potential impacts to whole station survival based on modifying the various input parameters. The Licensee has installed a new downstream bypass facility and guidance device during 2011. The new guidance device consists of a 10 ft deep floating guidance boom leading outmigrating salmon to the existing sluice adjacent to Unit 4. The floating guidance boom at the Weston Project should lead to increased effectiveness of the downstream bypass and reduced impact of turbine passage on outmigrating salmon. Table 33 provides whole station survival estimates for a range of theoretical bypass efficiency rates. Theoretical bypass effectiveness rates between 25 and 100% were modeled and produced a range of whole station survival estimates for outmigrating Atlantic salmon kelts between 78% and 96%.

7.1.1.2 Impacts to Estimated Kelt Survival Associated with Seasonal Distribution Assumption

In cases with no site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (e.g., spilling 50% of total river flow results in 50% of fish passing via the spillway). A basic implication of the deviation from the 1:1 assumption is that if a proportionally smaller percentage of kelts relative to the river flow enter the Project powerhouse area then the calculated station-related kelt survival would be higher. Under these conditions, a greater percentage of kelts would pass the project via spill and would avoid impacts associated with turbine passage. Alternatively, if a proportionally higher percentage of kelts are entering the Project powerhouse area than the calculated station related kelt survival would be lower. Under these conditions, a lower percentage of kelts would pass the project via spill and a greater number would be entrained through the Project turbines.

Potential impacts to the model estimating whole station kelt survival associated with deviation from the assumed 1:1 ratio of fish to flow at the Weston Project are presented in Table 34. A range of spill effectiveness rates for Atlantic salmon kelts from 5% (0.2:1) to 90% (2.8:1) was evaluated. For conditions where a proportionately lower percentage of kelts relative to river flow entered the powerhouse area (i.e. spill effectiveness rates of 50, 70, and 90%), the estimates for whole station survival were greater than that observed under the assumption of 1:1 spill effectiveness and ranged from 79% to 93%. For conditions where a proportionately higher percentage of kelts relative to river flow entered the powerhouse area (i.e. spill effectiveness rates of 5% or 10%), the estimates for whole station survival was lower (63% and 65%, respectively) than that observed under the assumption of 1:1 spill effectiveness.

7.1.1.3 Impacts to Estimated Kelt Survival Associated with Seasonal Flow Assumption

The model for estimating whole station survival for outmigrating kelts at Weston was constructed using the assumption of median Kennebec River flows (i.e. 50% exceedence) during the months of April, May, October, November, and December. Two "low flow" conditions (75 and 90% exceedence) and two "high flow" conditions (10 and 25% exceedence) were also examined. Estimated monthly Kennebec River flows for the months of April, May, October, November, and December under the 10, 25, 75, and 90% exceedence conditions are presented in Table 35. Table 36 presents the modeled whole station survival estimates for downstream migrating Atlantic salmon kelts under the additional low and high flow conditions. Under the low flow conditions (i.e. those exceeded 75 and 90 % of the time) the estimated whole station survival for salmon kelts at the Weston Project decreased to 65% and 62%, respectively. Under the high flow conditions (i.e. those exceeded only 10 or 25% of the time) the estimated whole station survival for salmon kelts at the Weston Project increased to 86% and 81%, respectively.

7.2 Summary of Modeled Estimate of Whole Station Survival for Kelts

A single model of whole station survival of Atlantic salmon kelts at the Weston Project was constructed using available empirical and modeled survival rates for passage via spill and through turbine units. Where data was unavailable for the kelt lifestage, empirical data from smolt studies was used as a surrogate. The model constructed for whole station survival of Atlantic salmon kelts at the Weston Project generated a survival estimate of 73% with modifications during the various sensitivity analyses expanding those bounds to 62%- 96%. A percentage of kelts will over winter in freshwater and resume feeding following the fall spawn (Danie et al. 1984). Although mortality is high upon reentry to saltwater, a percentage of kelts which successfully migrate to ocean feeding grounds may become repeat spawners (Danie et al. 1984). Baum (1997) states that repeat spawners can reach weights approaching 30 pounds and contain an average of approximately 11,300 eggs. For comparison, a first time returning two sea-winter salmon will contain an average of approximately 7,500 eggs. In the National Research Council's book "Atlantic Salmon in Maine" (NRC 2007) it was stated that most Atlantic salmon are semelparous, spawning once and then dying. It was estimated that 1%-6% of anadromous Atlantic salmon are iteroparous and will survive to make a second spawning run the following year. Baum (1997) notes that data collected during the 1960's and 1970's suggested that 5-10% of the salmon run in Maine rivers was composed of repeat spawners. Baum (1997) indicates that value has declined in recent years to less than 1% due primarily to commercial fisheries during the 1960's to early 1990's. During the five year period (1992-1996) wild salmon repeat spawners in the Magaguadavic River (New Brunswick) were noted to represent an overall percentage of 6% (Carr et al. 1997). Within the Miramichi River, considered to have the largest run of Atlantic salmon in eastern North America, the proportion of repeat spawners within the annual run has ranged from a low of approximately 2% to a high of approximately 53% during the forty year period of 1970-2010 (Chaput and Douglas 2010). The proportion of repeat spawners within the Miramichi River was greater than 10% during 34 of the 40 years, greater than 20% during 22 of the 40 years, greater than 30% during 16 of the 40 years, greater than 40% during 6 of the 40 years and greater than 50% during 2 of the 40 years.

8.0 Predation

8.1 Smolt Predation

The smolt survival model presented in Section 5.0 of this report represents mortality associated directly with smolt/Project interactions and does not account for indirect mortality (such as predation). Atlantic salmon smolts are a potential food source for a number of fish (i.e. black bass, northern pike), avian (i.e. cormorants, gulls and osprey) and mammalian predators which may frequent the Kennebec River below the Weston Project. However, direct quantification of predation rates for Atlantic salmon smolts passing the Weston Project is not available.

Due to the lack of predation rate data for outmigrating salmon smolts in the Kennebec River, a rate was estimated based on that used for Habitat Conservation Plans for the Rocky Reach hydroelectric project on the mid-Columbia River, Washington. Combined predation (upstream and downstream) for that project was estimated at 2.0% of smolts and was derived from site-specific empirical data as well as observations at other Columbia River hydroelectric projects (S. Hayes, personal communication). In the Columbia River, predation on juvenile salmonids by piscivorous fishes has been investigated in detail (Rieman et al 1991; Zimmerman 1999) and has resulted in an extensive management program to control smolt loss to predation by northern pikeminnow (Beamesderfer et al. 1996; Friesen and Ward 1999).

Given the absence of site-specific data, an estimate of 1.0% loss was used to represent predation that may occur in the tailwater area. This was based on the absence of a major controlling predator such as the northern pikeminnow on the Columbia River.

In addition to predation in the hydroelectric project tailwaters, outmigrating Atlantic salmon smolts are also subjected to predation within the impounded river portions located upstream of hydroelectric projects (Ruggles 1980; Blackwell et al. 1997; Jepsen et al. 1998). Although not intended to directly assess predation rates, the release of radio-tagged smolts into impounded portions of the Kennebec River upstream of the Lockwood and Hydro-Kennebec (owned and operated by Brookfield Power) Projects can be used in an attempt to estimate impoundment predation. During May and June, 2011, a total of 98 radio-tagged smolts were released into the impoundment approximately 0.6 miles upstream of the Hydro-Kennebec Project. Of those smolts, only 3 individuals (3.1%) did not pass the Project and may have been predated. Similarly, a total of 60 radio-tagged smolts were released into the impoundment approximately 0.5 miles upstream of the Lockwood Project. Of those smolts, only 1 individual (1.6%) did not pass the Project and may have been predated. A total of 22 radio-tagged smolts were released into the impoundment approximately 0.5 miles upstream of the Lockwood Project during the 2007 (Normandeau 2008) bypass efficiency evaluation. During that study, no individuals released in the impoundment above Lockwood were reported to have not passed the Project. It should be noted that these telemetry studies were not intended to directly assess natural predation rates and other factors such as tag retention, desmoltification, or behavioral differences associated with having been hatchery-reared may factor into the lack of downstream movement observed for some smolts. Based on the limited rates of loss for radio-tagged smolts in Kennebec River impoundments (3.1%, 1.6%, and 0.0%) a mean average rate of 1.6% was estimated for predation on Atlantic salmon smolts that may occur in the impoundment area.

8.2 Adult Predation

Outmigrating adult Atlantic salmon potentially delayed by the presence of the Weston Project may be exposed to predation risks. Atlantic salmon adults are a potential food source for a limited number of mammalian predators which may frequent the Kennebec River above the Weston Project. Additionally, mortality associated with catch and release angling injuries or poaching may also impact adult salmon delayed upstream of the Project. At this point, absent any data, it is unreasonable to assign a predation rate to adult salmon delayed upstream of the Weston project.

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FIGURES

Figure 1. Design plan and project layout of the Weston Project.

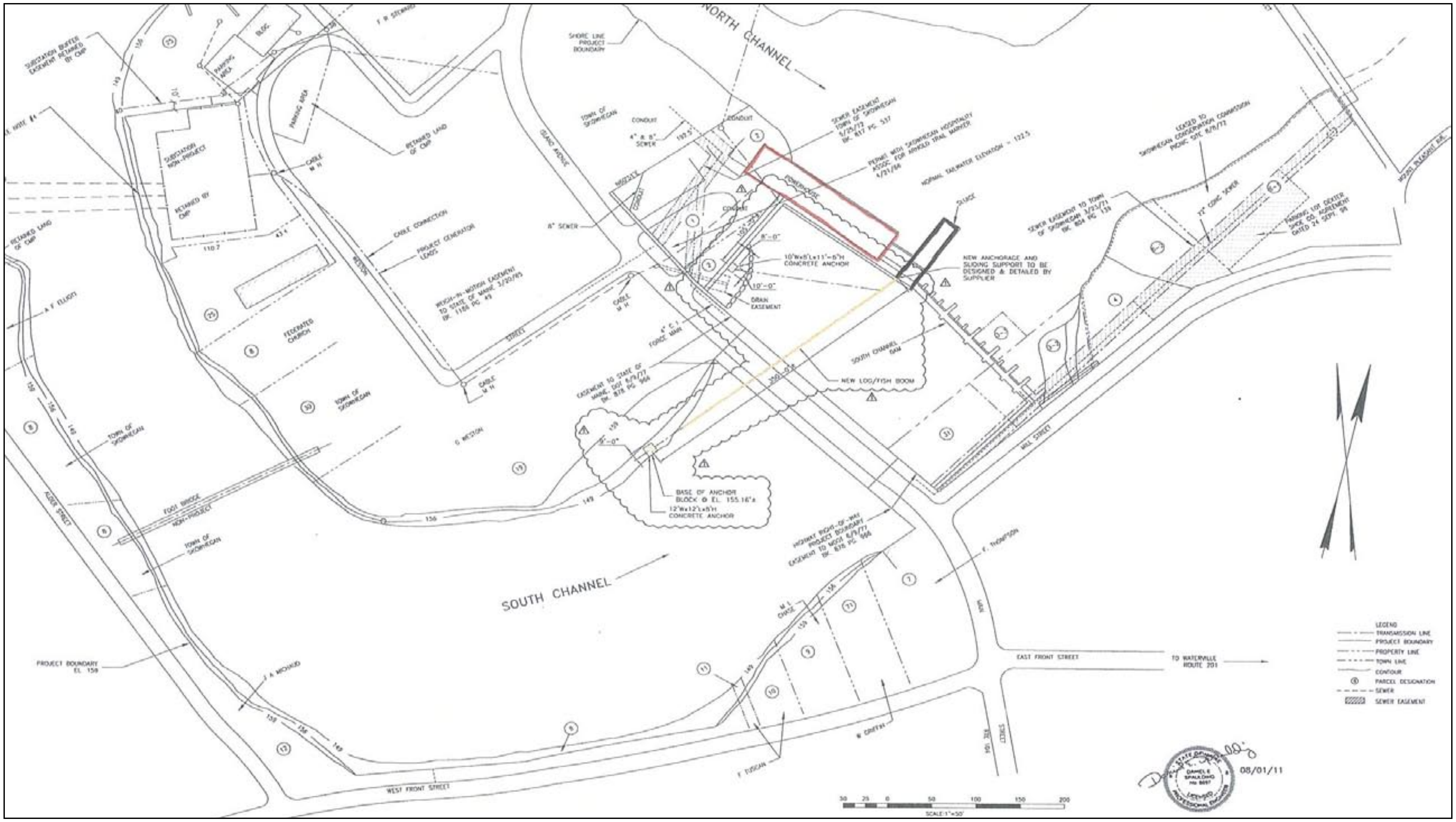


Figure 2. Potential downstream passage routes at the Weston Project.

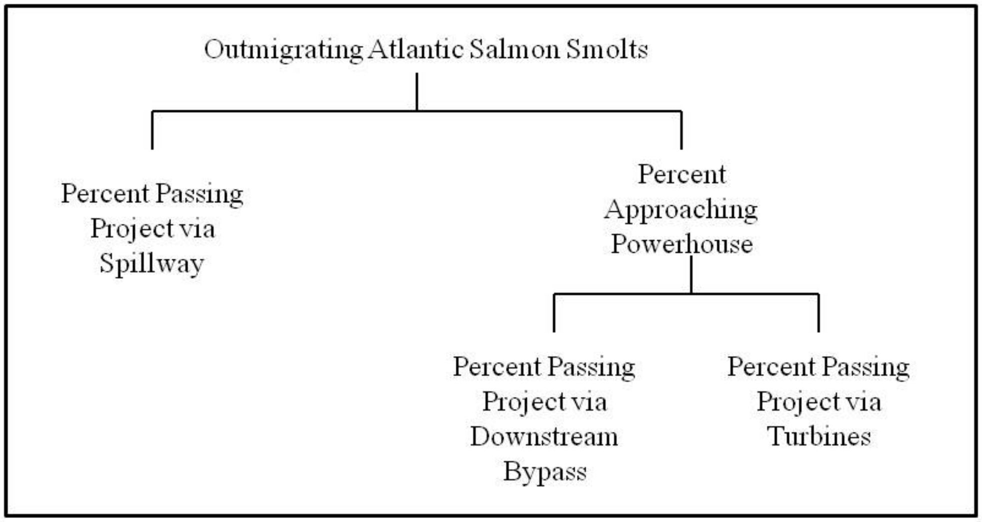


Figure 3. Kennebec River (Weston Project) flow duration curve for April.

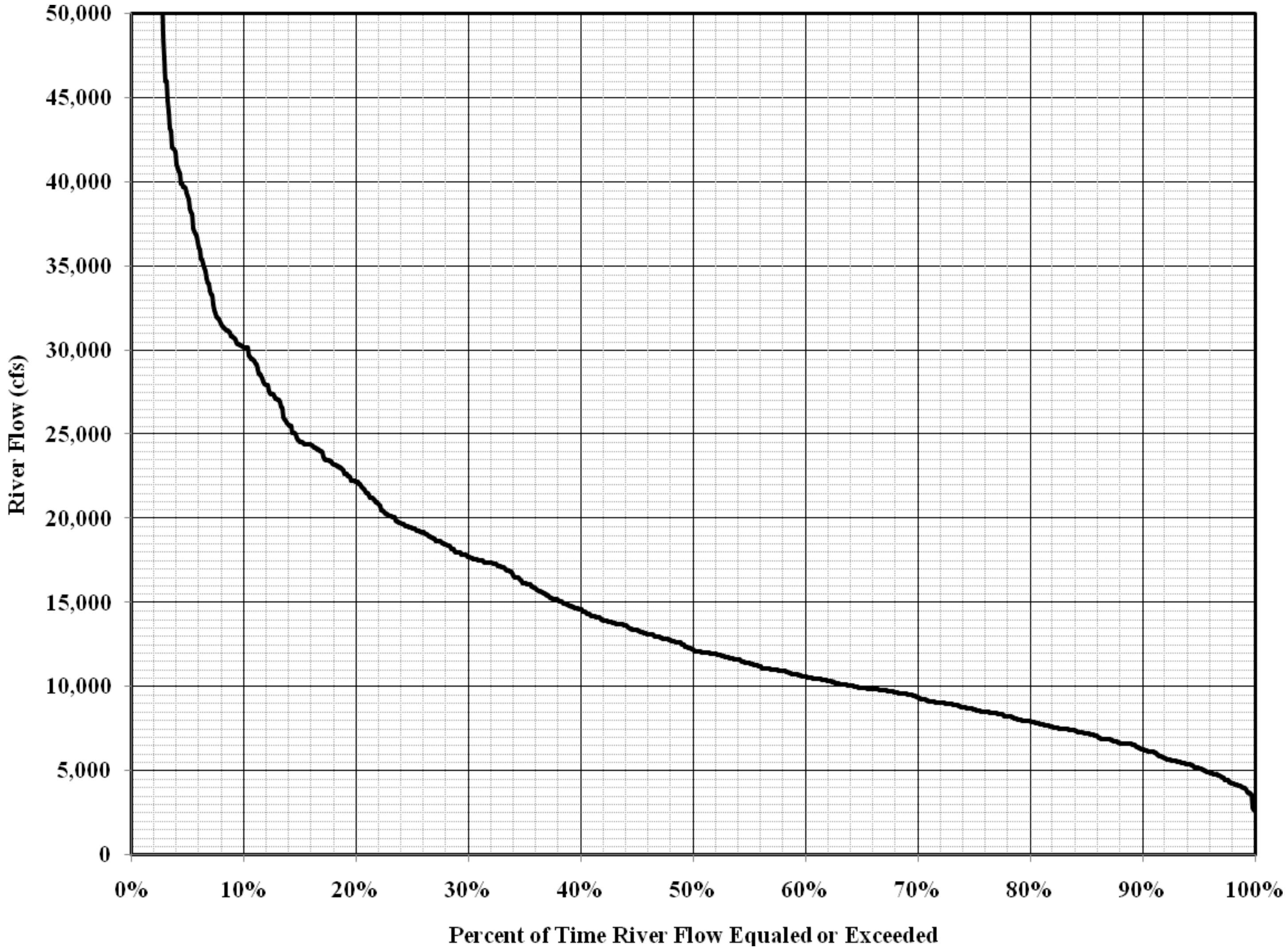


Figure 4. Kennebec River (Weston Project) flow duration curve for May.

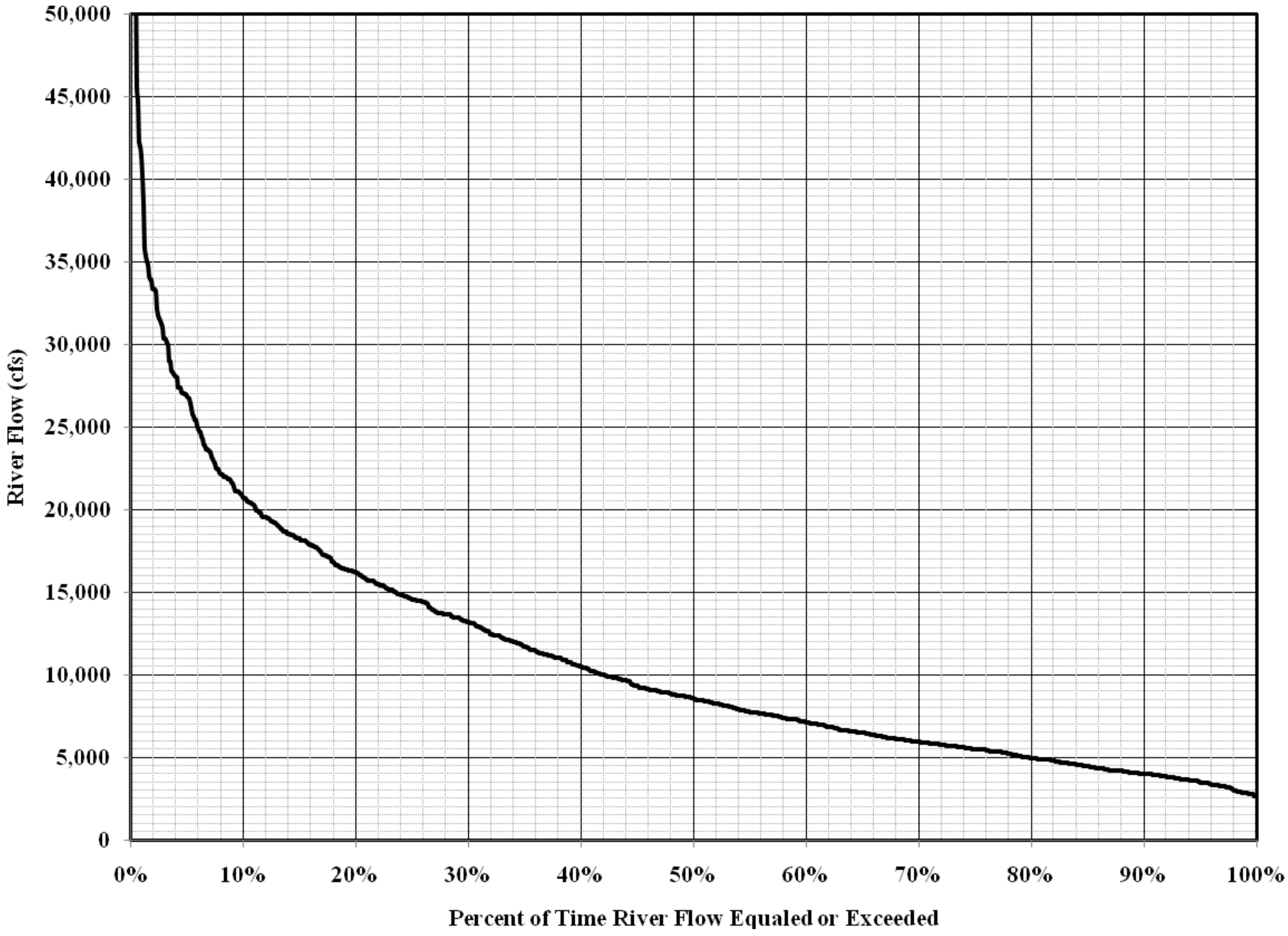


Figure 5. Kennebec River (Weston Project) flow duration curve for June.

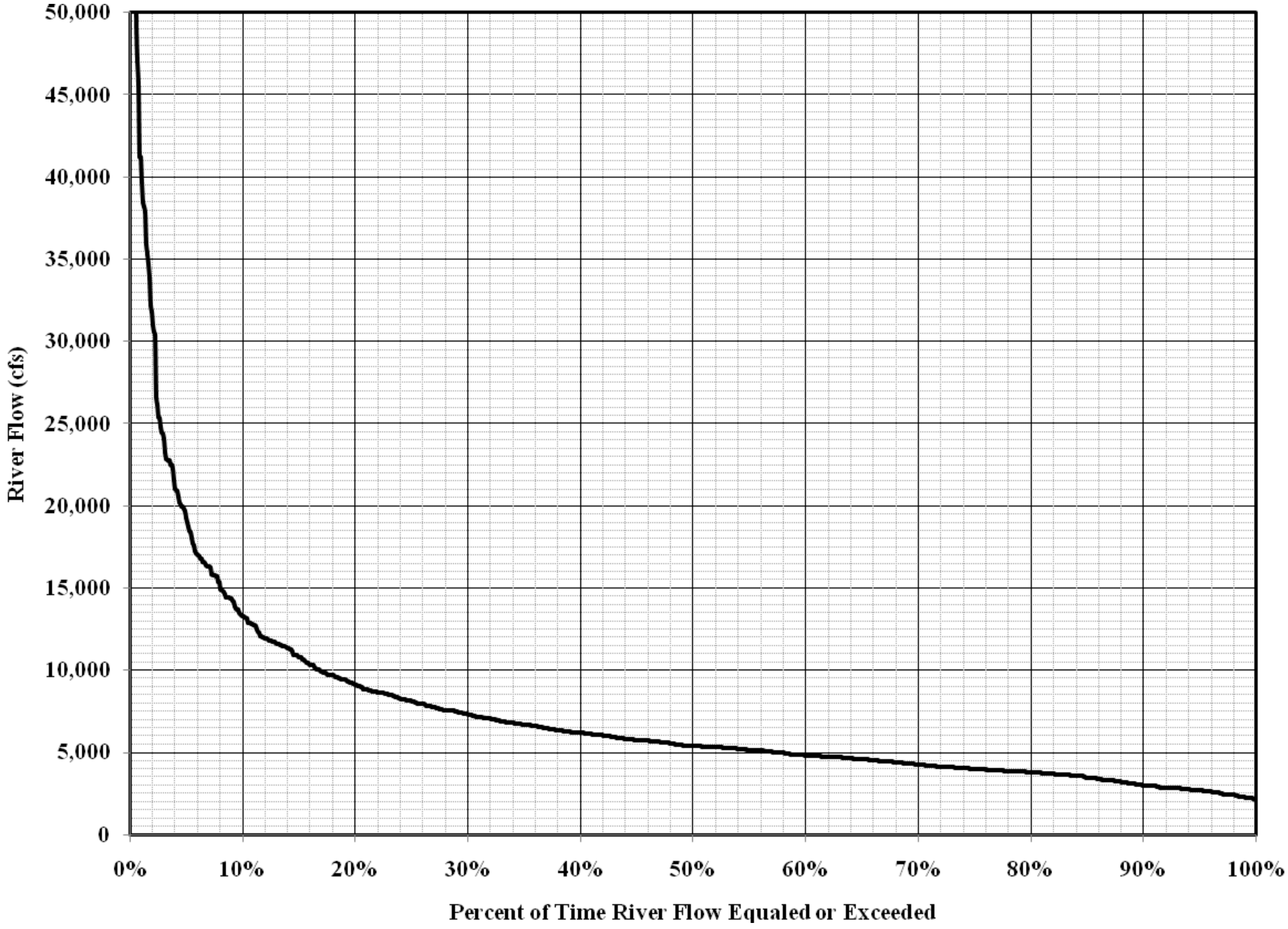


Figure 6. Smolt capture data from 2004 for the Narraguagus, Pleasant and Penobscot Rivers, Maine. Reprinted from USASAC 2005 Annual Report.

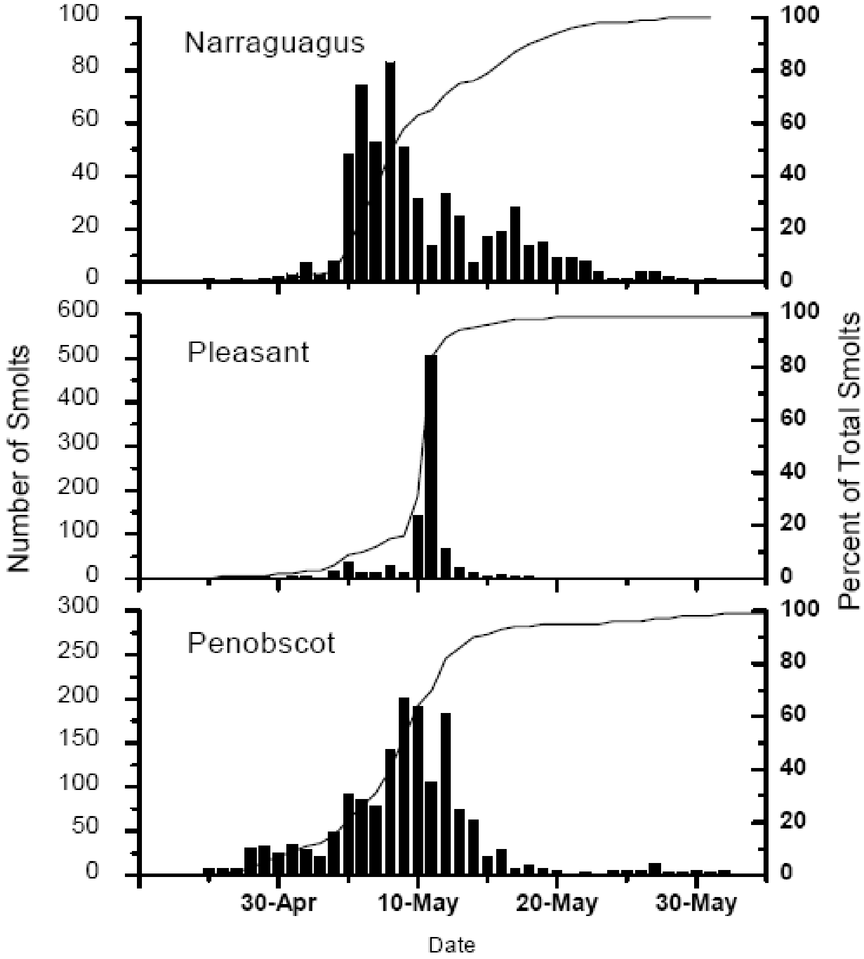


Figure 7. Kennebec River (Weston Project) flow duration curve for October.

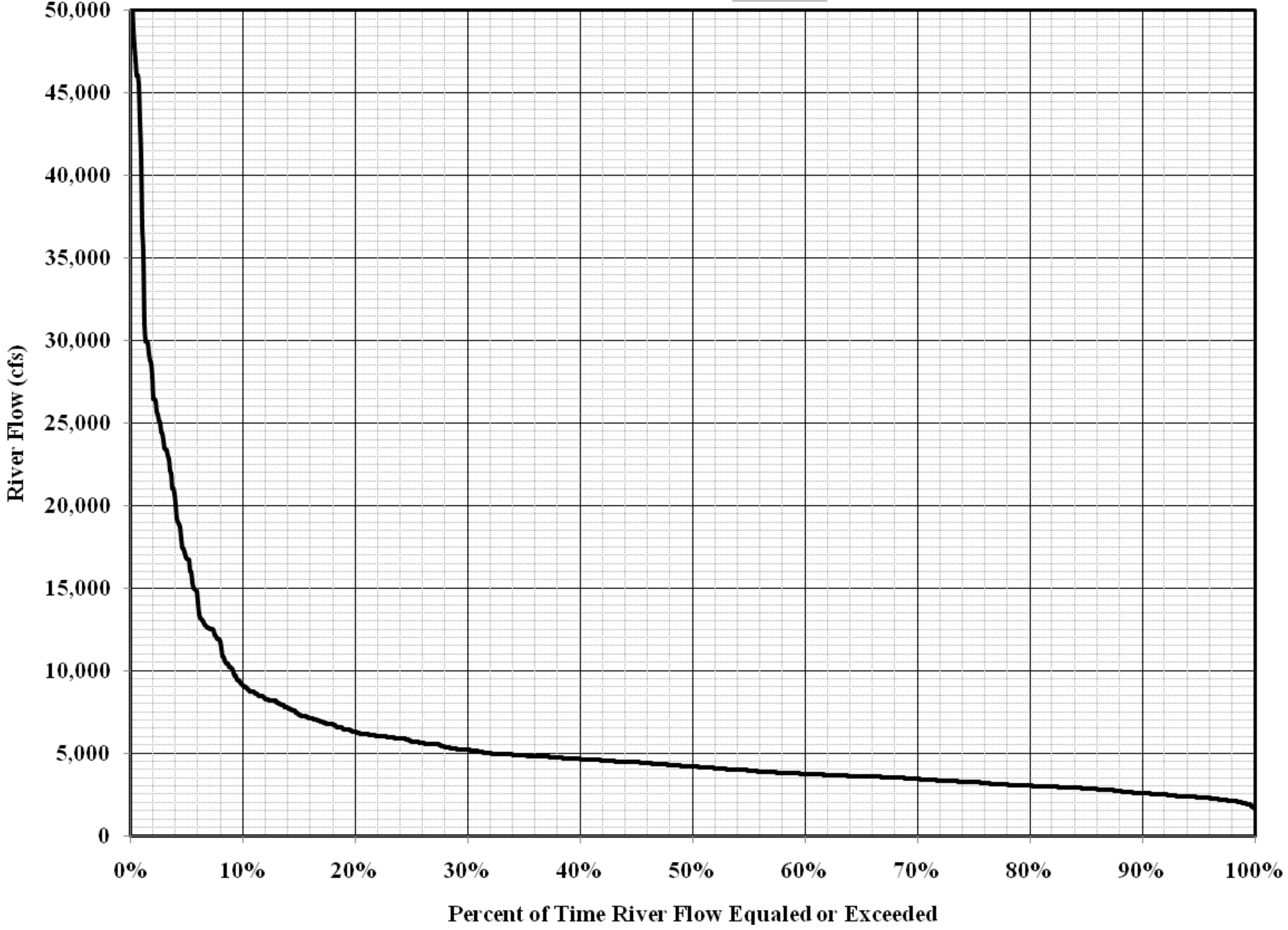


Figure 8. Kennebec River (Weston Project) flow duration curve for November.

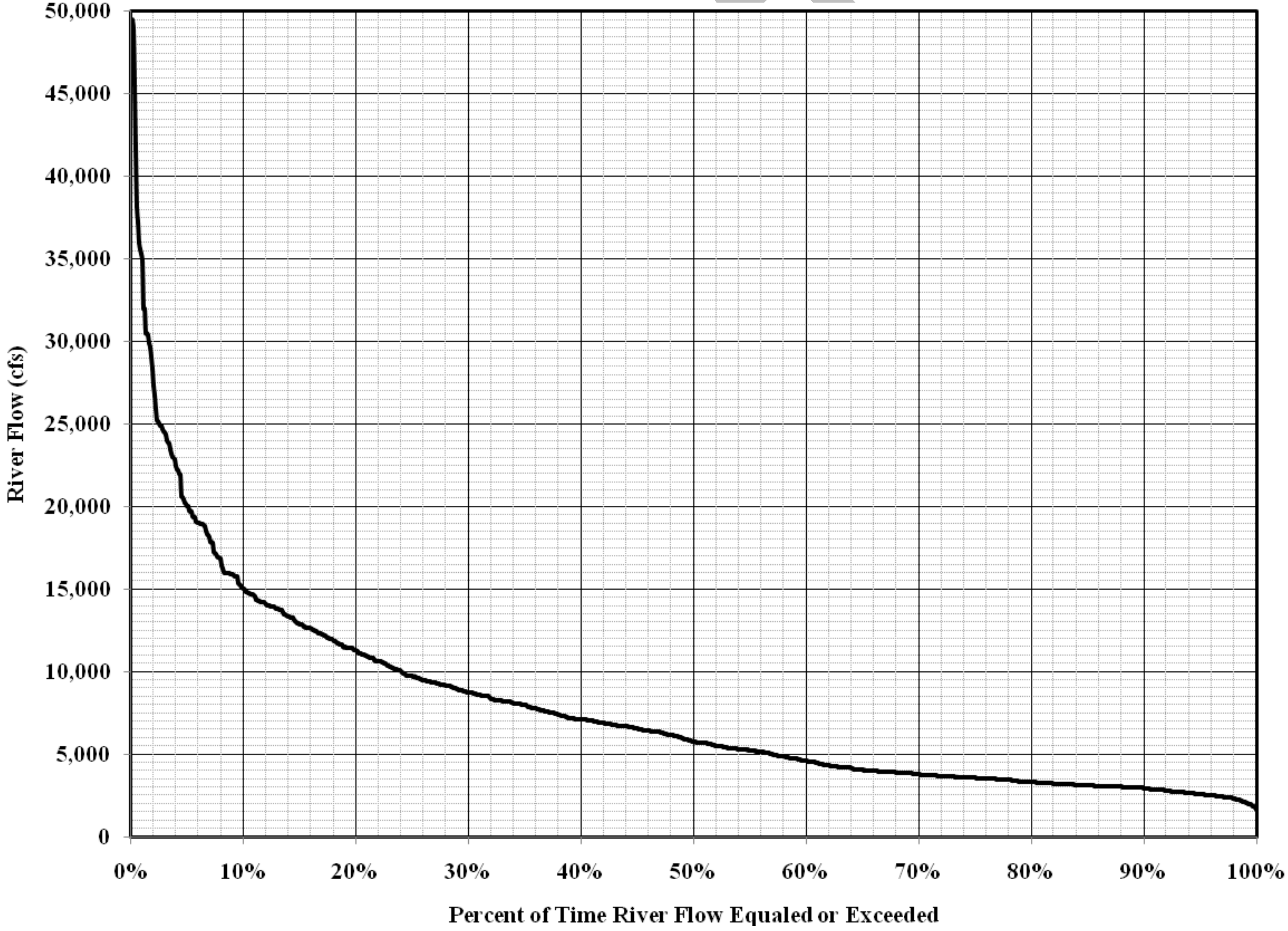
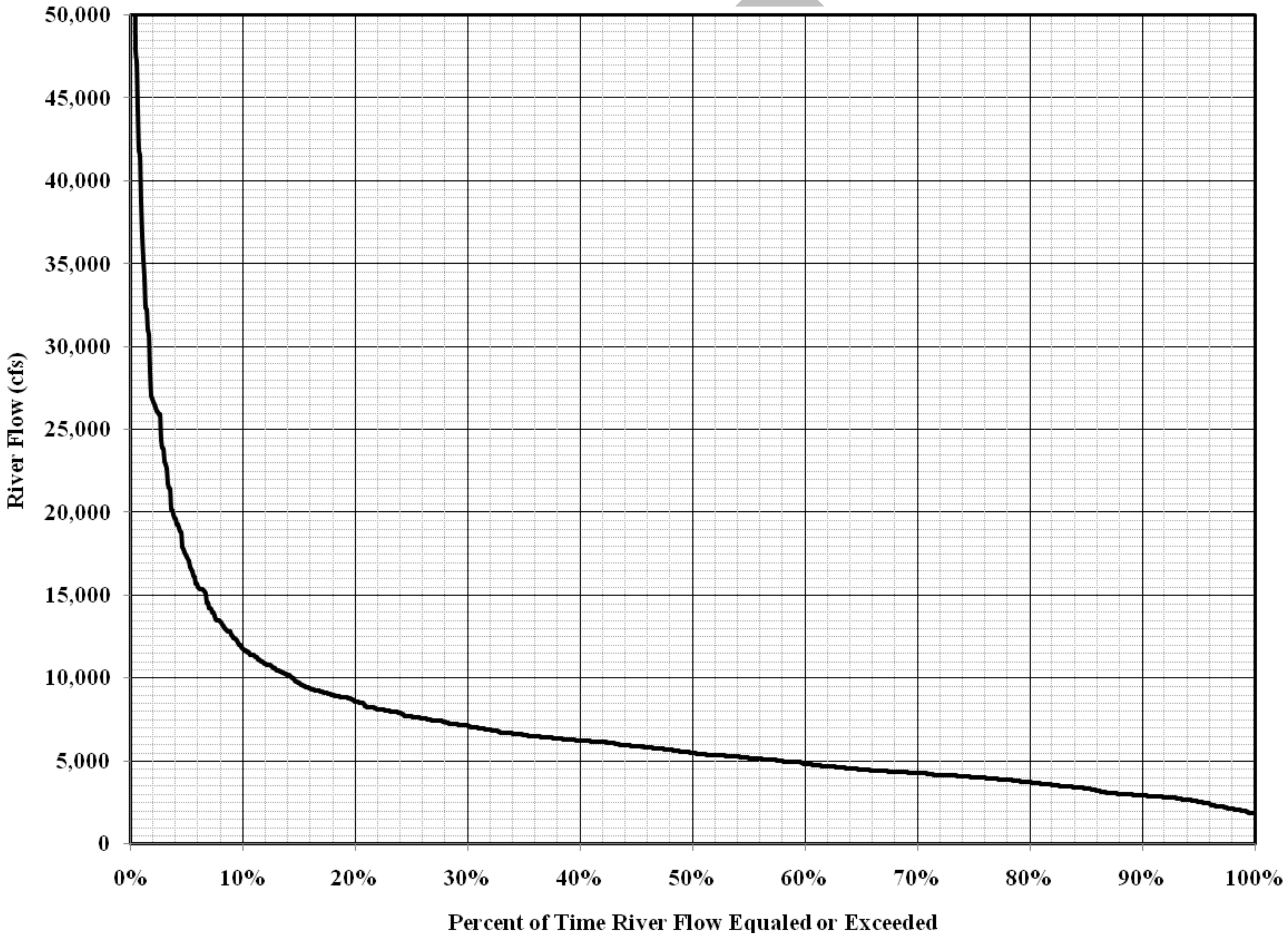


Figure 9. Kennebec River (Weston Project) flow duration curve for December.



TABLES

Table 1. Number of individuals collected and seasonal timing of downstream migration of Atlantic salmon smolts at the Mattaceunk Project (Weldon Dam) on the Penobscot River. Note: NS = no sample; data is reprinted from GNP 1997.

3-Days Starting	Sample Year					
	1995	1994	1993	1990	1989	1988
1-Apr	NS	0	0	0	NS	0
4-Apr	NS	0	0	0	NS	0
7-Apr	NS	0	0	0	NS	0
10-Apr	NS	0	0	0	NS	0
13-Apr	NS	0	0	0	NS	0
16-Apr	NS	0	0	0	0	0
19-Apr	NS	0	0	0	0	1
22-Apr	NS	0	0	0	0	0
25-Apr	0	0	1	1	0	0
28-Apr	1	0	0	1	0	0
1-May	3	0	0	2	0	0
4-May	15	3	13	1	3	0
7-May	33	1	46	27	9	15
10-May	130	6	189	27	19	43
13-May	238	9	133	33	11	214
16-May	975	7	179	79	38	113
19-May	2,123	32	290	76	267	152
22-May	298	309	699	40	671	262
25-May	264	37	873	25	233	202
28-May	211	620	642	33	294	529
31-May	172	517	81	14	171	208
3-Jun	108	673	30	44	357	106
6-Jun	51	256	38	15	192	16
9-Jun	21	126	16	3	109	12
12-Jun	16	61	25	4	559	21
15-Jun	15	31	5	7	89	9
18-Jun	8	5	3	4	68	NS
21-Jun	9	0	2	1	33	NS
24-Jun	NS	1	0	NS	NS	NS
27-Jun	NS	0	0	NS	NS	NS
30-Jun	NS	1	0	NS	NS	NS

Table 2. Seasonal distributions for smolt downstream migration used for assessment of whole station survival at the Weston Project.

River System	Year	Percent of Migration			Reference
		April	May	June	
Penobscot	1988	0.1	80.4	19.5	GNP 1997
Penobscot	1989	0.0	49.5	50.5	GNP 1997
Penobscot	1990	0.5	78.5	21.1	GNP 1997
Penobscot	1993	0.0	93.8	6.1	GNP 1997
Penobscot	1994	0.0	38.0	62.0	GNP 1997
Penobscot	1995	0.0	91.5	8.5	GNP 1997
Penobscot	2004	10.0	88.0	2.0	USASAC 2005
Narraguagus	2004	4.0	96.0	0.0	USASAC 2006
Average		**1.8**	**77.0**	**21.2**	

Table 3. Estimated percentage of smolts encountering the Weston Project powerhouse or passing via spillway.

Month	Discharge (cfs)			Percent of River Discharge		Smolt Run Distribution[4]	Project Smolt Distribution[5]	
	River Discharge[1]	Weston [2]	Calculated Spill [3]	Spill	Powerhouse		Spill	Powerhouse
April	12,250	6,000	6,250	51.0%	49.0%	1.8%	0.9%	0.9%
May	8,500	6,000	2,500	29.4%	70.6%	77.0%	22.6%	54.4%
June	5,500	5,500	0	0.0%	100.0%	21.2%	0.0%	21.2%
TOTAL	-	-	-	-	-	-	**23.6%**	**76.4%**

1 - Monthly average condition as obtained from Project flow duration curves (50% occurrence)

2 - Project capacity or total inflow

3 - Equal to River discharge - Project capacity

4 - Monthly distribution of Atlantic salmon smolt run for the Penobscot River (GNP 1997; USASAC2005) and Narraguagus River (USASAC 2005)

5 - Based on 1:1 assumption of spill effectiveness

Table 4. Initial (1-hr) and delayed (48-hr) injury/scale loss rates for Atlantic salmon smolts passed through spillways and sluices at various hydroelectric projects. All tests conducted using the Hi-Z Turb'N Tag.

			Initial (1hr) Rates		Delayed (48hr) Rates		
Site Name	**Passage Route**	**Normal head (ft)**	**Test Fish Injury Rates (%)**	**Control Fish Injury Rates (%)**	**Test Fish Injury Rates (%)**	**Control Fish Injury Rates (%)**	**Reference**
Garvins Falls, NH	Bypass	30	0.0	0.0	0.0	0.0	Normandeau 2005
Amoskeag, NH	Bypass	46	3.0	0.0	0.0	0.0	Normandeau 2006a
Bellows Falls, VT	Sluice	59	2.0	0.0	18.0	18.0	RMC 1991
Wilder, VT	Sluice	52	59.0	0.6	-	-	RMC 1992
Wilder, VT	Sluice	52	36.0	0.6	-	-	RMC 1992
Wilder, VT	Sluice	52	26.0	0.6	-	-	RMC 1992
Vernon, VT	Sluice	27	2.9	4.0			Normandeau 1995

Table 5. **Summary of injury types and frequency of occurrence (among injured and all smolts examined) for Atlantic salmon smolts passed through spillways and sluices at various hydroelectric projects. All tests conducted using the Hi-Z Turb'N Tag.**

Interval	Site Name	# of Individuals Examined	# of Individuals with Injuries	Injury Type			
				Minor scale loss, <25%	Major scale loss, >25%	Laceration(s), tear(s)	Hemorrhaging, bruised
Initial (1hr)	Garvins Falls, NH	30	0	0	0	0	0
	Amoskeag, NH	30	1	0	0	0	1
	Bellows Falls, VT	95	3	1	0	0	2
	Wilder, VT	100	59	22	20	7	24
	Wilder, VT	44	16	9	0	2	10
	Wilder, VT	99	26	11	4	0	14
	Vernon, VT	70	2	2	0	0	0
	All Projects	468	107	45	24	9	51
	Percent Occurrence for Smolts with Injuries			**42.1%**	**22.4%**	**8.4%**	**47.7%**
	Percent Occurrence for All Smolts Examined			**9.6%**	**5.1%**	**1.9%**	**10.9%**
Delayed (48 hr)	Garvins Falls, NH	30	0	0	0	0	0
	Amoskeag, NH	30	0	0	0	0	0
	Bellows Falls, VT	38	7	6	0	0	1
	All Projects	98	7	6	0	0	1
	Percent Occurrence for Smolts with Injuries			**85.7%**	**0.0%**	**0.0%**	**14.3%**
	Percent Occurrence for All Smolts Examined			**6.1%**	**0.0%**	**0.0%**	**1.0%**

Table 6. Survival and associated test parameters for Atlantic salmon smolts passed through spillways and sluices at various hydroelectric projects. All tests conducted using the Hi-Z Turb'N Tag.

Site Name	Normal head (ft)	Test Discharge (cfs)	Water Temperature (^oC)	Test Fish Size (mm)			Control Fish Size (mm)			No. of Fish Released		Immediate Survival (1-hr)	48-hr Survival	Reference
				Min.	Max.	Avg.	Min.	Max.	Avg.	T	C			
Garvins Falls, NH	30	80	13.0	174	208	190	155	203	185	30	20	100.0	100.0	Normandeau 2005
Amoskeag, NH	46	149	14.0	176	226	207.8	178	229	203.8	30	30	100.0	100.0	Normandeau 2006a
Bellows Falls, VT	59	275-340	10.0-11.5	145	358	-	-	-	-	100	100	96.0	96.0	RMC 1991
Wilder, VT	52	200	8.5-15.5	180	245	212	185	240	211.4	245	145	99.0	97.0	RMC 1992
Wilder, VT	52	300	8.5-15.6	180	245	212	185	240	211.4	245	145	93.3	91.1	RMC 1992
Wilder, VT	52	500	8.5-15.7	180	245	212	185	240	211.4	245	145	98.0	97.0	RMC 1992
Vernon, VT	27	40	16.0-17.5	115	216	156	119	200	149	75	25	93.3	93.3	Normandeau 1995

Table 7. Turbine characteristics for Units 1 through 4 at the Weston Project.

Parameter	Weston Turbines[3] Unit 1	Unit 2	Unit 3	Unit 4
Turbine Type	Vertical Francis	Vertical Francis	Vertical Francis	Vertical Francis
Number blades/buckets	13	16	13	16
Max turbine discharge (cfs)	1,750	1,498	1,822	1,661
Efficiency at max discharge	0.83	0.79	0.88	0.81
Peak turbine discharge (cfs)*	1,614	1,207	1,650	1,384
Efficiency at peak discharge	0.87	0.87	0.90	0.87
Runner Diameter at inlet (ft)	7.1	7.1	6.3	6.8
Runner diameter at discharge (ft)	10.2	10.6	10.2	10.8
Runner height at inlet (ft)	4.1	4.1	4.1	4.1
RPM	100	100	100	100
Rated head (ft)	34	34	34	34

*Peak turbine discharge is the maximum efficiency for a particular unit.

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[3] Turbine parameters for Unit 3 updated to reflect upgrade information provided by D. Beal (NextEra) and Unit 4 updated to reflect information provided by D. Beal (NextEra).

Table 8. **Initial (1-hr) injury/scale loss rates for Atlantic salmon smolts passed through Francis units at various hydroelectric projects. All tests conducted using the Hi-Z Turb'N Tag.**

Site Name	Normal head (ft)	RPM	Unit Flow (cfs)	No. of Blades or Buckets	Runner Diameter (ft)	Test Fish Injury Rates (%)	Control Fish Injury Rates (%)	Reference
West Buxton, ME	26.8	150	611	16	4.0	30.8	-	Normandeau 1999
Vernon, VT	34	133.3	1,280	14	5.2	16.7	0.0	Normandeau 1996
Vernon, VT	34	74	1,350 & 1,800	15	13.0	1.0	0.0	Normandeau 1996

Table 9. **Summary of injury types and frequency of occurrence for Atlantic salmon smolts passed through Francis units at various hydroelectric projects. All tests conducted using the Hi-Z Turb'N Tag.**

Site Name	Unit Type	# of Individuals Examined	# of Individuals with Injuries	Injury Type					
				Loss of Equilibrium	**Minor scale loss, <25%**	**Major scale loss, >25%**	**Severed body/ back bone**	**Bruised head or body**	**Cut/tear on head or body**
West Buxton, ME	Francis	39	12	6	2	1	2	2	2
Vernon, VT	Francis	24	4	1	1		3		
Vernon, VT	Francis	100	1	1					
All Projects		163	17	8	3	1	5	2	2
Percent Occurrence for Smolts with Injuries				**47.10%**	**17.60%**	**5.90%**	**29.40%**	**11.80%**	**11.80%**
Percent Occurrence for All Smolts Examined				**4.90%**	**1.80%**	**0.60%**	**3.10%**	**1.20%**	**1.20%**

Table 10. Immediate (1 hr) and delayed (48 hr) survival for Atlantic salmon smolts passed through Francis turbines at various hydroelectric projects. Note: All studies conducted using the Hi-Z Turb'N Tag.

Site Name	Normal head (ft)	RPM	Unit Flow (cfs)	No. of Blades or Buckets	Runner Diameter (ft)	Immediate Survival (1-hr)	Delayed Survival (48-hr)	Reference
West Buxton, ME	26.8	150	611	16	4.0	85.0	85.0 [2]	Normandeau 1999
Vernon, VT	34	133.3	1,280	14	5.2	85.1	85.1	Normandeau 1996
Vernon, VT [1]	34	74	1,350 & 1,800	15	13.0	95.9 & 100.0	94.9 & 100.0	Normandeau 1996

1 - Tested two different settings

2 - This value represents 24-hr survival

Table 11. Predicted survival rates for salmon smolts passed through horizontal Francis Units 1-4 at the Weston Project under maximum turbine operating conditions.

Unit	Maximum Discharge (cfs)	Efficiency at Max. Discharge	Correlation Factor	Predicted Survival (%) by Smolt Length (in)						Unit Average
				5	6	7	8	9	Range	
1	1,750	0.83	0.1	95.2	94.2	93.3	92.3	91.3	91.3 - 95.2	89.9
			0.2	90.4	88.5	86.5	84.6	82.7	82.7 - 90.4	
2	1,498	0.79	0.1	93.2	91.8	90.5	89.1	87.8	87.8 - 93.2	85.7
			0.2	86.4	83.7	81.0	78.3	75.5	75.5 - 86.4	
3	1,822	0.88	0.1	95.4	94.4	93.5	92.6	91.7	91.7 - 95.4	90.3
			0.2	90.7	88.9	87.0	85.2	83.3	83.3 - 90.7	
4	1,661	0.81	0.1	93.8	92.5	91.3	90.0	88.8	88.8 - 93.8	86.9
			0.2	87.5	85.0	82.6	80.1	77.6	77.6 - 87.5	

Table 12. Initial Survival Rate Model (Model A) for whole station survival of Atlantic salmon smolts passing the Weston Project under median (50% occurrence) river conditions.

		BASE MODEL
Theoretical Number of Smolts		1000
Proportion of Smolts to Spillway		0.236
Number of Smolts Passed via Spillway		236
Spillway/Bypass Survival Rate		0.971
Number Smolts Surviving Spill		229
Proportion of Smolts to Powerhouse		0.764
Total Number of Smolts to Powerhouse		764
Number of Smolts to Powerhouse by Month	April	14
	May	588
	June	162
Bypass Effectiveness Rate	April	0.020
	May	0.020
	June	0.022
Number of Smolts Passed via Bypass	April	0
	May	12
	June	4
Total Number of Smolts Passed via Bypass		16
Number of Smolts Surviving Bypass	April	0
	May	11
	June	3
Total Number of Smolts Surviving Bypass		15
Proportion of Smolts to Francis	April	0.980
	May	0.980
	June	0.978
Total Number of Smolts Passed via Francis		748
Number of Smolts Passed via Francis	April (1.8% of smolt run)	12
	May (77% of smolt run)	576
	June (21.2% of smolt run)	159
Francis Turbine Survival Rate		0.915
Number of Smolts Surviving Francis	April	11
	May	527
	June	145
Total Number of Smolts Surviving Francis		683
TOTAL SMOLT SURVIVAL		**928**
WHOLE STATION ESTIMATE		**93%**

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 13. Impacts to the whole station smolt survival estimate obtained using the Initial Survival Rate Model (Model A) for theoretical downstream bypass effectiveness rates.

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.236*	0.236	0.236	0.236	0.236	0.236
Number of Smolts Passed via Spillway		*236*	236	236	236	236	236
Spillway/Bypass Survival Rate		*0.971*	0.971	0.971	0.971	0.971	0.971
Number Smolts Surviving Spill		*229*	229	229	229	229	229
Proportion of Smolts to Powerhouse		*0.764*	0.764	0.764	0.764	0.764	0.764
Total Number of Smolts to Powerhouse		*764*	764	764	764	764	764
Number of Smolts to Powerhouse by Month	April	*14*	14	14	14	14	14
	May	*588*	588	588	588	588	588
	June	*162*	162	162	162	162	162
Bypass Effectiveness Rate	April	*0.020*	0.250	0.450	0.650	0.850	1.000
	May	*0.020*	0.250	0.450	0.650	0.850	1.000
	June	*0.022*	0.250	0.540	0.650	0.850	1.000
Number of Smolts Passed via Bypass	April	*0*	3	6	9	12	14
	May	*12*	147	265	382	500	588
	June	*4*	40	87	105	138	162
Total Number of Smolts Passed via Bypass		*16*	191	358	497	649	764
Number of Smolts Surviving Bypass	April	*0*	3	6	9	11	13
	May	*11*	143	257	371	486	571
	June	*3*	39	85	102	134	157
Total Number of Smolts Surviving Bypass		*15*	185	348	482	631	742
Proportion of Smolts to Francis	April	*0.980*	0.750	0.550	0.350	0.150	0.000
	May	*0.980*	0.750	0.550	0.350	0.150	0.000
	June	*0.978*	0.750	0.460	0.350	0.150	0.000
Total Number of Smolts Passed via Francis		*748*	573	406	267	115	0
Number of Smolts Passed via Francis	April	*12*	9	6	4	2	0
	May	*576*	441	312	206	88	0
	June	*159*	121	86	57	24	0
Francis Turbine Survival Rate		*0.915*	0.915	0.915	0.915	0.915	0.915
Number of Smolts Surviving Francis	April	*11*	8	6	4	2	0
	May	*527*	404	286	188	81	0
	June	*145*	111	79	52	22	0
Total Number of Smolts Surviving Francis		*683*	523	370	244	105	0
TOTAL SMOLT SURVIVAL		***928***	**938**	**948**	**956**	**964**	**971**
WHOLE STATION ESTIMATE		***93%***	**94%**	**95%**	**96%**	**96%**	**97%**

Italics indicates the base model constructed using median flow conditions in the Kennebec River

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 14. Impacts to the whole station smolt survival estimate obtained using the Initial Survival Rate Model (Model A) for theoretical spill effectiveness rates.

		Evaluated Spill Effectiveness Rates					
		1:1	**0.2:1**	**1.3:1**	**2.1:1**	**3:1**	**3.8:1**
		0.236	**0.05**	**0.3**	**0.5**	**0.7**	**0.9**
Proportion of River Flow to Spillway		*0.236*	0.236	0.236	0.236	0.236	0.236
Proportion of River Flow to Powerhouse		*0.764*	0.764	0.764	0.764	0.764	0.764
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.236*	0.05	0.3	0.5	0.7	0.9
Number of Smolts Passed via Spillway		*236*	50	300	500	700	900
Spillway/Bypass Survival Rate		*0.971*	0.971	0.971	0.971	0.971	0.971
Number Smolts Surviving Spill		*229*	49	291	486	680	874
Proportion of Smolts to Powerhouse		*0.764*	0.95	0.7	0.5	0.3	0.1
Total Number of Smolts to Powerhouse		*764*	950	700	500	300	100
Number of Smolts to Powerhouse by Month	April	*14*	17	13	9	5	2
	May	*588*	732	539	385	231	77
	June	*162*	201	148	106	64	21
Bypass Effectiveness Rate	April	*0.020*	0.020	0.020	0.020	0.020	0.020
	May	*0.020*	0.020	0.020	0.020	0.020	0.020
	June	*0.022*	0.022	0.022	0.022	0.022	0.022
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0	0
	May	*12*	15	11	8	5	2
	June	*4*	4	3	2	1	0
Total Number of Smolts Passed via Bypass		*16*	19	14	10	6	2
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0	0
	May	*11*	14	10	7	4	1
	June	*3*	4	3	2	1	0
Total Number of Smolts Surviving Bypass		*15*	19	14	10	6	2
Proportion of Smolts to Francis	April	*0.980*	0.980	0.980	0.980	0.980	0.980
	May	*0.980*	0.980	0.980	0.980	0.980	0.980
	June	*0.978*	0.978	0.978	0.978	0.978	0.978
Total Number of Smolts Passed via Francis		*748*	931	686	490	294	98
Number of Smolts Passed via Francis	April	*12*	15	11	8	5	2
	May	*576*	717	528	377	226	75
	June	*159*	197	145	104	62	21
Francis Turbine Survival Rate		*0.915*	0.915	0.915	0.915	0.915	0.915
Number of Smolts Surviving Francis	April	*11*	14	10	7	4	1
	May	*527*	656	483	345	207	69
	June	*145*	181	133	95	57	19
Total Number of Smolts Surviving Francis		*683*	850	626	447	268	89
TOTAL SMOLT SURVIVAL		***928***	**917**	**931**	**943**	**954**	**965**
WHOLE STATION ESTIMATE		***93%***	**92%**	**93%**	**94%**	**95%**	**97%**

Italics indicates model estimate is based 1:1 spill effectiveness ratio

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 15. **Approximate river discharge (cfs) for Kennebec River at Weston during April, May and June for low (i.e. 75 and 90% exceedence) and high (10 and 25% exceedence) conditions.**

Percent of Time Flow is Exceeded	River Discharge (cfs)		
	April	May	June
10	30,000	20,500	13,250
25	19,500	14,500	8,000
50	*12,250*	*8,500*	*5,500*
75	8,500	5,500	4,000
90	6,250	4,000	3,000

Italics indicates values used for primary model

Table 16. Impacts to the whole station smolt survival estimate obtained using the Initial Survival Rate Model (Model A) for theoretical seasonal flow conditions.

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.236*	0.675	0.517	0.005	0.001
Number of Smolts Passed via Spillway		*236*	675	517	5	1
Spillway/Bypass Survival Rate		*0.97*	0.971	0.971	0.971	0.971
Number Smolts Surviving Spill		*229*	655	502	5	1
Proportion of Smolts to Powerhouse		*0.764*	0.325	0.483	0.995	0.999
Total Number of Smolts to Powerhouse		*764*	325	483	995	999
Number of Smolts to Powerhouse by Month	April	*14*	6	9	18	18
	May	*589*	250	372	766	769
	June	*162*	69	102	211	212
Bypass Effectiveness Rate	April	*0.020*	*0.020*	*0.020*	*0.020*	*0.020*
	May	*0.020*	*0.020*	*0.020*	*0.022*	*0.030*
	June	*0.022*	*0.020*	*0.020*	*0.030*	*0.040*
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0
	May	*12*	5	7	17	23
	June	*4*	1	2	6	8
Total Number of Smolts Passed via Bypass		*16*	6	10	23	32
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0
	May	*11*	5	7	16	22
	June	*3*	1	2	6	8
Total Number of Smolts Surviving Bypass		*15*	6	9	23	31
Proportion of Smolts to Francis	April	*0.980*	0.980	0.980	0.980	0.980
	May	*0.980*	0.980	0.980	0.978	0.970
	June	*0.978*	0.980	0.980	0.970	0.960
Total Number of Smolts Passed via Francis		*749*	318	473	971	967
Number of Smolts Passed via Francis	April	*12*	5	8	16	15
	May	*577*	245	365	748	745
	June	*159*	68	100	206	205
Francis Turbine Survival Rate		*0.92*	0.915	0.915	0.915	0.915
Number of Smolts Surviving Francis	April	*11*	5	7	14	14
	May	*528*	224	334	684	682
	June	*145*	62	92	188	188
Total Number of Smolts Surviving Francis		*684*	291	432	887	883
TOTAL SMOLT SURVIVAL		***928***	**953**	**944**	**915**	**915**
WHOLE STATION ESTIMATE		***93%***	**95%**	**94%**	**91%**	**92%**

Italics indicates model estimate is based on median discharge conditions
Shading indicates the variable assessed in this sensitivity analysis
*Monthly smolt run distribution is presented in Table 3 of this report.

Table 17. Delayed Survival Rate Model (Model B) for whole station survival of Atlantic salmon smolts passing the Weston Project under median (50% occurrence) river conditions.

		BASE MODEL
Theoretical Number of Smolts		1000
Proportion of Smolts to Spillway		0.236
Number of Smolts Passed via Spillway		236
Spillway/Bypass Survival Rate		0.963
Number Smolts Surviving Spill		227
Proportion of Smolts to Powerhouse		0.764
Total Number of Smolts to Powerhouse		764
Number of Smolts to Powerhouse by Month	April	14
	May	588
	June	162
Bypass Effectiveness Rate	April	0.020
	May	0.020
	June	0.022
Number of Smolts Passed via Bypass	April	0
	May	12
	June	4
Total Number of Smolts Passed via Bypass		16
Number of Smolts Surviving Bypass	April	0
	May	11
	June	3
Total Number of Smolts Surviving Bypass		15
Proportion of Smolts to Francis	April	0.980
	May	0.980
	June	0.978
Total Number of Smolts Passed via Francis		748
Number of Smolts Passed via Francis	April (1.8% of smolt run)	12
	May (77% of smolt run)	576
	June (21.2% of smolt run)	159
Francis Turbine Survival Rate		0.913
Number of Smolts Surviving Francis	April	11
	May	526
	June	145
Total Number of Smolts Surviving Francis		682
TOTAL SMOLT SURVIVAL		**924**
WHOLE STATION ESTIMATE		**92%**

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 18. Impacts to the whole station smolt survival estimate obtained using the Delayed Survival Rate Model (Model B) for theoretical downstream bypass effectiveness rates.

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.236*	0.236	0.236	0.236	0.236	0.236
Number of Smolts Passed via Spillway		*236*	236	236	236	236	236
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963	0.963
Number Smolts Surviving Spill		*227*	227	227	227	227	227
Proportion of Smolts to Powerhouse		*0.764*	0.764	0.764	0.764	0.764	0.764
Total Number of Smolts to Powerhouse		*764*	764	764	764	764	764
Number of Smolts to Powerhouse by Month	April	*14*	14	14	14	14	14
	May	*588*	588	588	588	588	588
	June	*162*	162	162	162	162	162
Bypass Effectiveness Rate	April	*0.020*	0.250	0.450	0.650	0.850	1.000
	May	*0.020*	0.250	0.450	0.650	0.850	1.000
	June	*0.022*	0.250	0.540	0.650	0.850	1.000
Number of Smolts Passed via Bypass	April	*0*	3	6	9	12	14
	May	*12*	147	265	382	500	588
	June	*4*	40	87	105	138	162
Total Number of Smolts Passed via Bypass		*16*	191	358	497	649	764
Number of Smolts Surviving Bypass	April	*0*	3	6	9	11	13
	May	*11*	142	255	368	482	567
	June	*3*	39	84	101	133	156
Total Number of Smolts Surviving Bypass		*15*	184	345	478	625	736
Proportion of Smolts to Francis	April	*0.980*	0.750	0.550	0.350	0.150	0.000
	May	*0.980*	0.750	0.550	0.350	0.150	0.000
	June	*0.978*	0.750	0.460	0.350	0.150	0.000
Total Number of Smolts Passed via Francis		*748*	573	406	267	115	0
Number of Smolts Passed via Francis	April	*12*	9	6	4	2	0
	May	*576*	441	312	206	88	0
	June	*159*	121	86	57	24	0
Francis Turbine Survival Rate		*0.913*	0.913	0.913	0.913	0.913	0.913
Number of Smolts Surviving Francis	April	*11*	8	6	4	2	0
	May	*526*	403	285	188	81	0
	June	*145*	111	79	52	22	0
Total Number of Smolts Surviving Francis		*682*	522	370	244	104	0
TOTAL SMOLT SURVIVAL		***924***	**933**	**942**	**949**	**957**	**963**
WHOLE STATION ESTIMATE		***92%***	**93%**	**94%**	**95%**	**96%**	**96%**

Italics indicates the base model constructed using median flow conditions in the Kennebec River
Shading indicates the variable assessed in this sensitivity analysis
*Monthly smolt run distribution is presented in Table 3 of this report.

Table 19. Impacts to the whole station smolt survival estimate obtained using the Delayed Survival Rate Model (Model B) for theoretical spill effectiveness rates.

		Evaluated Spill Effectiveness Rates					
		1:1	**0.2:1**	**1.3:1**	**2.1:1**	**3:1**	**3.8:1**
		0.236	**0.05**	**0.3**	**0.5**	**0.7**	**0.9**
Proportion of River Flow to Spillway		*0.236*	0.236	0.236	0.236	0.236	0.236
Proportion of River Flow to Powerhouse		*0.764*	0.764	0.764	0.764	0.764	0.764
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.236*	0.05	0.3	0.5	0.7	0.9
Number of Smolts Passed via Spillway		*236*	50	300	500	700	900
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963	0.963
Number Smolts Surviving Spill		*227*	48	289	482	674	867
Proportion of Smolts to Powerhouse		*0.764*	0.95	0.7	0.5	0.3	0.1
Total Number of Smolts to Powerhouse		*764*	950	700	500	300	100
Number of Smolts to Powerhouse by Month	April	*14*	17	13	9	5	2
	May	*588*	732	539	385	231	77
	June	*162*	201	148	106	64	21
Bypass Effectiveness Rate	April	*0.020*	0.020	0.020	0.020	0.020	0.020
	May	*0.020*	0.020	0.020	0.020	0.020	0.020
	June	*0.022*	0.022	0.022	0.022	0.022	0.022
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0	0
	May	*12*	15	11	8	5	2
	June	*4*	4	3	2	1	0
Total Number of Smolts Passed via Bypass		*16*	19	14	10	6	2
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0	0
	May	*11*	14	10	7	4	1
	June	*3*	4	3	2	1	0
Total Number of Smolts Surviving Bypass		*15*	19	14	10	6	2
Proportion of Smolts to Francis	April	*0.980*	0.980	0.980	0.980	0.980	0.980
	May	*0.980*	0.980	0.980	0.980	0.980	0.980
	June	*0.978*	0.978	0.978	0.978	0.978	0.978
Total Number of Smolts Passed via Francis		*748*	931	686	490	294	98
Number of Smolts Passed via Francis	April	*12*	15	11	8	5	2
	May	*576*	717	528	377	226	75
	June	*159*	197	145	104	62	21
Francis Turbine Survival Rate		*0.913*	0.913	0.913	0.913	0.913	0.913
Number of Smolts Surviving Francis	April	*11*	14	10	7	4	1
	May	*526*	654	482	344	207	69
	June	*145*	180	133	95	57	19
Total Number of Smolts Surviving Francis		*682*	848	625	446	268	89
TOTAL SMOLT SURVIVAL		***924***	**915**	**927**	**938**	**948**	**958**
WHOLE STATION ESTIMATE		***92%***	**91%**	**93%**	**94%**	**95%**	**96%**

Italics indicates model estimate is based 1:1 spill effectiveness ratio

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 20. Impacts to the whole station smolt survival estimate obtained using the Delayed Survival Rate Model (Model B) for theoretical seasonal flow conditions.

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.236*	0.675	0.517	0.005	0.001
Number of Smolts Passed via Spillway		*236*	675	517	5	1
Spillway/Bypass Survival Rate		*0.971*	0.971	0.971	0.971	0.971
Number Smolts Surviving Spill		*229*	655	502	5	1
Proportion of Smolts to Powerhouse		*0.764*	0.325	0.483	0.995	0.999
Total Number of Smolts to Powerhouse		*764*	325	483	995	999
Number of Smolts to Powerhouse by Month	April	*14*	6	9	18	18
	May	*589*	250	372	766	769
	June	*162*	69	102	211	212
Bypass Effectiveness Rate	April	*0.020*	*0.020*	*0.020*	*0.020*	*0.020*
	May	*0.020*	*0.020*	*0.020*	*0.022*	*0.030*
	June	*0.022*	*0.020*	*0.020*	*0.030*	*0.040*
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0
	May	*12*	5	7	17	23
	June	*4*	1	2	6	8
Total Number of Smolts Passed via Bypass		*16*	6	10	23	32
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0
	May	*11*	5	7	16	22
	June	*3*	1	2	6	8
Total Number of Smolts Surviving Bypass		*15*	6	9	23	31
Proportion of Smolts to Francis	April	*0.980*	0.980	0.980	0.980	0.980
	May	*0.980*	0.980	0.980	0.978	0.970
	June	*0.978*	0.980	0.980	0.970	0.960
Total Number of Smolts Passed via Francis		*749*	318	473	971	967
Number of Smolts Passed via Francis	April	*12*	5	8	16	15
	May	*577*	245	365	748	745
	June	*159*	68	100	206	205
Francis Turbine Survival Rate		*0.915*	0.915	0.915	0.915	0.915
Number of Smolts Surviving Francis	April	*11*	5	7	14	14
	May	*528*	224	334	684	682
	June	*145*	62	92	188	188
Total Number of Smolts Surviving Francis		*684*	291	432	887	883
TOTAL SMOLT SURVIVAL		***928***	**953**	**944**	**915**	**915**
WHOLE STATION ESTIMATE		***93%***	**95%**	**94%**	**91%**	**92%**

Italics indicates model estimate is based on median discharge conditions

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 21. Delayed/Calculated Survival Rate Model (Model C) for whole station survival of Atlantic salmon smolts passing the Weston Project under median (50% occurrence) river conditions.

		BASE MODEL
Theoretical Number of Smolts		1000
Proportion of Smolts to Spillway		0.236
Number of Smolts Passed via Spillway		236
Spillway/Bypass Survival Rate		0.963
Number Smolts Surviving Spill		227
Proportion of Smolts to Powerhouse		0.764
Total Number of Smolts to Powerhouse		764
Number of Smolts to Powerhouse by Month	April	14
	May	588
	June	162
Bypass Effectiveness Rate	April	0.020
	May	0.020
	June	0.022
Number of Smolts Passed via Bypass	April	0
	May	12
	June	4
Total Number of Smolts Passed via Bypass		16
Number of Smolts Surviving Bypass	April	0
	May	11
	June	3
Total Number of Smolts Surviving Bypass		15
Proportion of Smolts to Francis	April	0.980
	May	0.980
	June	0.978
Total Number of Smolts Passed via Francis		748
Number of Smolts Passed via Francis	April (1.8% of smolt run)	12
	May (77% of smolt run)	576
	June (21.2% of smolt run)	159
Francis Turbine Survival Rate		0.882
Number of Smolts Surviving Francis	April	11
	May	508
	June	140
Total Number of Smolts Surviving Francis		659
TOTAL SMOLT SURVIVAL		**901**
WHOLE STATION ESTIMATE		**90%**

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 22. Impacts to the whole station smolt survival estimate obtained using the Delayed/Calculated Survival Rate Model (Model C) for theoretical downstream bypass effectiveness rates.

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.236*	0.236	0.236	0.236	0.236	0.236
Number of Smolts Passed via Spillway		*236*	236	236	236	236	236
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963	0.963
Number Smolts Surviving Spill		*227*	227	227	227	227	227
Proportion of Smolts to Powerhouse		*0.764*	0.764	0.764	0.764	0.764	0.764
Total Number of Smolts to Powerhouse		*764*	764	764	764	764	764
Number of Smolts to Powerhouse by Month	April	*14*	14	14	14	14	14
	May	*588*	588	588	588	588	588
	June	*162*	162	162	162	162	162
Bypass Effectiveness Rate	April	*0.020*	0.250	0.450	0.650	0.850	1.000
	May	*0.020*	0.250	0.450	0.650	0.850	1.000
	June	*0.022*	0.250	0.540	0.650	0.850	1.000
Number of Smolts Passed via Bypass	April	*0*	3	6	9	12	14
	May	*12*	147	265	382	500	588
	June	*4*	40	87	105	138	162
Total Number of Smolts Passed via Bypass		*16*	191	358	497	649	764
Number of Smolts Surviving Bypass	April	*0*	3	6	9	11	13
	May	*11*	142	255	368	482	567
	June	*3*	39	84	101	133	156
Total Number of Smolts Surviving Bypass		*15*	184	345	478	625	736
Proportion of Smolts to Francis	April	*0.980*	0.750	0.550	0.350	0.150	0.000
	May	*0.980*	0.750	0.550	0.350	0.150	0.000
	June	*0.978*	0.750	0.460	0.350	0.150	0.000
Total Number of Smolts Passed via Francis		*748*	573	406	267	115	0
Number of Smolts Passed via Francis	April	*12*	9	6	4	2	0
	May	*576*	441	312	206	88	0
	June	*159*	121	86	57	24	0
Francis Turbine Survival Rate		*0.882*	0.882	0.882	0.882	0.882	0.882
Number of Smolts Surviving Francis	April	*11*	8	6	4	2	0
	May	*508*	389	275	182	78	0
	June	*140*	107	76	50	21	0
Total Number of Smolts Surviving Francis		*659*	504	357	235	101	0
TOTAL SMOLT SURVIVAL		***901***	**916**	**929**	**941**	**954**	**963**
WHOLE STATION ESTIMATE		***90%***	**92%**	**93%**	**94%**	**95%**	**96%**

Italics indicates the base model constructed using median flow conditions in the Kennebec River
Shading indicates the variable assessed in this sensitivity analysis
*Monthly smolt run distribution is presented in Table 3 of this report.

Table 23. Impacts to the whole station smolt survival estimate obtained using the Delayed/Calculated Survival Rate Model (Model C) for theoretical spill effectiveness rates.

		Evaluated Spill Effectiveness Rates					
		1:1	**0.2:1**	**1.3:1**	**2.1:1**	**3:1**	**3.8:1**
		0.236	**0.05**	**0.3**	**0.5**	**0.7**	**0.9**
Proportion of River Flow to Spillway		*0.236*	0.236	0.236	0.236	0.236	0.236
Proportion of River Flow to Powerhouse		*0.764*	0.764	0.764	0.764	0.764	0.764
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.236*	0.05	0.3	0.5	0.7	0.9
Number of Smolts Passed via Spillway		*236*	50	300	500	700	900
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963	0.963
Number Smolts Surviving Spill		*227*	48	289	482	674	867
Proportion of Smolts to Powerhouse		*0.764*	0.95	0.7	0.5	0.3	0.1
Total Number of Smolts to Powerhouse		*764*	950	700	500	300	100
Number of Smolts to Powerhouse by Month	April	*14*	17	13	9	5	2
	May	*588*	732	539	385	231	77
	June	*162*	201	148	106	64	21
Bypass Effectiveness Rate	April	*0.020*	0.020	0.020	0.020	0.020	0.020
	May	*0.020*	0.020	0.020	0.020	0.020	0.020
	June	*0.022*	0.022	0.022	0.022	0.022	0.022
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0	0
	May	*12*	15	11	8	5	2
	June	*4*	4	3	2	1	0
Total Number of Smolts Passed via Bypass		*16*	19	14	10	6	2
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0	0
	May	*11*	14	10	7	4	1
	June	*3*	4	3	2	1	0
Total Number of Smolts Surviving Bypass		*15*	19	14	10	6	2
Proportion of Smolts to Francis	April	*0.980*	0.980	0.980	0.980	0.980	0.980
	May	*0.980*	0.980	0.980	0.980	0.980	0.980
	June	*0.978*	0.978	0.978	0.978	0.978	0.978
Total Number of Smolts Passed via Francis		*748*	931	686	490	294	98
Number of Smolts Passed via Francis	April	*12*	15	11	8	5	2
	May	*576*	717	528	377	226	75
	June	*159*	197	145	104	62	21
Francis Turbine Survival Rate		*0.882*	0.882	0.882	0.882	0.882	0.882
Number of Smolts Surviving Francis	April	*11*	13	10	7	4	1
	May	*508*	632	466	333	200	67
	June	*140*	174	128	92	55	18
Total Number of Smolts Surviving Francis		*659*	819	604	431	259	86
TOTAL SMOLT SURVIVAL		***901***	**886**	**906**	**922**	**939**	**955**
WHOLE STATION ESTIMATE		***90%***	**89%**	**91%**	**92%**	**94%**	**95%**

Italics indicates model estimate is based 1:1 spill effectiveness ratio

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 24. Impacts to the whole station smolt survival estimate obtained using the Delayed/Calculated Survival Rate Model (Model C) for theoretical seasonal flow conditions.

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.236*	0.675	0.517	0.005	0.001
Number of Smolts Passed via Spillway		*236*	675	517	5	1
Spillway/Bypass Survival Rate		*0.971*	0.971	0.971	0.971	0.971
Number Smolts Surviving Spill		*229*	655	502	5	1
Proportion of Smolts to Powerhouse		*0.764*	0.325	0.483	0.995	0.999
Total Number of Smolts to Powerhouse		*764*	325	483	995	999
Number of Smolts to Powerhouse by Month	April	*14*	6	9	18	18
	May	*589*	250	372	766	769
	June	*162*	69	102	211	212
Bypass Effectiveness Rate	April	*0.020*	*0.020*	*0.020*	*0.020*	*0.020*
	May	*0.020*	*0.020*	*0.020*	*0.022*	*0.030*
	June	*0.022*	*0.020*	*0.020*	*0.030*	*0.040*
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0
	May	*12*	5	7	17	23
	June	*4*	1	2	6	8
Total Number of Smolts Passed via Bypass		*16*	6	10	23	32
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0
	May	*11*	5	7	16	22
	June	*3*	1	2	6	8
Total Number of Smolts Surviving Bypass		*15*	6	9	23	31
Proportion of Smolts to Francis	April	*0.980*	0.980	0.980	0.980	0.980
	May	*0.980*	0.980	0.980	0.978	0.970
	June	*0.978*	0.980	0.980	0.970	0.960
Total Number of Smolts Passed via Francis		*749*	318	473	971	967
Number of Smolts Passed via Francis	April	*12*	5	8	16	15
	May	*577*	245	365	748	745
	June	*159*	68	100	206	205
Francis Turbine Survival Rate		*0.882*	0.882	0.882	0.882	0.882
Number of Smolts Surviving Francis	April	*11*	4	7	14	14
	May	*509*	216	322	660	657
	June	*140*	60	89	182	181
Total Number of Smolts Surviving Francis		*659*	280	417	855	852
TOTAL SMOLT SURVIVAL		***903***	**942**	**928**	**883**	**883**
WHOLE STATION ESTIMATE		***90%***	**94%**	**93%**	**88%**	**88%**

Italics indicates model estimate is based on median discharge conditions

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 25. Initial Injury Rate Model (Model D) for whole station survival of Atlantic salmon smolts passing the Weston Project under median (50% occurrence) river conditions.

		BASE MODEL
Theoretical Number of Smolts		1000
Proportion of Smolts to Spillway		0.236
Number of Smolts Passed via Spillway		236
Spillway/Bypass Survival Rate		0.816
Number Smolts Surviving Spill		193
Proportion of Smolts to Powerhouse		0.764
Total Number of Smolts to Powerhouse		764
Number of Smolts to Powerhouse by Month	April	14
	May	588
	June	162
Bypass Effectiveness Rate	April	0.020
	May	0.020
	June	0.022
Number of Smolts Passed via Bypass	April	0
	May	12
	June	4
Total Number of Smolts Passed via Bypass		16
Number of Smolts Surviving Bypass	April	0
	May	10
	June	3
Total Number of Smolts Surviving Bypass		13
Proportion of Smolts to Francis	April	0.980
	May	0.980
	June	0.978
Total Number of Smolts Passed via Francis		748
Number of Smolts Passed via Francis	April (1.8% of smolt run)	12
	May (77% of smolt run)	576
	June (21.2% of smolt run)	159
Francis Turbine Survival Rate		0.838
Number of Smolts Surviving Francis	April	10
	May	483
	June	133
Total Number of Smolts Surviving Francis		626
TOTAL SMOLT SURVIVAL		**831**
WHOLE STATION ESTIMATE		**83%**

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 26. Impacts to the whole station smolt survival estimate obtained using the Initial Injury Rate Model (Model D) for theoretical downstream bypass effectiveness rates.

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.236*	0.236	0.236	0.236	0.236	0.236
Number of Smolts Passed via Spillway		*236*	236	236	236	236	236
Spillway/Bypass Survival Rate		*0.816*	0.816	0.816	0.816	0.816	0.816
Number Smolts Surviving Spill		*193*	193	193	193	193	193
Proportion of Smolts to Powerhouse		*0.764*	0.764	0.764	0.764	0.764	0.764
Total Number of Smolts to Powerhouse		*764*	764	764	764	764	764
Number of Smolts to Powerhouse by Month	April	*14*	14	14	14	14	14
	May	*588*	588	588	588	588	588
	June	*162*	162	162	162	162	162
Bypass Effectiveness Rate	April	*0.020*	0.250	0.450	0.650	0.850	1.000
	May	*0.020*	0.250	0.450	0.650	0.850	1.000
	June	*0.022*	0.250	0.540	0.650	0.850	1.000
Number of Smolts Passed via Bypass	April	*0*	3	6	9	12	14
	May	*12*	147	265	382	500	588
	June	*4*	40	87	105	138	162
Total Number of Smolts Passed via Bypass		*16*	191	358	497	649	764
Number of Smolts Surviving Bypass	April	*0*	3	5	7	10	11
	May	*10*	120	216	312	408	480
	June	*3*	33	71	86	112	132
Total Number of Smolts Surviving Bypass		*13*	156	292	405	530	623
Proportion of Smolts to Francis	April	*0.980*	0.750	0.550	0.350	0.150	0.000
	May	*0.980*	0.750	0.550	0.350	0.150	0.000
	June	*0.978*	0.750	0.460	0.350	0.150	0.000
Total Number of Smolts Passed via Francis		*748*	573	406	267	115	0
Number of Smolts Passed via Francis	April	*12*	9	6	4	2	0
	May	*576*	441	312	206	88	0
	June	*159*	121	86	57	24	0
Francis Turbine Survival Rate		*0.838*	0.838	0.838	0.838	0.838	0.838
Number of Smolts Surviving Francis	April	*10*	8	5	4	2	0
	May	*483*	370	262	173	74	0
	June	*133*	102	72	48	20	0
Total Number of Smolts Surviving Francis		*626*	479	339	224	96	0
TOTAL SMOLT SURVIVAL		***831***	**828**	**824**	**821**	**818**	**816**
WHOLE STATION ESTIMATE		***83%***	**83%**	**82%**	**82%**	**82%**	**82%**

Italics indicates the base model constructed using median flow conditions in the Kennebec River

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 27. Impacts to the whole station smolt survival estimate obtained using the Initial Injury Rate Model (Model D) for theoretical spill effectiveness rates.

		Evaluated Spill Effectiveness Rates					
		1:1	**0.2:1**	**1.3:1**	**2.1:1**	**3:1**	**3.8:1**
		0.236	**0.05**	**0.3**	**0.5**	**0.7**	**0.9**
Proportion of River Flow to Spillway		*0.236*	0.236	0.236	0.236	0.236	0.236
Proportion of River Flow to Powerhouse		*0.764*	0.764	0.764	0.764	0.764	0.764
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.236*	0.05	0.3	0.5	0.7	0.9
Number of Smolts Passed via Spillway		*236*	50	300	500	700	900
Spillway/Bypass Survival Rate		*0.816*	0.816	0.816	0.816	0.816	0.816
Number Smolts Surviving Spill		*193*	41	245	408	571	734
Proportion of Smolts to Powerhouse		*0.764*	0.95	0.7	0.5	0.3	0.1
Total Number of Smolts to Powerhouse		*764*	950	700	500	300	100
Number of Smolts to Powerhouse by Month	April	*14*	17	13	9	5	2
	May	*588*	732	539	385	231	77
	June	*162*	201	148	106	64	21
Bypass Effectiveness Rate	April	*0.020*	0.020	0.020	0.020	0.020	0.020
	May	*0.020*	0.020	0.020	0.020	0.020	0.020
	June	*0.022*	0.022	0.022	0.022	0.022	0.022
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0	0
	May	*12*	15	11	8	5	2
	June	*4*	4	3	2	1	0
Total Number of Smolts Passed via Bypass		*16*	19	14	10	6	2
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0	0
	May	*10*	12	9	6	4	1
	June	*3*	4	3	2	1	0
Total Number of Smolts Surviving Bypass		*13*	16	12	8	5	2
Proportion of Smolts to Francis	April	*0.980*	0.980	0.980	0.980	0.980	0.980
	May	*0.980*	0.980	0.980	0.980	0.980	0.980
	June	*0.978*	0.978	0.978	0.978	0.978	0.978
Total Number of Smolts Passed via Francis		*748*	931	686	490	294	98
Number of Smolts Passed via Francis	April	*12*	15	11	8	5	2
	May	*576*	717	528	377	226	75
	June	*159*	197	145	104	62	21
Francis Turbine Survival Rate		*0.838*	0.838	0.838	0.838	0.838	0.838
Number of Smolts Surviving Francis	April	*10*	12	9	7	4	1
	May	*483*	601	442	316	190	63
	June	*133*	165	122	87	52	17
Total Number of Smolts Surviving Francis		*626*	778	573	410	246	82
TOTAL SMOLT SURVIVAL		***831***	**835**	**830**	**826**	**822**	**818**
WHOLE STATION ESTIMATE		***83%***	**83%**	**83%**	**83%**	**82%**	**82%**

Italics indicates model estimate is based 1:1 spill effectiveness ratio

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 28. Impacts to the whole station smolt survival estimate obtained using the Initial Injury Rate Model (Model D) for theoretical seasonal flow conditions.

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.236*	0.675	0.517	0.005	0.001
Number of Smolts Passed via Spillway		*236*	675	517	5	1
Spillway/Bypass Survival Rate		*0.816*	0.816	0.816	0.816	0.816
Number Smolts Surviving Spill		*192*	551	422	4	1
Proportion of Smolts to Powerhouse		*0.764*	0.325	0.483	0.995	0.999
Total Number of Smolts to Powerhouse		*764*	325	483	995	999
Number of Smolts to Powerhouse by Month	April	*14*	6	9	18	18
	May	*589*	250	372	766	769
	June	*162*	69	102	211	212
Bypass Effectiveness Rate	April	*0.020*	*0.020*	*0.020*	*0.020*	*0.020*
	May	*0.020*	*0.020*	*0.020*	*0.022*	*0.030*
	June	*0.022*	*0.020*	*0.020*	*0.030*	*0.040*
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0
	May	*12*	5	7	17	23
	June	*4*	1	2	6	8
Total Number of Smolts Passed via Bypass		*16*	6	10	23	32
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0
	May	*10*	4	6	14	19
	June	*3*	1	2	5	7
Total Number of Smolts Surviving Bypass		*13*	5	8	19	26
Proportion of Smolts to Francis	April	*0.980*	0.980	0.980	0.980	0.980
	May	*0.980*	0.980	0.980	0.978	0.970
	June	*0.978*	0.980	0.980	0.970	0.960
Total Number of Smolts Passed via Francis		*749*	318	473	971	967
Number of Smolts Passed via Francis	April	*12*	5	8	16	15
	May	*577*	245	365	748	745
	June	*159*	68	100	206	205
Francis Turbine Survival Rate		*0.838*	0.838	0.838	0.838	0.838
Number of Smolts Surviving Francis	April	*10*	4	6	13	13
	May	*483*	205	306	627	624
	June	*133*	57	84	173	172
Total Number of Smolts Surviving Francis		*626*	266	396	812	809
TOTAL SMOLT SURVIVAL		***831***	**822**	**826**	**836**	**836**
WHOLE STATION ESTIMATE		***83%***	**82%**	**83%**	**84%**	**84%**

Italics indicates model estimate is based on median discharge conditions

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 29. Summary of upstream passage and associated biological data for adult Atlantic salmon at the Lockwood Project during 2006-2011.

Passage Year	# Individuals	Fork Length (cm)			Sea Age (yrs)	
		Min	Max	Mean	Min	Max
2006	15	50.0	79.0	65.0	1	2
2007[a]	15	53.0	87.0	70.2	1	3
2008	22	55.0	80.0	68.4	1	2
2009[b]	32	58.0	81.0	72.1	1	2
2010	5	50.0	76.0	67.1	1	2
2011	64	53.0	82.0	73.5	1	2

a - length and weight data includes one individual captured in Sebasticook River

b - length and weight data based on 28 individuals

Table 30 Estimated percentage of kelts entering the Weston Project powerhouse or passing via spill.

Month	**Discharge (cfs)**			**Percent of River Discharge**		**Kelt Run Distribution[4]**	**Project Kelt Distribution[5]**	
	River Discharge[1]	**Weston [2]**	**Calculated Spill [3]**	**Spill**	**Powerhouse**		**Spill**	**Powerhouse**
April	12,250	6,000	6,250	51.0%	49.0%	40.0%	20.4%	19.6%
May	8,500	6,000	2,500	29.4%	70.6%	40.0%	11.8%	28.2%
October	4,250	4,250	0	0.0%	100.0%	5.0%	0.0%	5.0%
November	5,750	5,750	0	0.0%	100.0%	10.0%	0.0%	10.0%
December	5,500	5,500	0	0.0%	100.0%	5.0%	0.0%	5.0%
TOTAL	-	-	-	-	-	-	**32.2%**	**67.8%**

1 - Monthly median condition as obtained from Project flow duration curves (50% exceedence)

2 - Project capacity or total inflow

3 - Equal to River discharge - Project capacity

4 - Mean monthly distribution of Atlantic salmon kelt migrations based on Baum (1997)

5 - Based on 1:1 assumption of spill effectiveness

Table 31. Predicted survival rates for salmon kelts passed through Francis Units 1-4 at the Weston Project under maximum turbine operating conditions.

Unit	Maximum Discharge (cfs)	Efficiency at Max. Discharge	Correlation Factor	Predicted Survival (%) by Kelt Length (in)						Unit Average
				16	20	24	28	32	Range	
1	1,750	0.83	0.1	84.6	80.8	76.9	73.1	69.2	69.2 - 84.6	65.4
			0.2	69.2	61.5	53.9	46.2	38.5	38.5 - 69.2	
2	1,498	0.79	0.1	78.3	72.8	67.4	61.9	56.5	56.5 - 78.3	51.1
			0.2	56.5	45.6	34.8	23.9	13.0	13.0 - 56.5	
3	1,822	0.88	0.1	85.2	81.5	77.8	74.1	70.3	70.3 - 85.2	66.6
			0.2	70.3	62.9	55.5	48.1	40.7	40.7 - 70.3	
4	1,661	0.81	0.1	80.1	75.1	70.1	65.1	60.1	60.1 - 80.1	55.1
			0.2	60.1	50.2	40.2	30.2	20.3	20.3 - 60.1	

Table 32. Model for the whole station survival of Atlantic salmon kelts passing the Weston Project under median (50% occurrence) river conditions.

		BASE MODEL
Theoretical Number of Kelts		100
Proportion of Kelts to Spillway		0.322
Number of Kelts Passed via Spillway		32.2
Spillway/Bypass Survival Rate		0.963
Number Kelts Surviving Spill		31
Proportion of Kelts to Powerhouse		0.678
Total Number of Kelts to Powerhouse		68
Number of Kelts to Powerhouse by Month	April (40% of kelt run)	27
	May (40% of kelt run)	27
	October (5% of kelt run)	3
	November (10% of kelt run)	7
	December (5% of kelt run)	3
Bypass Effectiveness Rate	April	0.020
	May	0.020
	October	0.028
	November	0.021
	December	0.022
Number of Kelts Passed via Bypass	April	1
	May	1
	October	0
	November	0
	December	0
Total Number of Kelts Passed via Bypass		1
Number of Kelts Surviving Bypass	April	1
	May	1
	October	0
	November	0
	December	0
Total Number of Smolts Surviving Bypass		1
Proportion of Kelts to Francis	April	0.980
	May	0.980
	October	0.972
	November	0.979
	December	0.978
Total Number of Kelts Directed to Francis		66
Proportion of Kelts Through 4" Racks (Francis)		0.976
Proportion of Kelts Screened at 4" Racks (Francis) and to Spill		0.024
Number of Kelts Through 4" Racks (Francis)		65
Number of Kelts Screened at 4" Racks (Francis) and to Spill		2

(continued)

Table 32. (Continued).

		BASE MODEL
Number of Kelts Passed via Francis	April	26
	May	26
	October	3
	November	6
	December	3
Number of Kelts Passed via Spill	April	1
	May	1
	October	0
	November	0
	December	0
Francis Turbine Survival Rate		0.596
Number of Kelts Surviving Francis	April	15
	May	15
	October	2
	November	4
	December	2
Total Number of Kelts Surviving Francis		39
Number of Kelts Surviving Spill	April	1
	May	1
	October	0
	November	0
	December	0
Total Number of Kelts Surviving Spill		2
TOTAL KELT SURVIVAL		**73**
WHOLE STATION ESTIMATE		**73%**

*Monthly kelt run distribution is presented in Table 30 of this report.

Table 33. Impacts to the whole station kelt survival estimate for theoretical downstream bypass effectiveness rates.

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Theoretical Number of Kelts		*100*	100	100	100	100	100
Proportion of Kelts to Spillway		*0.322*	0.322	0.322	0.322	0.322	0.322
Number of Kelts Passed via Spillway		*32.2*	32.2	32.2	32.2	32.2	32.2
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963	0.963
Number Kelts Surviving Spill		*31*	31	31	31	31	31
Proportion of Kelts to Powerhouse		*0.678*	0.678	0.678	0.678	0.678	0.678
Total Number of Kelts to Powerhouse		*68*	68	68	68	68	68
Number of Kelts to Powerhouse by Month	April	*27*	27	27	27	27	27
	May	*27*	27	27	27	27	27
	October	*3*	3	3	3	3	3
	November	*7*	7	7	7	7	7
	December	*3*	3	3	3	3	3
Bypass Effectiveness Rate	April	*0.020*	0.250	0.450	0.650	0.850	1.000
	May	*0.020*	0.250	0.450	0.650	0.850	1.000
	October	*0.028*	0.250	0.450	0.650	0.850	1.000
	November	*0.021*	0.250	0.450	0.650	0.850	1.000
	December	*0.022*	0.250	0.450	0.650	0.850	1.000
Number of Kelts Passed via Bypass	April	*1*	7	12	18	23	27
	May	*1*	7	12	18	23	27
	October	*0*	1	2	2	3	3
	November	*0*	2	3	4	6	7
	December	*0*	1	2	2	3	3
Total Number of Kelts Passed via Bypass		*1*	17	31	44	58	68
Number of Kelts Surviving Bypass	April	*1*	7	12	17	22	26
	May	*1*	7	12	17	22	26
	October	*0*	1	1	2	3	3
	November	*0*	2	3	4	6	7
	December	*0*	1	1	2	3	3
Total Number of Smolts Surviving Bypass		*1*	16	29	42	55	65
Proportion of Kelts to Francis	April	*0.980*	0.750	0.550	0.350	0.150	0.000
	May	*0.980*	0.750	0.550	0.350	0.150	0.000
	October	*0.972*	0.750	0.550	0.350	0.150	0.000
	November	*0.979*	0.750	0.550	0.350	0.150	0.000
	December	*0.978*	0.750	0.550	0.350	0.150	0.000
Total Number of Smolts Passed via Francis		*66*	51	37	24	10	0
Proportion of Kelts Through 4" Racks (Francis)		*0.976*	0.976	0.976	0.976	0.976	0.976
Proportion of Kelts Screened at 4" Racks (Francis) and to Spill		*0.024*	0.024	0.024	0.024	0.024	0.024
Number of Kelts Through 4" Racks (Francis)		*65*	50	36	23	10	0
Number of Kelts Screened at 4" Racks (Francis) and to Spill		*2*	1	1	1	0	0

(continued)

Table 33. (Continued)

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Number of Kelts Passed via Francis	April	*26*	20	15	9	4	0
	May	*26*	20	15	9	4	0
	October	*3*	2	2	1	0	0
	November	*6*	5	4	2	1	0
	December	*3*	2	2	1	0	0
Number of Kelts Passed via Spill	April	*1*	0	0	0	0	0
	May	*1*	0	0	0	0	0
	October	*0*	0	0	0	0	0
	November	*0*	0	0	0	0	0
	December	*0*	0	0	0	0	0
Francis Turbine Survival Rate		*0.596*	0.596	0.596	0.596	0.596	0.596
Number of Kelts Surviving Francis	April	*15*	12	9	6	2	0
	May	*15*	12	9	6	2	0
	October	*2*	1	1	1	0	0
	November	*4*	3	2	1	1	0
	December	*2*	1	1	1	0	0
Total Number of Kelts Surviving Francis		*39*	30	22	14	6	0
Number of Kelts Surviving Spill	April	*1*	0	0	0	0	0
	May	*1*	0	0	0	0	0
	October	*0*	0	0	0	0	0
	November	*0*	0	0	0	0	0
	December	*0*	0	0	0	0	0
Total Number of Kelts Surviving Spill		*2*	1	1	1	0	0
TOTAL KELT SURVIVAL		***73***	**78**	**83**	**88**	**93**	**96**
WHOLE STATION ESTIMATE		***73%***	**78%**	**83%**	**88%**	**93%**	**96%**

Italics indicates the base model constructed using median flow conditions in the Androscoggin River
Shading indicates the variable assessed in this sensitivity
analysis

*Monthly kelt run distribution is presented in Table 30 of this report.

Table 34. Impacts to the whole station kelt survival estimate for theoretical spill effectiveness rates.

		Evaluated Spill Effectiveness Rates					
		1:1	**0.2:1**	**0.3:1**	**1.6:1**	**2.2:1**	**2.8:1**
		0.322	**0.05**	**0.1**	**0.5**	**0.7**	**0.9**
Proportion of River Flow to Spillway		*0.322*	*0.322*	*0.322*	*0.322*	*0.322*	*0.322*
Proportion of River Flow to Powerhouse		*0.678*	0.678	0.678	0.678	0.678	0.678
Theoretical Number of Kelts		*100*	100	100	100	100	100
Proportion of Kelts to Spillway		*0.322*	0.05	0.1	0.5	0.7	0.9
Number of Kelts Passed via Spillway		*32.2*	5	10	50	70	90
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963	0.963
Number Kelts Surviving Spill		*31*	5	10	48	67	87
Proportion of Kelts to Powerhouse		*0.678*	0.95	0.9	0.5	0.3	0.1
Total Number of Kelts to Powerhouse		*68*	95	90	50	30	10
Number of Kelts to Powerhouse by Month	April	*27*	38	36	20	12	4
	May	*27*	38	36	20	12	4
	October	*3*	5	5	3	2	1
	November	*7*	10	9	5	3	1
	December	*3*	5	5	3	2	1
Bypass Effectiveness Rate	April	*0.020*	0.020	0.020	0.020	0.020	0.020
	May	*0.020*	0.020	0.020	0.020	0.020	0.020
	October	*0.028*	0.028	0.028	0.028	0.028	0.028
	November	*0.021*	0.021	0.021	0.021	0.021	0.021
	December	*0.022*	0.022	0.022	0.022	0.022	0.022
Number of Kelts Passed via Bypass	April	*1*	1	1	0	0	0
	May	*1*	1	1	0	0	0
	October	*0*	0	0	0	0	0
	November	*0*	0	0	0	0	0
	December	*0*	0	0	0	0	0
Total Number of Kelts Passed via Bypass		*1*	2	2	1	1	0
Number of Kelts Surviving Bypass	April	*1*	1	1	0	0	0
	May	*1*	1	1	0	0	0
	October	*0*	0	0	0	0	0
	November	*0*	0	0	0	0	0
	December	*0*	0	0	0	0	0
Total Number of Smolts Surviving Bypass		*1*	2	2	1	1	0
Proportion of Kelts to Francis	April	*0.980*	0.980	0.980	0.980	0.980	0.980
	May	*0.980*	0.980	0.980	0.980	0.980	0.980
	October	*0.972*	0.972	0.972	0.972	0.972	0.972
	November	*0.979*	0.979	0.979	0.979	0.979	0.979
	December	*0.978*	0.978	0.978	0.978	0.978	0.978
Total Number of Smolts Passed via Francis		*66*	93	88	49	29	10
Proportion of Kelts Through 4" Racks (Francis)		*0.976*	0.976	0.976	0.976	0.976	0.976
Proportion of Kelts Screened at 4" Racks (Francis) and to Spill		*0.024*	0.024	0.024	0.024	0.024	0.024
Number of Kelts Through 4" Racks (Francis)		*65*	91	86	48	29	10
Number of Kelts Screened at 4" Racks (Francis) and to Spill		*2*	2	2	1	1	0

(continued)

Table 34. (Continued)

		Evaluated Spill Effectiveness Rates					
		1:1	**0.2:1**	**0.3:1**	**1.6:1**	**2.2:1**	**2.8:1**
		0.322	**0.05**	**0.1**	**0.5**	**0.7**	**0.9**
Number of Kelts Passed via Francis	April	*26*	36	34	19	11	4
	May	*26*	36	34	19	11	4
	October	*3*	5	4	2	1	0
	November	*6*	9	9	5	3	1
	December	*3*	5	4	2	1	0
Number of Kelts Passed via Spill	April	*1*	1	1	0	0	0
	May	*1*	1	1	0	0	0
	October	*0*	0	0	0	0	0
	November	*0*	0	0	0	0	0
	December	*0*	0	0	0	0	0
Francis Turbine Survival Rate		*0.596*	0.596	0.596	0.596	0.596	0.596
Number of Kelts Surviving Francis	April	*15*	22	21	11	7	2
	May	*15*	22	21	11	7	2
	October	*2*	3	3	1	1	0
	November	*4*	5	5	3	2	1
	December	*2*	3	3	1	1	0
Total Number of Kelts Surviving Francis		*39*	54	51	28	17	6
Number of Kelts Surviving Spill	April	*1*	1	1	0	0	0
	May	*1*	1	1	0	0	0
	October	*0*	0	0	0	0	0
	November	*0*	0	0	0	0	0
	December	*0*	0	0	0	0	0
Total Number of Kelts Surviving Spill		*2*	2	2	1	1	0
TOTAL KELT SURVIVAL		***73***	**63**	**65**	**79**	**86**	**93**
WHOLE STATION ESTIMATE		***73%***	**63%**	**65%**	**79%**	**86%**	**93%**

Italics indicates the base model constructed using median flow conditions in the Androscoggin River

Shading indicates the variable assessed in this sensitivity analysis

*Monthly kelt run distribution is presented in Table 30 of this report.

Table 35. Approximate river discharge (cfs) for the Kennebec River at Weston during April, May, June, October and November for low (i.e. 75 and 90% exceedence) and high (10 and 25% exceedence) conditions.

Percent of Time Flow is Exceeded	River Discharge (cfs)				
	April	May	October	November	December
10	30,000	20,500	9,000	15,000	11,750
25	19,500	14,500	5,750	9,750	7,500
50	*12,250*	*8,500*	*4,250*	*5,750*	*5,500*
75	8,500	5,500	3,250	3,500	4,000
90	6,250	4,000	2,500	2,750	3,000

Italics indicates values used for 50% exceedence model

Table 36. Impacts to the whole station kelt survival estimate for seasonal flow conditions.

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Theoretical Number of Kelts		*100*	100	100	100	100
Proportion of Kelts to Spillway		*0.322*	0.704	0.560	0.118	0.016
Number of Kelts Passed via Spillway		*32.2*	70	56	12	1.6
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963
Number Kelts Surviving Spill		*31*	68	54	11	2
Proportion of Kelts to Powerhouse		*0.678*	0.296	0.440	0.882	0.984
Total Number of Kelts to Powerhouse		*68*	30	44	88	98
Number of Kelts to Powerhouse by Month	April (40% of smolt run)	*27*	12	18	35	39
	May (40% of smolt run)	*27*	12	18	35	39
	October (5% of smolt run)	*3*	1	2	4	5
	November (10% of smolt run)	*7*	3	4	9	10
	December (5% of smolt run)	*3*	1	2	4	5
Bypass Effectiveness Rate	April	*0.020*	0.020	0.020	0.020	0.020
	May	*0.020*	0.020	0.020	0.022	0.030
	October	*0.028*	0.020	0.021	0.037	0.048
	November	*0.021*	0.020	0.020	0.034	0.044
	December	*0.022*	0.020	0.020	0.030	0.040
Number of Kelts Passed via Bypass	April	*1*	0	0	1	1
	May	*1*	0	0	1	1
	October	*0*	0	0	0	0
	November	*0*	0	0	0	0
	December	*0*	0	0	0	0
Total Number of Kelts Passed via Bypass		*1*	1	1	2	3
Number of Kelts Surviving Bypass	April	*1*	0	0	1	1
	May	*1*	0	0	1	1
	October	*0*	0	0	0	0
	November	*0*	0	0	0	0
	December	*0*	0	0	0	0
Total Number of Smolts Surviving Bypass		*1*	1	1	2	3
Proportion of Kelts to Francis	April	*0.980*	0.980	0.980	0.980	0.980
	May	*0.980*	0.980	0.980	0.978	0.970
	October	*0.972*	0.980	0.979	0.963	0.952
	November	*0.979*	0.980	0.980	0.966	0.956
	December	*0.978*	0.980	0.980	0.970	0.960
Total Number of Smolts Passed via Francis		*66*	29	43	86	96
Proportion of Kelts Through 4" Racks (Francis)		*0.976*	0.976	0.976	0.976	0.976
Proportion of Kelts Screened at 4" Racks (Francis) and to Spill		*0.024*	0.024	0.024	0.024	0.024
Number of Kelts Through 4" Racks (Francis)		*65*	28	42	84	93
Number of Kelts Screened at 4" Racks (Francis) and to Spill		*2*	1	1	2	2

(continued)

Table 36. (Continued)

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Number of Kelts Passed via Francis	April	*26*	11	17	34	37
	May	*26*	11	17	34	37
	October	*3*	1	2	4	5
	November	*6*	3	4	8	9
	December	*3*	1	2	4	5
Number of Kelts Passed via Spill	April	*1*	0	0	1	1
	May	*1*	0	0	1	1
	October	*0*	0	0	0	0
	November	*0*	0	0	0	0
	December	*0*	0	0	0	0
Francis Turbine Survival Rate		*0.596*	0.596	0.596	0.596	0.596
Number of Kelts Surviving Francis	April	*15*	7	10	20	22
	May	*15*	7	10	20	22
	October	*2*	1	1	3	3
	November	*4*	2	3	5	6
	December	*2*	1	1	3	3
Total Number of Kelts Surviving Francis		*39*	17	25	50	56
Number of Kelts Surviving Spill	April	*1*	0	0	1	1
	May	*1*	0	0	1	1
	October	*0*	0	0	0	0
	November	*0*	0	0	0	0
	December	*0*	0	0	0	0
Total Number of Kelts Surviving Spill		*2*	1	1	2	2
TOTAL KELT SURVIVAL		***73***	**86**	**81**	**65**	**62**
WHOLE STATION ESTIMATE		***73%***	**86%**	**81%**	**65%**	**62%**

Italics indicates the base model constructed using median flow conditions in the Androscoggin River
Shading indicates the variable assessed in this sensitivity analysis
*Monthly kelt run distribution is presented in Table 30 of this report.

APPENDIX A

Appendix Table A-1. Site characteristics and study parameters for turbine survival studies conducted using the Hi-Z Turb'N Tag method.

Site Name	Species Tested	Sampling Method	Unit Type	Normal head (ft)	RPM	Wicket Gate (%)	Unit Flow (cfs)	No. of Blades or Buckets	Runner Diameter (ft)	Water Temp. (^{o}C)	Test Season or Month	Test Fish Size (mm)			Control Fish Size (mm)			No. of Fish Released		Immediate Survival (1-hr)	24-hr Survival	48-hr Survival	Reference
												Min	Max	Avg	Min	Max	Avg	T	C				
West Buxton, ME	Atlantic salmon	Hi-Z Turb'N Tag	Francis	26.8	150	100	611	16	4.0	15.0	May	192	250	217	192	226	210	73	20	85.0	85.0	-	Normandeau 1999
Vernon, VT	Atlantic salmon	Hi-Z Turb'N Tag	Francis	34	133.3	75	1,280	14	5.2	-	May	123	194	-	110	208	-	25	80	85.1	-	85.1	Normandeau 1996
Vernon, VT [1]	Atlantic salmon	Hi-Z Turb'N Tag	Francis	34	74	75 & 100	1,350 & 1,800	15	13.0	-	May	120	214	-	110	208	-	105	80	95.9 & 100.0	-	94.9 & 100.0	Normandeau 1996

[1] Tested two different settings

APPENDIX B

The following methodology was provided by Don Dow (NOAA) for the development of the set of monthly flow duration curves for the Weston Project used in the modeling of smolt and kelt survival described in this Report.

Weston Hydroelectric Project FERC No. 2325-ME - Flow Duration Curves

Prepared by Don Dow, PE, National Marine Fisheries Service, Orono Maine
The flow duration curve is based upon 32 years (1979-2010) of daily stream flow. In order to understand how the flow from various USGS gages was prorated to the site, it is important to understand the locations of the gages and their drainage areas.

The Sebasticook River flows into the Kennebec River downstream of the Weston Project. The entire Sebasticook River has a drainage area of 946 mi^2. There is a gage on the Sebasticook River which is USGS Gage No. 01049000 Sebasticook River near Pittsfield, Maine that has a drainage area of 572 mi^2. For the periods of January 1, 1979 to September 30, 1993 and October 1, 2000 to present, USGS Gage No. 01049265 Kennebec River at North Sidney, Maine was operating. This gage is located some distance downstream of the confluence of the Sebasticook and Kennebec Rivers and has a drainage area of 5,403 mi^2. For the period of October 1, 1993 to September 30, 2000, USGS Gage No. 01049205 Kennebec River near Waterville, ME was in operation. This gage is located just downstream of the confluence of the Sebasticook and Kennebec Rivers and has a drainage area of 5,179 mi^2. The drainage area of the Kennebec just above the confluence with the Sebasticook River is 5,179 mi^2 less 946 mi^2 which is 4,233 mi^2. The drainage area at the project which is upstream of the confluence with the Sebasticook is 3,950 mi^2.

Therefore, for the period where the North Sydney gage was in operation, the flow at the site was prorated from the following formula:

$$QWeston = (Qns \times (5{,}179\ mi^2 / 5{,}403\ mi^2)^{0.85} - Qseb \times (946\ mi^2/572\ mi^2)^{0.85}) \times (3950\ mi^2/4{,}233\ mi^2)^{0.85}$$

Where:
QWeston = Average Daily Flow at the Project
Qns= Average Daily Flow at the North Sydney Gage
Qseb= Average Daily Flow at the Sebasticook Gage

For the period where the Waterville gage was in operation, the flow at the site was prorated from the following formula:

$$QWeston= (Qwat - Qseb \times (946\ mi^2/572\ mi^2)^{0.85}) \times (3950\ mi^2/4{,}233\ mi^2)^{0.85}$$

Where:
Qwat = Average Daily Flow at the Waterville Gage

Although there is a gage on the Kennebec River upstream of the Weston Project in Madison below the Anson and Abenaki Projects, it has only been in operation since 2009, therefore, we have opted not to use it.

A REVIEW OF THE BRUNSWICK PROJECT ON THE ANDROSCOGGIN RIVER, MAINE ON ATLANTIC SALMON (*SALMO SALAR*) SMOLT AND KELT DOWNSTREAM PASSAGE AND ADULT UPSTREAM PASSAGE

January 20, 2012

A Review of the Brunswick Project on the Androscoggin River, Maine on Atlantic Salmon (*Salmo salar*) Smolt and Kelt Downstream Passage and Adult Upstream Passage

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R-22794.000

January 20, 2012

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1.0 Introduction

In 2009, the Gulf of Maine population of Atlantic salmon was listed as an endangered species under the Endangered Species Act (ESA). The Brunswick Project located on the Androscoggin River is within the designated critical habitat for the species. Consequently, continued operation of the hydropower project will require the Licensee (FPL Energy Maine Hydro LLC (FPLE)) to prepare a habitat conservation plan (HCP) and secure an incidental take permit (ITP). In order to issue an ITP, the HCP must outline measures to be undertaken by the Licensee to avoid, minimize and mitigate Project impacts, so as to assure that there is “no jeopardy" to the species as a result of continued operation of the Project. A first step in considering appropriate performance standards and measures to be included in the HCP is a common understanding of the effect of the Project on Atlantic salmon and its habitat. The purpose of this white paper is to evaluate current Project effects and examine whole station survival on downstream migrating Atlantic salmon smolts and kelts as well as upstream migrating Atlantic salmon. The whole station survival of downstream migrating Atlantic salmon smolts was modeled based on available environmental, biological and physical data related to or similar to the Brunswick Project. The construction and output of that modeling process are discussed in Sections 3, 4 and 5 of this paper. Additionally, the whole station survival of downstream migrating Atlantic salmon kelts was also modeled based on available environmental, biological and physical data related to or similar to the Brunswick Project. The construction and output of that modeling process are discussed in Sections 6 and 7 of this report. Additional considerations such as predation are discussed in Section 8.

This white paper has been revised from the original draft (provided during April, 2011) based on comments received from agencies and other members of the HCP Technical Advisory Committee (TAC). A summary of comments and a description of how comments were addressed in both the August, 2011 and this version (January, 2012) of the white paper is provided in Appendix C of the Lockwood white paper.

2.0 Background

2.1 Project Facilities and Operation

The Brunswick Project, owned by FPL Energy Maine Hydro LLC is located at river mile 6 (head of tide) and is the first dam on the mainstem of the Androscoggin River. The dam and powerhouse span the Androscoggin River immediately above the U.S. Route 201 Bridge, connecting Topsham and Brunswick, along a site originally known as Brunswick Falls. The Brunswick Project includes a 4.5 mile long 300 acre impoundment, a 605 ft concrete gravity dam approximately 39.4 ft high, a gate section containing two Taintor gates and an emergency spillway and a powerhouse and associated intake structure. In addition, the project has one upstream and one downstream fishway, a 21 ft high fish barrier wall between the dam and Shad Island in the tailrace, and a 3 ft high 20 ft long concrete fish barrier weir across the spillway ledges on the Topsham side of the river (Figure 1).

The concrete gravity dam consists of two ogee overflow spillway sections separated by a pier and barrier wall. The right spillway section, about 128 ft long, is topped with wooden flashboards that are 2.6 ft high. These flashboards are designed to prevent spill from entering the tailrace below this location so as not to attract upstream migrants to this location. The left section does not have flashboards. The two Taintor gates, each measuring 32.5 ft wide by 22 ft high, and an emergency spillway are located at the left abutment on the Topsham shoreline. The intake structure and powerhouse are integral with the dam and located adjacent to the Brunswick shoreline. The 3.5 inch clear spacing trashracks, which are situated in front of the unit gate slots, are cleaned using a motor-operated trash rake from a concrete deck. The 1983 powerhouse contains one vertical propeller unit and two horizontal propeller units having an installed capacity of 19 MW and a flow of 7,800 cfs. The project's tailrace is excavated river bed. The normal tailwater elevation is 2.5 ft mean sea level (msl).

Upstream passage for the target fish species at Brunswick is provided via a vertical slot fishway and associated trap and sort facility that were installed in 1983. The fishway is 570 ft long and consists of 42 individual pools, with a one-foot drop between each. The fishway is designed to pass American shad, river herring, and Atlantic salmon. The trapping facility, located at the upstream end of the fishway, provides biologists the opportunity to sort undesirable fish and also to collect data on migratory and resident fish species that use the fishway. As fish swim to the top of the fishway, fixed grating guides them past a viewing window and into a 500-gallon capacity fish hoist (trap). The hoist elevates the fish to overhead sorting tanks where staff sort and pass fish upstream. Atlantic salmon pass upstream above the Brunswick Project after biological data are collected. The Brunswick upstream fishway is owned and maintained by FPLE and under prior agreement; MDMR personnel operate the fishway each season. A downstream fishway consisting of an adjustable surface sluice gate and eighteen inch pipe is located in between units 1 and 2. The pipe passes through the powerhouse and discharges to the tailrace.

FPLE operates the Brunswick project in a near run-of-river mode. Unit 1 typically operates at maximum efficiency during periods of river flow less than or equal to 4,400 cfs, during which periods, the unit will run in an on-off mode. During river flows of 4,400 cfs to 5,000 cfs, the unit discharge will typically approximate river flows and the pond level will be relatively constant. Unit 2 and 3 will then normally come on line for river flows of 7,400 cfs or greater.

There is no minimum flow requirement in the existing license. However, during fishway operation from May 1 to October 31, upstream fishway flow is 100 cfs and downstream fishway flow is 60 cfs regardless of unit operations.

2.2 Target Species: Atlantic salmon

Numerous reviews detailing the life history of Atlantic salmon exist (NRC 2004, Fay et al. 2006, NMFS 2009) and their life cycle is summarized here. Adult Atlantic salmon begin to return to freshwater rivers during the spring. Redds are constructed and fertilized eggs are buried during the late fall. Following the fall spawn, approximately 20% of spent adult salmon (kelts) move back downstream and into the ocean; but the majority move back downstream and into the ocean the following spring (Baum 1997). Eggs remain in the gravel until hatching during the early spring. Following a three to six week period, the young salmon emerge from the gravel as fry and begin to actively seek food. As fry begin to feed they develop cryptic vertical stripes and are then known as parr. Atlantic salmon remain in the parr stage for one to three years and remain resident to freshwater during that period. Following that period, each parr undergoes a series of physiological and morphological changes known as smoltification. It is at that time that these fish move downstream through the freshwater river system and into the ocean. This downstream migration takes place during the spring season (April-June) with the majority of Maine smolts entering the ocean during May (NFMS 2009). A review of downstream migration timing data from the Penobscot and Narraguagus Rivers indicates that approximately 2% of smolts depart during April, 77% during May and 21% during June (GNP 1997, USUSUC 2005). Those individuals remain in the ocean for a period of 1-2 years prior to returning as adults and continuing the cycle.

2.3 Fish Passage Operations at the Brunswick Project

Upstream passage at the Brunswick Project is provided by a 570 ft long vertical slot fishway built in 1983. The fishway also includes a manual trap, sort and truck facility at the upper end. The fishway is operated annually from May 1 - October 31. Upstream migrants are attracted to the fishway with 100 cfs attraction flow and water velocities of four to six ft/s at the lift entrance. Following collection of biological information by the Maine Department of Marine Resources, returning adult Atlantic salmon, are released back into the fishway to complete their upstream migration. Adult salmon passed above the Brunswick Project can pass the next two hydroelectric projects on the Androscoggin (Pejepscot and Worumbo) and move as far upstream as Lewiston Falls (located 23 miles upstream from Brunswick). Adult returns during the last sixteen years (1995-2010) have ranged from a high of 39 individuals during 1996 to a low of 1 during 1997. Spawning and rearing behavior for returning Atlantic salmon and their offspring in the Androscoggin is poorly understood. Downstream smolt and kelt passage at Brunswick can occur via unregulated spillage or through the existing downstream fish passage facility. The downstream fish passage is opened for smolt and kelt passage generally from April 1 June 15 and November 1 through December 15 if river and ice conditions allow.

NextEra, in consultation with resource agency personnel is presently evaluating options to further enhance downstream fish passage measures at the project. At the request of the resource agencies, NextEra in the summer of 2011, contracted with a consultant to evaluate various downstream fish passage options using Computational Fluid Dynamics (CFD) modeling. The initial model runs using various floating fish guidance boom locations and surface sluices have been completed and were presented to resource agency personnel in December 2011. Additional model runs to refine the existing ones are scheduled for the first quarter of 2012. The resultant data will be used in consultation with the resource agencies, to propose new downstream fish passage enhancements at the project.

The focus of this assessment is the potential Project impacts to downstream migrating Atlantic salmon smolts (Sections 3, 4, and 5) as well as an initial consideration to the impacts on kelts and upstream migrating Atlantic salmon (Section 6).

3.0 Methods: Downstream Migrating Smolt Survival

Outmigrating Atlantic salmon smolts encountering the Brunswick Project can pass downstream via the Project spillway, the existing downstream passage facility or turbines. These three potential routes of passage were considered and incorporated into the model of whole station survival at the Brunswick Project (Figure 2). Information from the primary literature, reports and literature reviews on fish passage through turbines and non-turbine exit routes was assembled for examination and analysis for application to the Brunswick Project. Necessary components for assessing the impact of safe fish passage at the Brunswick Project include: smolt run timing, prevailing river flows, proportion diverted to the Project spillway and the associated survival rate, proportion diverted to the Project powerhouse, proportion passed downstream via the downstream facility and the associated survival, and the proportion transported through the three propeller turbines and the associated survival. The turbines have blades set at fixed positions.

3.1 Smolt Downstream Bypass Efficiency

There is no site-specific data for the effectiveness rate of the downstream passage facility located between Units 1 and 2 at the Brunswick Project. For the purposes of estimating the downstream bypass efficiency component of whole station survival, smolts passing through the powerhouse and associated downstream bypass were partitioned by assuming an equal distribution to that of outflow. This may be a conservative estimate as the intake at Unit 1 is a deep intake and migrating smolts are generally surface oriented.

NextEra, in consultation with resource agency personnel is presently evaluating options to further enhance downstream fish passage measures at the project. At the request of the resource agencies, NextEra in the summer of 2011, contracted with a consultant to evaluate various downstream fish passage options using Computational Fluid Dynamics (CFD) modeling. The initial model runs using various floating fish guidance boom locations and surface sluices have been completed and were presented to resource agency personnel in December 2011. Additional model runs to refine the existing ones are scheduled for the first quarter of 2012. The resultant data will be used in consultation with the resource agencies, to propose new downstream fish passage enhancements at the project. Estimated impacts of a downstream facility to the whole station survival estimate for smolts passing the Brunswick Project are evaluated in Section 5.1 of this report.

3.2 Spillway and Downstream Bypass Passage Smolt Survival Assessment

Due to the lack of site-specific field-test information, estimates for passage survival of Atlantic salmon smolts through the Brunswick spillway and downstream facility were developed based on existing empirical studies conducted at other hydroelectric projects with similar characteristics. The principal causes of injury and mortality for fish passed through either a spillway or bypass sluice are shear forces, turbulence, rapid deceleration, terminal velocity, impact against the base of the spillway, scraping against the rough concrete face of the spillway and rapid pressure changes (Heisey et al. 1996). Empirical studies related to spillway and bypass survival were pooled into a single data set. Existing studies described in the peer-reviewed primary literature and gray literature reports were collected and reviewed for potential application to the Brunswick Project. Professional judgment was used to sort through the existing studies and select those appropriate for and similar to Brunswick. Selection criteria used for this assessment included physical characteristics of the spillways/sluices at those projects, fish species tested, and geographical location.

Acceptability criteria for spillway and bypass survival studies were as follows:

- Completeness of the reported data on the important spill characteristics known to affect fish survival, information on the tested species, and other relevant information such as environmental conditions.
- Ensure control group survival >75% and sample size >25. The use of a control group allows for the isolation of effects due to the experimental treatment from those associated with the experimental procedure (e.g., handling stress or scale loss injury due to netting). Low control group survival may mask treatment effects or indicate that the experimental design and/or implementation were flawed to an extent that the results may not be reliable. Adequate sample size is important to achieve reasonable precision levels and to reduce the importance of each individual fish in a given test. For example, if 100 fish are used in a treatment group, each fish represents 1% of the sample. However, if 10 fish are used, each fish represents 10% of the sample. As control group survival decreases or the recapture rate of treatment and control fish decreases, the sample size must increase to achieve a particular level of precision.

3.3 Turbine Passage Smolt Survival Assessment

Due to the lack of site-specific information, estimates of turbine passage survival of Atlantic salmon smolts at Brunswick were developed using a combination of existing empirical studies and modeled calculations. Existing studies described in the peer-reviewed primary literature, gray literature reports, review documents and databases were collected and reviewed for potential application to the Brunswick Project. Professional judgment was used to sort through the existing studies and select those appropriate for Brunswick estimates. Selection criteria used for this assessment included physical characteristics of the projects, characteristics of the turbines at those projects, fish species tested, and geographical location. In addition to existing empirical data from similar hydroelectric projects, established models for determination of blade strike probabilities for fish passing through propeller turbines were constructed for Units 1 through 3 at Brunswick.

An examination of the results of recent studies indicate that turbine passage survival is largely a function of fish size relative to size of the water passageway (as indexed by runner diameter), clearance between structural components (*e.g.*, spacing between runner blades or buckets, wicket gates, and turbine housing), flow, angle of flow, and the number of buckets/blades, though other non-mechanical factors (*e.g.*, hydraulic) may also contribute to fish injury/mortality. Thus, species *per se* is not as important as fish size (Heisey et al. 1996; Franke et al. 1997) in safe passage through turbines.

3.3.1 Empirical Estimates of Smolt Turbine Passage Survival

Acceptance criteria were established prior to the review of existing empirical data for turbine survival studies. Acceptability criteria were as follows:

- Completeness of the reported data on the important turbine characteristics known to affect fish survival and information on the tested species, fish size, and other relevant information such as station discharge or environmental conditions.
- Ensure control group survival >75% and sample size >25. The use of a control group allows for the isolation of effects due to the experimental treatment from those associated with the experimental procedure (e.g., handling stress or scale loss injury due to netting). Low control group survival may mask treatment effects and indicates that the experimental design and/or implementation were flawed to an extent that the results may not be reliable. Adequate sample size is important to achieve reasonable precision levels and to reduce the importance

of each individual fish in a given test. For example, if 100 fish are used in a treatment group, each fish represents 1% of the sample. However, if 10 fish are used, each fish represents 10% of the sample. As control group survival decreases or the recapture rate of treatment and control fish decreases, the sample size must increase to achieve a particular level of precision.

3.3.2 Modeled Estimates of Smolt Turbine Passage Survival

Franke et al. (1997) defined the three primary risks to outmigrating fish passing through the turbine environment as 1) mechanical mechanisms, 2) fluid mechanisms, and 3) pressure mechanisms. Mechanical mechanisms were primarily defined as forces on fish body resulting from direct contact with turbine structural components (e.g. rotating runner blades, wicket gates, stay vanes, discharge ring, draft tube, passage through gaps between the blades and hub or at the distal end of blades or other structures placed into the water passageway). The probability of that contact is dependent on distance between blades, number of blades and fish body length. Additional sources of mechanical injury may include gap grinding, abrasion, wall strike and mechanical chop. Fluid mechanisms were defined as shear-turbulence (the effect on fish of encountering hydraulic forces due to rapidly changing water velocities) and cavitation (injury resulting from forces on fish body due to vapor pockets imploding near fish tissue). Impacts to fish from pressure resulted from the inability of fish to adjust from the regions of high pressure immediately upstream of turbine to regions of low pressure immediately downstream of turbines. Results from most studies indicate that mechanical related injuries are the dominant source of mortality for fish in the turbine environment at low head (< 30 m or 100 ft) projects (Franke et al. 1997). Blade strike is considered the primary mechanism of mortality when fish pass through turbines (Eicher Associates Inc. 1987; Cada 2001). Franke et al. (1997) noted that pressure related injuries appear to be of minor secondary importance when working at low head (< 30 m or 100 ft) hydroelectric projects. In addition, Franke et al. (1997) noted that tolerance to pressure reduction is greater for physostomous fish species, such as salmonids. Physostomous fish species are defined by having a pneumatic duct connecting the air bladder to the esophagus so that gasses from the air bladder can quickly dissipate through the mouth to accommodate changing pressures. Franke et al. (1997) noted that although evidence of injuries due to fluid shear forces does exist, relative to other injury types, they are not a dominant source of mortality during turbine passage.

Given that mechanical related injuries comprise the dominant source of mortality for fish passing through low head (< 30 m or 100 ft) hydroelectric projects, blade strike probabilities and turbine passage survival at Units 1 through 3 of the Brunswick Project was estimated for outmigrating Atlantic salmon smolts using the Advanced Hydro Turbine model developed by Franke et al. (1997). The Franke et al. (1997) blade strike model was developed as part of the U.S. Department of Energy program to develop more "fish friendly" turbines and is a modified form of the equation originally proposed by VonRaben (Bell 1981). Franke et al. (1997) refined the VonRaben model to consider tangential projection of the fish length and calculation of flow angles based on overall operating head and discharge parameters because most turbine passage mortality is likely caused by fish striking a blade or other component of the turbine unit. The Franke blade strike model predicts the probabilities of leading edge strikes (a possible mechanical injury source). Those strikes could result from contact between a fish body and a blade, a gap between blade and an adjacent structure, stay vane leading edge, wicket gate leading edge, or leading edge to any support pieces in the intake or draft tube.

The probability (*P*) of direct contact between a fish and a leading edge depends on a number of factors including the number of turbine blades (or buckets; N), fish length (L), runner blade speed (rpm), turbine type, runner diameter (D), and total discharge. Additionally, a correlation function (λ) is added to the equations to account for several factors (Franke et al. 1997). Among these are that an individual fish may not lie entirely in the plane of revolution due either to internal forces within the turbine or the physical movement of the individual fish. Additionally, a length-related fraction could be applied to account for the fact that an impact on a sensitive portion of the fish body (i.e. the head) may be more damaging than an impact to a less sensitive portion (i.e. the tail) of the fish (Franke et al. 1997). The use of the correlation factor also extends the applicability for the blade strike equations to all injury mechanisms related to the variable NL/D (number of blades*body length / runner diameter). These include both mechanical (leading edge strikes and gap grinding) and fluid mechanisms (Franke et al. 1997). As used in this analysis, the equation assumes that any strike results in immediate mortality whether the fish actually died, was injured, or not. The probability of survival predicted by this model will provide a useful perspective for fish sizes where site-specific data is not available.

Turbine passage survival was calculated for a range of fish body lengths (5-9 inches) considered to be representative of outmigrating salmon smolts in Maine rivers (NRC 2004; Fay et al. 2006). The blade strike probability for Propeller units was calculated using Equation 1:

$$P = \lambda \frac{N \cdot L}{D} \cdot \left[\frac{\cos \alpha_{\alpha}}{8\, Q_{\omega d}} + \pi \frac{r}{R}\right] \qquad \text{(Equation 1)}$$

where Equation 2 was used to calculate the value of α_{α} for a Propeller Unit:

$$\tan \alpha_{\alpha} = \frac{\frac{\pi}{2} \cdot E_{\omega d} \cdot \eta}{Q_{\omega d} \frac{r}{R}} + \frac{\frac{\pi r}{8R}}{Q_{\omega d}} - \tan \beta \qquad \text{(Equation 2)}$$

and Equation 3 was used to calculate the value of tan β.

$$\tan \beta = \frac{\frac{\pi r}{8R}}{Q_{opt}} \qquad \text{(Equation 3)}$$

Input parameters for Equations 1 through 3 were defined as:

B = Runner height at inlet
D = Diameter of runner
D_1 = Diameter of runner at the inlet
D_2 = Diameter of runner at the discharge
g = Acceleration due to gravity
H = Turbine head
L = Length of fish
N = Number of turbine blades or buckets
P = Predicted strike probability
Q = Turbine discharge
Q_{opt} = Turbine discharge at best efficiency
r = Fish entry point (along blade)
R = Radius

RPM = Revolutions per minute

α_α = Angle to axial of absolute flow upstream of runner (for Kaplan and Propeller units)

β = Relative flow angle at runner discharge

λ = Strike mortality correlation factor

η = Turbine efficiency

ω = Rotational speed (calculated as $\omega = RPM \cdot \frac{2\pi}{60}$)

$E_{\omega d}$ = Energy coefficient (calculated as $E_{\omega d} = \frac{gH}{(\omega d)^2}$)

$Q_{\omega d}$ = Discharge coefficient (calculated as $Q_{\omega d} = \frac{Q}{\omega D^3}$)

Calculated blade strike probabilities (P) generated by leading edge strike equations for Propeller turbines were converted into a percent survival (S) using equation 4.

$S = 100 - P$ (Equation 4)

4.0 Results: Downstream Migrating Smolt Survival

4.1 Smolt Run Timing

In order to model whole station survival for Atlantic salmon smolts passing the Brunswick Project, it is necessary to know the timing and seasonal distribution of smolts moving downstream. Seasonal distribution data for smolt downstream migration on the Androscoggin River is unavailable. As a result, distribution data collected from the smolt downstream migration on other Maine rivers was used as a surrogate. Seasonal run timing data was collected from seven different sampling years and two Maine rivers. Smolt passage was assessed during the months of April, May and June during 1988, 1989, 1990, 1993, 1994, and 1995 at the Mattaceunk Project (Weldon Dam) on the Penobscot River (Table 1; GNP 1997). During those six sampling years, a total of 16,114 Atlantic salmon smolts were collected. The average seasonal distribution for smolts during those six years was 0.09% during April (range = 0-0.46%), 71.94 during May (range = 38.0-93.84%) and 27.96 during June (range = 6.13-62.0%) (Table 2). Additional sampling was conducted and data was available related to smolt outmigration in the Penobscot River during 2004 (USASAC 2005). Total catch of Atlantic salmon smolts within Penobscot River rotary screw traps during spring 2004 is presented in Figure 6 (Note – this figure is reprinted from USASAC 2005). Based on visual assessment of Penobscot River data in Figure 6, it was estimated that approximately 10% of the Atlantic salmon smolt run took place during April, approximately 88% of the run took place during May and the remaining approximately 2% of the run took place during June. Rotary screw trap data from the Narraguagus River was also collected during 2004 (USASAC 2005). Based on visual assessment of Narraguagus River data in Figure 6, it was estimated that approximately 4% of the Atlantic salmon smolt run took place during April, approximately 96% of the run took place during May and 0% took place during June.

For the purposes of estimating whole station survival for downstream migrating Atlantic salmon smolts moving past the Brunswick Project it was assumed the average smolt distribution from the seven years of available data on seasonal smolt distribution from the Penobscot and Narraguagus Rivers would account for annual variation and be representative of patterns observed within the Androscoggin River. Patterns in mean daily discharge for the three rivers were examined for the years 2006-2010 and similar trends in the timing of spring run-off events were observed. Although not readily available, it is likely that spring water temperatures are also similar among the three rivers. Similarity in spring water temperatures and run-off timing for the three rivers supports the extrapolation of smolt run timing from those systems for application to the Androscoggin River. As a result, the model presented here is based on a seasonal distribution of Atlantic salmon smolts of 1.8% during April, 77.0% during May and 21.2% during June (Table 2). Variations in this seasonal distribution and their impacts to whole station survival are examined in Section 5.1 of this report.

4.1.1 Additional Considerations Related to Smolt Run Timing

There are additional ecological and anthropogenic factors that may influence smolt run timing in the Androscoggin River on an annual basis. Potential sources of variation to the seasonal distribution of Atlantic salmon smolts used in the model presented in this report could include smolt origin (hatchery-reared vs. wild) as well as differences in river temperature between upstream smolt rearing areas and the downstream hydroelectric Projects.

Smolt Origin:

Differences in the timing and seasonal distribution for smolts moving downstream may vary depending on the origin of the individuals (hatchery-reared vs. wild). Holbrook (2007) observed hatchery-reared smolts released during April (2005 and 2006) to exhibit downstream migratory behavior earlier than wild smolts within the Penobscot River. It was theorized that premature smolting of hatchery-reared individuals may potentially cause them to miss the natural environmental "window of opportunity" for successful outmigration. This "window of opportunity" (McCormick et al. 1998) is defined by impacts to smolt survival based on a number of physiological and ecological factors. The impact of potential differences in the timing and seasonal distribution of hatchery-reared and wild smolts is complicated by the long history of hatchery supplementation for the species (Holbrook 2007). Collections of outmigrating smolts during the studies used in this white paper assessment (and the resulting models for the NextEra Projects) did not distinguish between hatchery-reared or wild individuals.

Source Water Temperatures:

It has been suggested that rising spring water temperatures may be the key environmental trigger for initiation of outmigration of Atlantic salmon smolts from freshwater systems with the peak of migration occurring at water temperatures of approximately 10^{o}C (Ruggles 1980). Currently there is little available data related to the source water temperatures on run timing for Androscoggin River smolts. In the nearby Kennebec River, smolts originate in the upper reaches of the Sandy River (a tributary located upstream of the Weston, Shawmut and Lockwood Projects). Water temperature data recorded by MDMR at three locations (upper Orbeton spawning shoals, Route 4 Bridge, and Old Sandy River dam site) in the Sandy River during 2007 was examined in an attempt to provide support for the seasonal distribution of smolts used in the NextEra white papers (G. Wippelhauser, MDMR, personal communication). Daily average water temperatures (based on 24-hour records) were calculated for the period 23 April – 27 May 2007 at the most upstream (upper Orbeton spawning shoals) and most downstream (Old Sandy River dam site) water temperature sampling sites. Those two sampling sites are separated by approximately 60 miles of river. During 2007, Sandy River water temperatures first hit 10^{o}C in the upper reaches of the river on 24 May. Given the literature-reported peak of smolt migration (10^{o}C; Ruggles 1980) and the temporal occurrence of that peak temperature within the upper reaches of the Sandy River during 2007 , the seasonal distribution of Atlantic salmon smolts at the NextEra Projects of 1.8% during April, 77.0% during May and 21.2% during June seems reasonable. Given the lack of smolt outmigration data from the Sandy and Kennebec Rivers, the models for smolt outmigration presented in this report will rely on the data acquired from other Maine Rivers and described in Section 4.1.

4.2 Androscoggin River Flows

Flow duration curves for the Androscoggin River at the Brunswick Project were used for this analysis. Flow duration curves were developed from the flow record for the Androscoggin River as recorded by the USGS gage No. 0105900 near Auburn, Maine for the period 1990-2009. The USGS gage No. 0105900 is located upstream of the Brunswick Project. As a result, flow data from that gage was prorated by drainage to account for additional inflows into the Androscoggin between Auburn and the Brunswick Project. For the purposes of modeling project survival of Atlantic salmon smolts migrating past the Brunswick Project, the median monthly flow condition (i.e. the value with 50% flow exceedence) was used. It is likely that the use of the 50% flow exceedence value will provide a conservative estimate of the percentage of smolts passing via spill (as well as a conservative estimate of whole station survival). Once environmental cues thought to initiate the smolt outmigration period (such as water temperature) are triggered and the smolt migration is underway, it is likely that during years with seasonal pulses of flow greater than the 50% flow exceedence value will pass a greater number of smolts via spill. The median flow condition for the Androscoggin River during April was 13,466 cfs (Figure 3), during May was 8,816 cfs (Figure 4) and during June was 5,260 cfs (Figure 5). Impacts to the model of whole station smolt survival during years of high flow (10 and 25% flow exceedence) and low flow (75 and 90% flow exceedence) are examined in Section 5.1 of this report.

4.3 Smolt Downstream Route Determination

River discharge during the spring migration period will dictate the proportion of Atlantic salmon smolts passed downstream of the Brunswick Project though the spillway (and conversely, through the powerhouse or downstream passage facility). Determination of the spill effectiveness, defined as the proportion of smolts passed through spill relative to the total number passing the project, is the first step in assessing whole station survival (Figure 2). Spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (i.e., spilling 50% of total river flow results in 50% of smolts passing via the spillway). Although a number of site specific factors may impact spill effectiveness (i.e. project configuration and operations, forebay bathymetry, fish behavior, etc) the 1:1 spill effectiveness assumption has been validated at other hydroelectric projects (Normandeau 2010) and serves as a good initial value for this model. To date, no studies have been conducted to provide any empirical evidence to confirm the 1:1 assumption for spill effectiveness at the Brunswick Project.

An overall spill effectiveness for the period April through June of 9.6% was used for the assessment of whole station smolt survival at Brunswick. This value was calculated using a Project turbine capacity of 7,800 cfs, the monthly distribution of Atlantic salmon smolt outmigration for the nearby Penobscot and Narraguagus Rivers (Section 4.1), monthly median Androscoggin River flow conditions (Section 4.2) and the assumption of 1:1 spill effectiveness. Table 3 provides a summary of that calculation as well as the monthly values used for the assessment of Brunswick Project spill effectiveness.

4.4 Smolt Downstream Bypass Efficiency

Downstream passage for Atlantic salmon smolts approaching the powerhouse at Brunswick is currently provided by an adjustable surface sluice located between Units 1 and 2 and an 18 inch pipe which discharges into the tailrace. Given the lack of site specific data related to movement patterns for Atlantic salmon smolts through the Brunswick powerhouse area, it was assumed (for modeling purposes) that the passage distribution of smolts through the powerhouse is equal to the distribution of outflow through the powerhouse and downstream bypass. Design flow for the current downstream passage sluice at the Brunswick Project is 60 cfs.

The downstream bypass efficiency rate was allowed to vary by month to account for occasions when river discharge was less than the Project operating flow. For example, as presented in Table 3, the monthly median Androscoggin discharge (cfs) values during April and May were greater than the Project operating flow of 7,800 cfs. In those instances, the downstream bypass efficiency rate (assuming passage distribution of smolts through the powerhouse is equal to the distribution of outflow through the powerhouse and downstream bypass) was calculated as 0.8% ((60 cfs/7,800 cfs)*100 = 0.8%). However, during June, the monthly median Androscoggin discharge (cfs) value was 5,260 cfs. For that month, the downstream bypass efficiency rate (assuming passage distribution of smolts through the powerhouse is equal to the distribution of outflow through the powerhouse and downstream bypass) was calculated as

1.1% ((60 cfs/5,260 cfs)*100 = 1.1%). The remainder of the powerhouse area flow passes via the turbine units.

4.5 Smolt Spillway and Downstream Bypass Passage Survival Assessment

The Brunswick Project spillway consists of two ogee overflow spillway sections separated by a pier and barrier wall. The right spillway section, about 128 ft long, is topped with wooden flashboards that are 2.6 ft high. The left section does not have flashboards. Two taintor gates, each measuring 32.5 ft wide by 22 ft high, and an emergency spillway are located at the left abutment on the Topsham shoreline.

As the principal causes of injury and mortality for fish passed through either a spillway or bypass sluice are similar (Heisey et al. 1996) empirical studies related to spillway and bypass survival were pooled into a single data set. Injury/scale loss rates for Atlantic salmon smolt test and control fish released through sluices and bypasses at five different hydroelectric projects are presented in Table 4. Initial (1-hr) injury rates were available at all five projects and for test fish varied widely from 0% to 59% (average 18.4%) while those for control fish ranged from 0% to 4%. When initial (1-hr) test fish injuries from each of the five locations were pooled (Table 5), bruising/hemorrhaging had the greatest frequency of occurrence, being noted on 47.7% of individual smolts with injuries (10.9% of all individuals examined). Minor scale loss (<25% of body), major scale loss (>25% scale loss) and lacerations/tears were noted on 42.1%, 22.4%, and 8.4%, respectively of the individual smolts with injuries (9.6%, 5.1%, and 1.9%, respectively, of all individuals examined). Delayed (48-hr) injury rates were available at three of the five projects and for both test and control fish varied from 0% to 18% (average 6.0%). When delayed (48-hr) test fish injuries from each of the three locations were pooled (Table 5), minor scale loss (<25% of body) had the greatest frequency of occurrence, being noted on 85.7% of individual smolts with injuries (6.1% of all individuals examined). Bruising/hemorrhaging was noted on 14.3% of the individual smolts with injuries (1.0% of all individuals examined). Note that multiple injury types could be assigned to a single individual during each of the studies included in Tables 4 and 5.

Table 6 presents the measured initial (1-hr) and delayed (48-hr) survival for Atlantic salmon smolts passed through sluices and bypasses at five different hydroelectric projects. Selection of studies was limited to only those using the Hi-Z balloon tag method so that survival estimates were based solely on direct impacts from passage through the spill and not from indirect effects such as predation. Survival data collected from efficiency or fish movement studies do not represent actual Project survival and as a result, were not used in this analysis. Immediate survival (1-hr) estimates for Atlantic salmon smolts following passage through sluiceways and bypasses ranged from 93.3 to 100.0%, resulting in a mean overall spill survival of 97.1%. Delayed survival (48-hr) estimates for Atlantic salmon smolts following passage through sluiceways and bypasses ranged from 91.1 to 100.0%, resulting in a mean overall spill survival of 96.3%.

A review of 17 different spillway and sluice Hi-Z balloon tag studies conducted by Franke et al. (1997) reported an average immediate survival (1-hr) of 97.2%. That review included studies conducted for Atlantic salmon, Chinook salmon, American shad and blueback herring. Additionally, observations of post-passage movements for a limited number (N=18) of radio-tagged Atlantic salmon smolts which passed the nearby Lockwood Project (Kennebec River) via the spillway or surface sluice during 2007 (Normandeau 2008) were determined to have survived passage.

4.6 Smolt Entrainment Rates and Turbine Passage Survival Assessment

The Brunswick powerhouse contains three generating units (one vertical propeller and two horizontal propeller units) and has a total Project generating capacity of 19.0 MW. Peak capacity (cfs) is 1,336 cfs for the two horizontal propeller units and 4,519 cfs for the single vertical propeller unit (Table 7). Total unit flow for the Project is approximately 7,800 cfs. Normal operating head for the Brunswick Project is approximately 39 feet but is directly affected by the tide. The trash racks screening the intakes are 3.5 inch spacing. Additional turbine characteristics for Brunswick Units 1, 2, and 3 are provided in Table 7.

4.6.1 Turbine Entrainment Rates

Given the lack of site-specific data related to movement patterns for Atlantic salmon smolts through the Brunswick powerhouse area, it was assumed (for modeling purposes) that the distribution of smolt passage through the Project turbines and associated downstream bypass is equal to the distribution of outflow through the Project turbines and associated downstream bypass. Turbine entrainment rates at the Brunswick Project were calculated on a monthly basis as 100% minus the downstream bypass efficiency rate. As previously stated, this is a conservative assumption, given the deep intake opening of Unit 1.

4.6.2 Empirical Estimates of Turbine Passage Survival

Although existing information for turbine passage survival for Kaplan and propeller turbines is extensive (e.g. Franke et al. 1997, EPRI 1997), studies specific to the passage of Atlantic salmon are not as plentiful. Injury/scale loss rates for Atlantic salmon smolt test and control fish having passed through Kaplan/propeller turbines at ten different hydroelectric projects are presented in Table 8. Smolts recaptured during Normandeau turbine tag studies were assessed for scale loss and injuries following their initial recapture. Individuals were then held for a 48-hr period after which any incidence of latent mortality was recorded. Initial (1-hr) injury rates for test fish varied widely from 0.6% to 13.7% (average = 7.5%) while those for control fish ranged from 0% to 2.0%.

When initial (1-hr) test fish injuries from each of the studies involving Kaplan and propeller units were pooled (Table 9), mechanical related injuries such as severed body/back bone, bruised head/body, and operculum/gill damage had the highest frequency of occurrence, being noted on 28.9%, 20.6%, and 15.5% of individual smolts with injuries (2.1%, 1.5%, and 1.1%, respectively, of all individuals examined). Smolts displaying a loss of equilibrium (i.e. dazed) had a 25.8% frequency of occurrence in smolts injured passing through Kaplan/propeller units (1.8% of all individuals examined following Kaplan passage). Note that multiple injury types could be assigned to a single individual during each of the studies included in Table 9.

Table 10 presents the initial (1-hr) and delayed (48-hr) survival rates and basic Project characteristics for turbine passage survival studies conducted to evaluate turbine survival for Atlantic salmon smolts passing though Kaplan/propeller units. Results for ten different studies conducted at ten different hydroelectric projects are presented in Table 10. Initial survival (1-hr) estimates of Atlantic salmon smolt survival from individual tests (N=15) for Kaplan/propeller units ranged from 88.0 to 100.0%, resulting in a mean overall survival of 94.7%. Delayed survival (~48-hr) estimates for Atlantic salmon smolts from individual tests (N=15) following passage through Kaplan units ranged from 87.5 to 100.0%, resulting in a mean overall delayed survival of 92.8%. Selection of studies was limited to only those using the Hi-Z balloon tag method so that estimates were based solely on direct impacts from passage through a turbine unit. Survival data collected from efficiency or fish movement studies do not represent actual Project survival and as a result, were not used in this analysis. Additional study-specific information related to each study presented in Table 10 is presented in Appendix A of this report.

4.6.3 Modeled Estimates of Turbine Passage Survival

Survival estimates for turbine passage were generated for three propeller units in operation at Brunswick. Estimates were calculated for five body lengths considered representative of the range of total length for outmigrating Atlantic salmon smolts (5, 6, 7, 8, and 9 inches). Two correlation factors (λ) were used in this analysis (0.1 and 0.2). Franke et al. (1997) recommended the value for the correlation factor be within the range of 0.1 to 0.2 based on a review of empirical results associated with a substantial number of salmonid survival studies. Three *r* values were used in this analysis and each represents the point along the runner radius that the fish enters the turbine. Values for *r* used in this assessment were 0.1, 0.5, and 0.9% of the runner radius. Brunswick units 2 and 3 have a single setting (Table 7). As a result, survival estimates for Brunswick units1-3 were modeled using the peak turbine discharge (cfs) and the associated efficiency.

Model runs for the five body lengths, two correlation factors and three *r* values resulted in a total of 30 survival estimates which likely bracket the actual survival for salmon smolts passing through the three propeller units at Brunswick. Predicted survival values for salmon smolts ranged from a high of 98.7% for a five inch smolt passing near the hub of Unit 1 to a low of 75.3% for a nine inch smolt passing near the blade tip at Units 2 and 3 (Table 11). Predicted survival probabilities increased as smolt body length and entry point proximity to the turbine hub decreased. The average survival of salmon smolts passing through the propeller units at Brunswick was determined by averaging the modeled survival estimates for each combination of fish length, entry point and λ at Units 1, 2, and 3. The calculated mean survival for the Brunswick propeller units was 92.7%.

4.6.4 Comparison of Modeled and Empirical Passage Survival

Survival estimates for propeller and Kaplan turbines obtained from empirical data collected at other hydroelectric projects were compared with the predictive model developed specifically for the Brunswick Project Units 1, 2, and 3. The average modeled survival rate for the Brunswick propeller units (92.7%) was near the mid-point for the observed range (88.0-100.0%) of empirical survival estimates for Kaplan/propeller turbines at other hydroelectric projects.

5.0 Estimated Project Impact on Outmigrating Atlantic salmon Smolts

5.1 Modeled Estimate of Whole Station Survival for Smolts

Whole station survival for the Brunswick Project was estimated by integrating Androscoggin River flows, Project operating flows, the proportion of smolts diverted towards the spillway and powerhouse, spillway survival rate (as estimated from empirical data), turbine passage survival rates (as estimated through a combination of empirical and modeled data), downstream bypass efficiency, and fish bypass passage survival rate (as estimated from empirical data). Four models intended to estimate whole station survival of smolts passing the Brunswick Project were constructed using the available empirical and modeled survival estimates for both spill and turbine passage. The four individual models were:

1) Initial Survival Rate Model (Model A): Spill survival based on 1-hr empirical survival data and Kaplan and Francis turbine survival based on 1-hr empirical survival data
2) Delayed Survival Rate Model (Model B): Spill survival based on 48-hr empirical survival data and Kaplan and Francis turbine survival based on 48-hr empirical survival data
3) Delayed/Calculated Survival Rate Model (Model C): Spill survival based on 48-hr empirical data and Kaplan and Francis turbine survival based Franke estimates
4) Initial Injury Rate Model (Model D): survival based on 1-hr empirical injury data and Kaplan and Francis turbine survival based on 1-hr empirical injury data

5.1.1 Whole Station Smolt Survival Modeled Using Initial Survival Rates

The Model A whole station smolt survival estimate was generated using initial (1-hr) survival rates for spill and turbine passed fish obtained from empirical data collected at other hydroelectric projects. The following values for each of the necessary model parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in this calculation of whole station survival for salmon smolts at the Brunswick Project:

- Androscoggin River Flow – monthly medians of 13,466 cfs (April), 8,816 cfs (May) and 5,260 cfs (June);
- Project operating flow – 7,800 cfs;
- Proportion of salmonid smolts diverted – utilized a ratio of 1:1 fish to river flow;
- Project spillway survival – 97.1% (based on review of initial (1-hr) empirical survival data from other hydroelectric projects);
- Fish bypass guidance efficiency – as determined on a monthly basis based on the relationship of bypass discharge (60 cfs) and Project operating flow;
    - April: (60 cfs / 7,800 cfs)*100 = 0.8%
    - May: (60 cfs / 7,800 cfs)*100 = 0.8%
    - June: (60 cfs / 5,260 cfs)*100 = 1.1%
- Entrainment rate through turbines – as determined on a monthly basis as 100% - fish bypass guidance efficiency
    - April: 100% - 0.8% = 99.2%
    - May: 100% - 0.8% = 99.2%
    - June: 100% - 1.1% = 98.9%

- Propeller turbine passage survival – 94.7% (based on review of initial (1-hr) empirical survival data from other hydroelectric projects);
- Fish bypass system survival – 97.1% (based on review of initial (1-hr) empirical survival data from other hydroelectric projects).

The integration of the above values is provided in Table 12 for a hypothetical case of 1,000 Atlantic salmon smolts approaching the Brunswick Project during the spring migration period (April-June). The Model A whole station survival estimate for Atlantic salmon smolts passing the Brunswick Project generated using initial (1-hr) empirical data for spillway and turbine survival estimates is 95%[1].

5.1.1.1 Impacts to Estimated Smolt Survival Associated with Bypass Efficiency Assumption

The Initial Survival Rate Model (Model A) for Brunswick can be manipulated to provide insight into impacts to whole station survival based on modifying the various input parameters. NextEra, in consultation with resource agency personnel is presently evaluating options to further enhance downstream fish passage measures at the project. At the request of the resource agencies, NextEra in the summer of 2011, contracted with a consultant to evaluate various downstream fish passage options using Computational Fluid Dynamics (CFD) modeling. The initial model runs using various floating fish guidance boom locations and surface sluices have been completed and were presented to resource agency personnel in December 2011. Additional model runs to refine the existing ones are scheduled for the first quarter of 2012. The resultant data will be used in consultation with the resource agencies, to propose new downstream fish passage enhancements at the project. Installation of a downstream facility at the Brunswick Project should reduce the impact of turbine passage on outmigrating smolts. Table 13 provides whole station survival estimates for a range of theoretical downstream facility efficiency rates. Theoretical downstream facility effectiveness rates between 25 and 100% were modeled and produced a range of whole station survival estimates for outmigrating Atlantic salmon smolts between 95% and 97%.

5.1.1.2 Impacts to Estimated Smolt Survival Associated with Seasonal Distribution Assumption

In cases with no site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (e.g., spilling 50% of total river flow results in 50% of smolts passing via the spillway). A basic implication of the deviation from the 1:1 assumption is that if a proportionally smaller percentage of smolts relative to the river flow enter the Project powerhouse area then the calculated station-related smolt survival would be higher. Under these conditions, a greater percentage of smolts would pass the project via spill and would avoid impacts associated with turbine passage. Alternatively, if a proportionally higher percentage of smolts are entering the Project powerhouse area than the calculated station related smolt survival would be lower. Under these conditions, a lower percentage of smolts would pass the project via spill and a greater number would be entrained through the Project turbines.

The sensitivity of the Initial Survival Rate Model (Model A) associated with deviation from the assumed 1:1 ratio of fish to flow at the Brunswick Project is presented in Table 14. A range of spill effectiveness rates for Atlantic salmon smolts from 5% (0.5:1) to 90% (9.4:1) was evaluated. For conditions where a proportionately lower percentage of smolts relative to river flow entered the powerhouse area (i.e. spill effectiveness rates of 30% and greater), the estimates for whole station survival were equal to or greater than that observed under the assumption of 1:1 spill effectiveness and ranged from 95% to 97%. For conditions where a proportionately higher percentage of smolts relative to river flow entered the

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[1] Whole station survival estimates are reported to the nearest whole percentage so as to not overstate the accuracy of these models. This was done following comments made at the Technical Advisory Committee meeting held on 7 September 2011.

powerhouse area (i.e. spill effectiveness rates of 5%), the estimate for whole station survival was equal to that observed under the assumption of 1:1 spill effectiveness.

5.1.1.3 Impacts to Estimated Smolt Survival Associated with Seasonal Flow Assumption

The Initial Survival Rate Model (Model A) for Brunswick was constructed using the assumption of average Androscoggin River flows (i.e. 50% exceedence) during the months of April, May and June. Two “low flow” conditions (75 and 90% exceedence) and two “high flow” conditions (10 and 25% exceedence) were also examined. Estimated monthly Androscoggin River flows for the months of April, May and June under the 10, 25, 75, and 90% exceedence conditions are presented in Table 15. Table 16 presents the modeled whole station survival estimates for downstream migrating Atlantic salmon smolts under the additional low and high flow conditions. Under the low flow conditions (i.e. those exceeded 75 and 90% of the time) the estimated whole station survival for salmon smolts at the Brunswick Project remained the same at 95%. Under the high flow conditions (i.e. those exceeded only 10 or 25% of the time) the estimated whole station survival for salmon smolts at the Brunswick Project increased to 96% or remained the same, respectively.

5.1.2 Whole Station Smolt Survival Modeled Using Delayed Survival Rates

The Model B whole station smolt survival estimate was generated using delayed (48-hr) survival rates for spill and turbine passed fish obtained from empirical data collected at other hydroelectric projects. The following values for each of the necessary model parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in this calculation of whole station survival for salmon smolts at the Brunswick Project:

- Androscoggin River Flow – monthly medians of 13,466 cfs (April), 8,816 cfs (May) and 5,260 cfs (June);
- Project operating flow – 7,800 cfs;
- Proportion of salmonid smolts diverted – utilized a ratio of 1:1 fish to river flow;
- Project spillway survival – 97.1% (based on review of initial (1-hr) empirical survival data from other hydroelectric projects);
- Fish bypass guidance efficiency – as determined on a monthly basis based on the relationship of bypass discharge (60 cfs) and Project operating flow;
    - April: (60 cfs / 7,800 cfs)*100 = 0.8%
    - May: (60 cfs / 7,800 cfs)*100 = 0.8%
    - June: (60 cfs / 5,260 cfs)*100 = 1.1%
- Entrainment rate through turbines – as determined on a monthly basis as 100% - fish bypass guidance efficiency
    - April: 100% - 0.8% = 99.2%
    - May: 100% - 0.8% = 99.2%
    - June: 100% - 1.1% = 98.9%
- Propeller turbine passage survival – 92.8% (based on review of delayed (48-hr) empirical survival data from other hydroelectric projects);
- Fish bypass system survival – 96.3% (based on review of delayed (48-hr) empirical survival data from other hydroelectric projects).

The integration of the above values is provided in Table 17 for a hypothetical case of 1,000 Atlantic salmon smolts approaching the Brunswick Project during the spring migration period (April-June). The Model B whole station survival estimate for Atlantic salmon smolts passing the Brunswick Project generated using delayed (48-hr) empirical data for spillway and turbine survival estimates is 93%.

5.1.2.1 Impacts to Estimated Smolt Survival Associated with Bypass Efficiency Assumption

The Delayed Survival Rate Model (Model B) for Brunswick can be manipulated to provide insight into impacts to whole station survival based on modifying the various input parameters. NextEra, in consultation with resource agency personnel is presently evaluating options to further enhance downstream fish passage measures at the project. At the request of the resource agencies, NextEra in the summer of 2011, contracted with a consultant to evaluate various downstream fish passage options using Computational Fluid Dynamics (CFD) modeling. The initial model runs using various floating fish guidance boom locations and surface sluices have been completed and were presented to resource agency personnel in December 2011. Additional model runs to refine the existing ones are scheduled for the first quarter of 2012. The resultant data will be used in consultation with the resource agencies, to propose new downstream fish passage enhancements at the project. Installation of a downstream facility at the Brunswick Project should reduce the impact of turbine passage on outmigrating smolts. Table 18 provides whole station survival estimates for a range of theoretical downstream facility efficiency rates. Theoretical downstream facility effectiveness rates between 25 and 100% were modeled and produced a range of whole station survival estimates for outmigrating Atlantic salmon smolts between 94% and 96%.

5.1.2.2 Impacts to Estimated Smolt Survival Associated with Seasonal Distribution Assumption

In cases with no site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (e.g., spilling 50% of total river flow results in 50% of smolts passing via the spillway). A basic implication of the deviation from the 1:1 assumption is that if a proportionally smaller percentage of smolts relative to the river flow enter the Project powerhouse area then the calculated station-related smolt survival would be higher. Under these conditions, a greater percentage of smolts would pass the project via spill and would avoid impacts associated with turbine passage. Alternatively, if a proportionally higher percentage of smolts are entering the Project powerhouse area than the calculated station related smolt survival would be lower. Under these conditions, a lower percentage of smolts would pass the project via spill and a greater number would be entrained through the Project turbines.

The sensitivity of the Delayed Survival Rate Model (Model B) associated with deviation from the assumed 1:1 ratio of fish to flow at the Brunswick Project is presented in Table 19. A range of spill effectiveness rates for Atlantic salmon smolts from 5% (0.5:1) to 90% (9.4:1) was evaluated. For conditions where a proportionately lower percentage of smolts relative to river flow entered the powerhouse area (i.e. spill effectiveness rates of 30% and greater), the estimates for whole station survival were greater than that observed under the assumption of 1:1 spill effectiveness and ranged from 94% to 96%. For conditions where a proportionately higher percentage of smolts relative to river flow entered the powerhouse area (i.e. a spill effectiveness rate of 5%), the estimate (93%) for whole station survival was equal to that observed under the assumption of 1:1 spill effectiveness.

5.1.2.3 Impacts to Estimated Smolt Survival Associated with Seasonal Flow Assumption

The Delayed Survival Rate Model (Model B) for Brunswick was constructed using the assumption of average Androscoggin River flows (i.e. 50% exceedence) during the months of April, May and June. Two “low flow” conditions (75 and 90% exceedence) and two “high flow” conditions (10 and 25%

exceedence) were also examined. Estimated monthly Androscoggin River flows for the months of April, May and June under the 10, 25, 75, and 90% exceedence conditions are presented in Table 15. Table 20 presents the modeled whole station survival estimates for downstream migrating Atlantic salmon smolts under the additional low and high flow conditions. Under the low flow conditions (i.e. those exceeded 75 and 90% of the time) the estimated whole station survival for salmon smolts at the Brunswick Project remained the same (93%). Under the high flow conditions (i.e. those exceeded only 10 or 25% of the time) the estimated whole station survival for salmon smolts at the Brunswick Project increased to 95% and 94%, respectively.

5.1.3 Whole Station Smolt Survival Modeled Using Delayed/Calculated Survival Rates

The Model C whole station smolt survival estimate was generated using delayed (48-hr) survival rates for spill obtained from empirical data collected at other hydroelectric projects in conjunction with modeled estimates of turbine passed fish obtained using the Franke (Franke et al. 1997) formula. The following values for each of the necessary model parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in this calculation of whole station survival for salmon smolts at the Brunswick Project:

- Androscoggin River Flow – monthly medians of 13,466 cfs (April), 8,816 cfs (May) and 5,260 cfs (June);
- Project operating flow – 7,800 cfs;
- Proportion of salmonid smolts diverted – utilized a ratio of 1:1 fish to river flow;
- Project spillway survival – 97.1% (based on review of initial (1-hr) empirical survival data from other hydroelectric projects);
- Fish bypass guidance efficiency – as determined on a monthly basis based on the relationship of bypass discharge (60 cfs) and Project operating flow;
    - April: (60 cfs / 7,800 cfs)*100 = 0.8%
    - May: (60 cfs / 7,800 cfs)*100 = 0.8%
    - June: (60 cfs / 5,260 cfs)*100 = 1.1%
- Entrainment rate through turbines – as determined on a monthly basis as 100% - fish bypass guidance efficiency
    - April: 100% - 0.8% = 99.2%
    - May: 100% - 0.8% = 99.2%
    - June: 100% - 1.1% = 98.9%
- Propeller turbine passage survival – 92.7% (based on modeled values generated using site-specific turbine parameters);
- Fish bypass system survival – 96.3% (based on review of delayed (48-hr) empirical survival data from other hydroelectric projects).

The integration of the above values is provided in Table 21 for a hypothetical case of 1,000 Atlantic salmon smolts approaching the Brunswick Project during the spring migration period (April-June). The Model C whole station survival estimate for Atlantic salmon smolts passing the Brunswick Project generated using delayed (48-hr) empirical data for spill and site-specific modeled values for turbine survival estimates is 93%.

5.1.3.1 Impacts to Estimated Smolt Survival Associated with Bypass Efficiency Assumption

The Delayed/Calculated Survival Rate Model (Model C) for Brunswick can be manipulated to provide insight into impacts to whole station survival based on modifying the various input parameters. NextEra, in consultation with resource agency personnel is presently evaluating options to further enhance downstream fish passage measures at the project. At the request of the resource agencies, NextEra in the summer of 2011, contracted with a consultant to evaluate various downstream fish passage options using Computational Fluid Dynamics (CFD) modeling. The initial model runs using various floating fish guidance boom locations and surface sluices have been completed and were presented to resource agency personnel in December 2011. Additional model runs to refine the existing ones are scheduled for the first quarter of 2012. The resultant data will be used in consultation with the resource agencies, to propose new downstream fish passage enhancements at the project. Installation of a downstream facility at the Brunswick Project should reduce the impact of turbine passage on outmigrating smolts. Table 22 provides whole station survival estimates for a range of theoretical downstream facility efficiency rates. Theoretical downstream facility effectiveness rates between 25 and 100% were modeled and produced a range of whole station survival estimates for outmigrating Atlantic salmon smolts between 94% and 97%.

5.1.3.2 Impacts to Estimated Smolt Survival Associated with Seasonal Distribution Assumption

In cases with no site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (e.g., spilling 50% of total river flow results in 50% of smolts passing via the spillway). A basic implication of the deviation from the 1:1 assumption is that if a proportionally smaller percentage of smolts relative to the river flow enter the Project powerhouse area then the calculated station-related smolt survival would be higher. Under these conditions, a greater percentage of smolts would pass the project via spill and would avoid impacts associated with turbine passage. Alternatively, if a proportionally higher percentage of smolts are entering the Project powerhouse area than the calculated station related smolt survival would be lower. Under these conditions, a lower percentage of smolts would pass the project via spill and a greater number would be entrained through the Project turbines.

The sensitivity of the Delayed/Calculated Survival Rate Model (Model C) associated with deviation from the assumed 1:1 ratio of fish to flow at the Brunswick Project is presented in Table 23. A range of spill effectiveness rates for Atlantic salmon smolts from 5% (0.5:1) to 90% (9.4:1) was evaluated. For conditions where a proportionately lower percentage of smolts relative to river flow entered the powerhouse area (i.e. spill effectiveness rates of 30% and greater), the estimates for whole station survival were higher than that observed under the assumption of 1:1 spill effectiveness and ranged from 94% to 97%. For conditions where a proportionately higher percentage of smolts relative to river flow entered the powerhouse area (i.e. a spill effectiveness rate of 5%), the estimate for whole station survival was similar to that observed under the assumption of 1:1 spill effectiveness.

5.1.3.3 Impacts to Estimated Smolt Survival Associated with Seasonal Flow Assumption

The Delayed/Calculated Survival Rate Model (Model C) for Brunswick was constructed using the assumption of average Androscoggin River flows (i.e. 50% exceedence) during the months of April, May and June. Two "low flow" conditions (75 and 90% exceedence) and two "high flow" conditions (10 and 25% exceedence) were also examined. Estimated monthly Androscoggin River flows for the months of April, May and June under the 10, 25, 75, and 90% exceedence conditions are presented in Table 15. Table 24 presents the modeled whole station survival estimates for downstream migrating Atlantic salmon smolts under the additional low and high flow conditions. Under the low flow conditions (i.e. those exceeded 75 and 90% of the time) the estimated whole station survival for salmon smolts at the

Brunswick Project remained similar to that observed under median conditions. Under the high flow conditions (i.e. those exceeded only 10 or 25% of the time) the estimated whole station survival for salmon smolts at the Brunswick Project increased to 95% and 94%, respectively.

5.1.4 Whole Station Smolt Survival Modeled Using Initial Injury Rates

The Model D whole station smolt survival estimate was generated using initial (1-hr) injury rates for spill and turbine passed fish obtained from empirical data collected at other hydroelectric projects. Comparisons of initial injury assessment and delayed survival rates for Atlantic salmon smolts subjected to mark-recapture spill and turbine passage studies suggest that not all injuries sustained by smolts during dam passage will result in mortality. However, for the purposes of this analysis, it was assumed that any fish subjected to an injury (regardless of the magnitude of that injury) suffered mortality. Model D was intended to provide a "worst case" scenario for Atlantic salmon smolts passing the Brunswick Project. The following values for each of the necessary model parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in this calculation of whole station survival for salmon smolts at the Brunswick Project:

- Androscoggin River Flow – monthly medians of 13,466 cfs (April), 8,816 cfs (May) and 5,260 cfs (June);
- Project operating flow – 7,800 cfs;
- Proportion of salmonid smolts diverted – utilized a ratio of 1:1 fish to river flow;
- Project spillway survival – 81.6% (based on review of initial (1-hr) empirical injury data from other hydroelectric projects used as a surrogate for survival);
- Fish bypass guidance efficiency – as determined on a monthly basis based on the relationship of bypass discharge (60 cfs) and Project operating flow;
    - April: (60 cfs / 7,800 cfs)*100 = 0.8%
    - May: (60 cfs / 7,800 cfs)*100 = 0.8%
    - June: (60 cfs / 5,260 cfs)*100 = 1.1%
- Entrainment rate through turbines – as determined on a monthly basis as 100% - fish bypass guidance efficiency
    - April: 100% - 0.8% = 99.2%
    - May: 100% - 0.8% = 99.2%
    - June: 100% - 1.1% = 98.9%
- Propeller turbine passage survival – 92.5% (based on review of initial (1-hr) empirical injury data from other hydroelectric projects used as a surrogate for survival);
- Fish bypass system survival – 81.6% (based on review of initial (1-hr) empirical injury data from other hydroelectric projects used as a surrogate for survival).

The integration of the above values is provided in Table 25 for a hypothetical case of 1,000 Atlantic salmon smolts approaching the Brunswick Project during the spring migration period (April-June). The Model D whole station survival estimate for Atlantic salmon smolt passing the Brunswick Project generated using initial (1-hr) empirical injury data as a surrogate for spillway and turbine survival estimates is 91%.

5.1.4.1 Impacts to Estimated Smolt Survival Associated with Bypass Efficiency Assumption

The Initial Injury Rate Model (Model D) for Brunswick can be manipulated to provide insight into impacts to whole station survival based on modifying the various input parameters. NextEra, in consultation with resource agency personnel is presently evaluating options to further enhance downstream fish passage measures at the project. At the request of the resource agencies, NextEra in the summer of 2011, contracted with a consultant to evaluate various downstream fish passage options using Computational Fluid Dynamics (CFD) modeling. The initial model runs using various floating fish guidance boom locations and surface sluices have been completed and were presented to resource agency personnel in December 2011. Additional model runs to refine the existing ones are scheduled for the first quarter of 2012. The resultant data will be used in consultation with the resource agencies, to propose new downstream fish passage enhancements at the project. Installation of a downstream facility at the Brunswick Project should reduce the impact of turbine passage on outmigrating smolts. Table 26 provides whole station survival estimates for a range of theoretical downstream facility efficiency rates. Theoretical downstream facility effectiveness rates between 25 and 100% were modeled and produced a range of whole station survival estimates for outmigrating Atlantic salmon smolts between 89% and 82%.

5.1.4.2 Impacts to Estimated Smolt Survival Associated with Seasonal Distribution Assumption

In cases with no site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (e.g., spilling 50% of total river flow results in 50% of smolts passing via the spillway). A basic implication of the deviation from the 1:1 assumption is that if a proportionally smaller percentage of smolts relative to the river flow enter the Project powerhouse area then the calculated station-related smolt survival would be higher. Under these conditions, a greater percentage of smolts would pass the project via spill and would avoid impacts associated with turbine passage. Alternatively, if a proportionally higher percentage of smolts are entering the Project powerhouse area than the calculated station related smolt survival would be lower. Under these conditions, a lower percentage of smolts would pass the project via spill and a greater number would be entrained through the Project turbines.

The sensitivity of the Initial Injury Rate Model (Model D) associated with deviation from the assumed 1:1 ratio of fish to flow at the Brunswick Project is presented in Table 27. A range of spill effectiveness rates for Atlantic salmon smolts from 5% (0.5:1) to 90% (9.4:1) was evaluated. For conditions where a proportionately lower percentage of smolts relative to river flow entered the powerhouse area (i.e. spill effectiveness rates of 30% and greater), the estimates for whole station survival were lower than that observed under the assumption of 1:1 spill effectiveness and ranged from 89% to 83%. For conditions where a proportionately higher percentage of smolts relative to river flow entered the powerhouse area (i.e. a spill effectiveness rate of 5%), the estimate for whole station survival was greater (92%) than that observed under the assumption of 1:1 spill effectiveness.

5.1.4.3 Impacts to Estimated Smolt Survival Associated with Seasonal Flow Assumption

The Initial Injury Rate Model (Model D) for Brunswick was constructed using the assumption of average Androscoggin River flows (i.e. 50% exceedence) during the months of April, May and June. Two “low flow” conditions (75 and 90% exceedence) and two “high flow” conditions (10 and 25% exceedence) were also examined. Estimated monthly Androscoggin River flows for the months of April, May and June under the 10, 25, 75, and 90% exceedence conditions are presented in Table 15. Table 28 presents the modeled whole station survival estimates for downstream migrating Atlantic salmon smolts under the additional low and high flow conditions. Under the low flow conditions (i.e. those exceeded 75 and 90% of the time) the estimated whole station survival for salmon smolts at the Brunswick Project increased to

92%. Under the high flow conditions (i.e. those exceeded only 10 or 25% of the time) the estimated whole station survival for salmon smolts at the Brunswick Project decreased to 86% and 89%, respectively.

5.2 Summary of Modeled Estimate of Whole Station Survival for Smolts

Four models of whole station survival of Atlantic salmon smolts at the Brunswick Project were constructed using available empirical and modeled survival rates for passage via spill and through turbine units. The primary estimates of whole station survival generated by those four models ranged from 95% to 91% with modifications during the various sensitivity analyses expanding those bounds to 97% and 82%. Use of initial (1-hr) empirical spill and turbine survival data (Model A; Initial Survival Rate Model) from other hydroelectric projects yielded the highest estimate of whole station smolt survival. Model D, the Initial Injury Rate Model (using 1-hr empirical spill and turbine injury rates as a surrogate for survival) produced the lowest estimate of whole station smolt survival. Model D was constructed under the assumption that any fish subjected to an injury (regardless of the magnitude of that injury) suffered mortality. It should be noted that comparisons of initial injury assessment and delayed survival rates for Atlantic salmon smolts subjected to mark-recapture spill and turbine passage studies suggest that not all injuries sustained by smolts during dam passage will result in mortality. In addition, the sensitivity analyses for the Initial Injury Rate Model (Model D) showed an increase in whole station survival as a greater proportion of smolts were passed via turbine units. This was due to the relatively low survival rate (81.6%) when empirical injury data collected at other hydroelectric projects for spill passed salmon smolts was used as a surrogate for survival. The majority of injuries observed for Atlantic salmon smolts passed via spill (Table 5) were minor scale loss and bruising/hemorrhaging. Although some studies have suggested that descaling of smolts may reduce performance and decrease survival during migration (Gadomski et al. 1994; Zydlewski et al. 2010), another study has suggested that the required time (in freshwater) for a smolt to recover from a loss of scales that would be lethal in saltwater is within one day (Bouck and Smith 1979). While injuries to smolts passed via spill and turbines will lead to mortality for a percentage of individuals, it is likely that the Initial Injury Rate Model, Model A (using 1-hr injury rates as a surrogate for survival), underestimates whole station smolt survival at Brunswick. Model C, the Delayed/Calculated Survival Rate Model, provides the most conservative and reliable estimate of whole station smolt survival at Brunswick (93%).

6.0 Atlantic Salmon Adults and Kelts

6.1 Adult Upstream Migration

Within the Androscoggin River, returning adult salmon are captured at the Brunswick fish lift by MDMR personnel, processed for biological information and then released upstream of the Project. Collection totals for the previous seventeen years (1995-2011) have ranged from a low of one individual during 1997 to a high of 48 individuals during 2011[2] (Table 29).

6.1.1 Upstream Migration Delays

Delays to the upstream migration of Atlantic salmon have been observed below hydroelectric facilities. Fay et al. (2006) provided a review of available literature (Dube 1988; Shepard 1989; Shepard and Hall 1991; Shepard 1995) related to the observed passage delays at a number of hydroelectric projects on the Penobscot River. Results from these radio-telemetry studies indicate that the duration of delay varies widely among year and hydroelectric facility. Yearly pooled median passage times for adult Atlantic salmon at Veazie ranged from 4.7 to 33.2 days over five years of study. Yearly pooled median passage times for adult Atlantic salmon at Great Works ranged from 1.4 to 2.7 days over four years of study. Yearly pooled median passage times for adult Atlantic salmon at Milford Dam ranged from 1.0 to 5.3 days over five years of study. A recent (2005/2006) radio-telemetry assessment of upstream passage for Atlantic salmon adults at Penobscot River projects reported individual passage times (defined as interval between first tailrace detection and first upstream detection) for a limited number of fish at Veazie, Great Works and Milford Dams (Holbrook et al. 2009). Individual passage times (2005) for adult salmon approaching Veazie from Penobscot Bay were 2.0 and 3.3 days (for 2 of 4 individuals detected in tailrace) and for salmon approaching Great Works were 1.9, 13.1, and 25.4 days (for 3 of 6 individuals detected in tailrace). Individual passage times for all adult salmon having passed Great Works were 0.1, 2.9, and 3.7 days at Milford. Individual passage times (2006) for adult salmon reapproaching Veazie (following passage over the dam) were 2.1, 6.8 and 58.4 days (for 3 of 7 individuals detected in tailrace) and for salmon approaching Great Works were 8.6, 8.7, and 12.5 days (for 3 of 25 individuals detected in tailrace).

At this point, absent any site-specific field-test data, it is reasonable to assume that adult salmon approaching the Brunswick Project on their upstream migration may be subject to delays similar in duration as to what has been observed for radio-tagged individuals on the Penobscot River.

6.2 Kelt Downstream Migration

Following the fall season spawning period, Atlantic salmon kelts either outmigrate during the fall or remain in the freshwater portion of the river before outmigrating during the following spring. Baum (1997) indicated that following the fall spawn, approximately 20% of kelts move back downstream with the remainder (80%) moving downstream and the following spring. Quantitative data obtained from studies regarding timing, duration and survival of Atlantic salmon kelts during their downstream migration in the Androscoggin River and through the Brunswick Project are unavailable at this time. However, MDMR radio tagged 20 adult Atlantic salmon at the Brunswick fishway in the spring of 2011 and the resultant passage data should be available in the spring of 2012.

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[2] 2011 total as of 12 August 2011 (M. Brown, MDMR, personal communication)

Although sample size and information related to passage routes are limited, successful downstream passage through the hydroelectric projects on the nearby lower Kennebec River was observed for a single kelt radio tagged as part of a study on the Sandy River (MDMR 2009). A total of 18 sea-run Atlantic salmon were captured at the Lockwood Project (on the Kennebec River), radio tagged and trucked to the Sandy River during the spring seasons of 2007 and 2008 (MDMR 2008, MDMR 2009). The majority (8 of 9) of those fish were determined to have remained in the Sandy River through the spawning season during both years. A single individual released in the Sandy River during early June 2008 successfully passed downstream of the Weston Project and was located in the mainstem of the Kennebec River during August and September of 2008. That same individual was next detected downstream of Lockwood during January 2009. Detection of that fish below Lockwood demonstrates that it successfully passed downstream past the Weston, Shawmut, and Lockwood projects as well as Hydro Kennebec (owned and operated by Brookfield Power).

6.3 Modeled Downstream Migrating Kelt Survival

Limited data for Atlantic salmon kelts make it difficult to assess the specific effects of the Brunswick Project on kelt survival. Observations on the Penobscot and other river systems in the Northeast suggest that kelts tend to linger in spawning areas and in parts of the freshwater river system, including hydropower impoundments and facilities. Similar to the behavior recorded on the Penobscot River, anecdotal observations by Normandeau personnel working on the Merrimack River, NH have noted adult salmon to remain within the forebay canal of the Garvins Falls Project and individuals are often visible within the upper portion of the water column at that site. Kelts are not thought to sound frequently and that notion is supported through the reduction in turbine passage at Weldon following the installation of 1 in spaced trashracks over the upper 16 feet of the intakes. In addition, adult salmon are strong swimmers and have the ability to avoid turbine intakes. Observed burst speeds for adult salmon range between 14.1 to 19.7 ft/s with a maximum sustained swim speed of 3.4 f/s (Beamish 1978). These behaviors suggest that salmon could be successful at locating and using surface bypasses.

6.3.1 Kelt Run Timing

In order to model whole station survival for Atlantic salmon kelts passing the Brunswick Project, it is necessary to know the timing and seasonal distribution of their downstream migration. Seasonal distribution data for kelt downstream migration on the Androscoggin River is unavailable. Baum (1997) indicated that following the fall spawn, approximately 20% of kelts move back downstream and into the ocean but the majority move back downstream and into the ocean the following spring. Based on observations during MDMR redd surveys, outmigration of kelts immediately following the fall spawn occurs during the latter half of October, November, and the first half of December (N. Dube, MDMR, personal communication). For the purposes of estimating whole station kelt survival at Brunswick, it was assumed that the percentage of the total kelt outmigration occurring during the fall (20%) would be partitioned among the known salmon outmigration months of October (5%), November (10%) and December (5%). Likewise, the percentage of the total kelt outmigration occurring during the spring (80%) would be equally divided between the known salmon outmigration months of April (40%) and May (40%). Variations in this seasonal distribution and their impacts to whole station survival are examined in Section 7.1.1.2 of this report.

6.3.2 Androscoggin River Flows

Flow duration curves for the Androscoggin River at the Brunswick Project were used for this analysis. Flow duration curves for the months of April and May were developed from the flow record for the

Androscoggin River as recorded by the USGS gage No. 0105900 near Auburn, Maine for the period 1990-2009. The USGS gage No. 0105900 is located upstream of the Brunswick Project. As a result, flow data from that gage was prorated by drainage areas to account for additional inflows into the Androscoggin between Auburn and the Brunswick Project. Flow duration curves for the months of October, November and December were developed from the flow record for the Androscoggin River as recorded for the period 2000-2009. For the purposes of modeling project survival of Atlantic salmon kelts migrating past the Brunswick Project, the median monthly flow condition (i.e. the value with 50% flow exceedence) was used. Median flow conditions at the Brunswick Project used to estimate whole station survival for outmigrating kelts were the same as those used for smolts during the spring months of April and May (Section 4.2). The median flow condition for the Androscoggin River at the Brunswick Project during April was 13,466 cfs (Figure 3), during May was 8,816 cfs (Figure 4), during October was approximately 3,820 cfs (Figure 7), during November was approximately 6,670 cfs (Figure 8), and during December was approximately 6,400 cfs (Figure 9). Impacts to the model of whole station kelt survival during years of high flow (10 and 25% flow exceedence) and low flow (75 and 90% flow exceedence) are examined in Section 7.1.1.3 of this report.

6.3.3 Kelt Downstream Route Determination

Similar to the assumption for outmigrating smolts, it was assumed that river discharge during the months of October, November, December, April and May will dictate the proportion of Atlantic salmon kelts passed downstream of the Brunswick Project though the spillway (and conversely, through the powerhouse or downstream bypass facility). This is likely a conservative estimate given the strong swimming ability of adult salmon and their behavioral reluctance to sound. Determination of the spill effectiveness, defined as the proportion of kelts passed through spill relative to the total number passing the project, is the first step in assessing whole station survival. As was done for smolts, it was assumed that the Project spillway has a 1:1 ratio of percent total fish to percent total river flow passed (i.e., spilling 50% of total river flow results in 50% of kelts passing via the spillway). An overall spill effectiveness for the outmigration months of October, November, December, April and May of 21.4% was used for the assessment of whole station kelt survival at Brunswick. This value was calculated using a Project capacity of 7,800 cfs, the monthly distribution of Atlantic salmon kelt outmigration (Section 6.3.1), monthly median Androscoggin River flow conditions (Section 6.3.2) and the assumption of 1:1 spill effectiveness. Table 30 provides a summary of that calculation as well as the monthly values used for the assessment of Brunswick Project spill effectiveness for kelts.

6.3.4 Kelt Downstream Bypass Efficiency

Given the lack of downstream bypass efficiency studies for Atlantic salmon kelts at the Brunswick Project on the Androscoggin River the guidance efficiency rate used for the smolt model (Section 4.4) was used as a surrogate value for estimation of whole station survival for kelts. That efficiency rate was based on the assumption that passage distribution of smolts through the powerhouse is equal to the distribution of outflow through the powerhouse and downstream bypass. Design flow for the current downstream passage sluice at the Brunswick Project is 60 cfs.

The downstream bypass efficiency rate was allowed to vary by month to account for occasions when river discharge was less than the Project operating flow. For example, as presented in Table 30, the monthly median Androscoggin discharge (cfs) values during April and May were greater than the Project operating flow of 7,800 cfs. In those instances, the downstream bypass efficiency rate (assuming passage distribution of smolts through the powerhouse is equal to the distribution of outflow through the powerhouse and downstream bypass) was calculated as 0.8% ((60 cfs/7,800 cfs)*100 = 0.8%). However, during October, the monthly median Androscoggin discharge (cfs) value was 3,820 cfs. For that month, the downstream bypass efficiency rate (assuming passage distribution of kelts through the powerhouse is equal to the distribution of outflow through the powerhouse and downstream bypass) was calculated as 1.6% ((60 cfs/3,820 cfs)*100 = 1.6%). The remainder of the powerhouse area flow passes via the turbine units. Variations in bypass efficiency and their impacts to whole station survival for kelts are examined in Section 7.1.1.1 of this report.

6.3.5 Kelt Spillway and Downstream Bypass Passage Survival Assessment

The Brunswick Project spillway consists of two ogee overflow spillway sections separated by a pier and barrier wall. The right spillway section, about 128 ft long, is topped with wooden flashboards that are 2.6 ft high. The left section does not have flashboards. Two taintor gates, each measuring 32.5 ft wide by 22 ft high, and an emergency spillway are located at the left abutment on the Topsham shoreline.

Based on the lack of survival studies conducted for Atlantic salmon kelts at the NextEra and other hydroelectric projects, it was assumed that survival for Atlantic salmon kelts passing the Project via the downstream bypass or spillway was 96.3%. That value was based on a review of empirical studies conducted for Atlantic salmon smolts passed through sluices and bypasses at five different hydroelectric projects (See Section 4.5). Delayed survival (48-hr) estimates for Atlantic salmon smolts following passage through sluiceways and bypasses ranged from 91.1 to 100.0%, resulting in a mean overall spill survival of 96.3%.

6.3.6 Kelt Entrainment Rates and Turbine Passage Survival

The Brunswick powerhouse contains three generating units (one vertical propeller and two horizontal propeller units) and has a total Project generating capacity of 19.0 MW. Peak capacity (cfs) is 1,336 cfs for the two horizontal propeller units and 4,519 cfs for the single vertical propeller unit (Table 7). Total unit flow for the Project is approximately 7,800 cfs. Normal operating head for the Brunswick Project is 39 ft. The trash racks screening the intakes are 3.5 in spacing. Additional turbine characteristics for Brunswick Units 1, 2, and 3 are provided in Table 7.

Turbine Entrainment Rates

Empirical data related to the route selection of Atlantic salmon kelts using the Brunswick turbine units to move downstream of the project does not exist. Turbine entrainment rates at the Brunswick Project were calculated on a monthly basis as 100% minus the downstream bypass efficiency rate.

Ten records of adult Atlantic salmon total lengths (762 – 821mm) and maximum body widths (79-100mm) were obtained from sea-run returns to the Deerfield River during spring 2011 (B. Hanson, Normandeau, personal communication). Total lengths from that data set were converted to fork lengths using the equation FL = 0.9173TL (Carlander 1969) where FL = fork length and TL = total length. The linear relationship for the log-transformed (ln) fork length and body width was determined to be ln(width) = 1.3113(lnFL) – 4.1717. Although the relationship was weak ($r^2 = 0.155$), it was used to predict body widths for theoretical salmon fork lengths to determine the longest fork length that would fit through the 3.5 in trash rack spacing in front of Units 1-3 . Based on that relationship, it was determined that adult Atlantic salmon with a fork length of greater than 29.4 inches would have achieved a body width greater than the 3.5 in trash rack spacing at Brunswick Units 1-3.

Fork length data was obtained for sea-run Atlantic salmon returns collected within the Kennebec and Sebasticook Rivers during the years 2006-2010 (P. Christman, MDMR, personal communication) as well as at the Veazie fishway trap on the Penobscot River for the years 1978-2009 (J. Murphy, NMFS, personal communication). Fork lengths recorded for returning Atlantic salmon (86 individuals) to the Kennebec drainage had a mean fork length of 27.3 in (range 19.7-34.3 in). Fork lengths recorded for 25,721 individual Atlantic salmon to the Penobscot River ranged from 15.7-40.9 in (mean 27.5in).

The length-frequency distribution for sea run returns to the Penobscot River was used as a surrogate for outmigrating kelts on the Androscoggin due to the robust nature of the data set. It was assumed that fork lengths of kelts approaching the propeller units at Brunswick would be of a similar length-frequency distribution to that of the Penobscot River data set. For Atlantic salmon kelts approaching the propeller units, 70.9% of individuals were predicted to pass through the 3.5 in trash racks and be subjected to turbine passage. This is likely a conservative estimate, given the strong swimming capabilities of kelts and the deep intake configuration of Unit 1. The remaining 29.1% would be excluded from turbine passage and were assumed to pass via bypass spill.

Turbine Passage Survival

Kelt survival estimates for turbine passage were generated for the three propeller units in operation at Brunswick using the same equations (Franke et al. 1997) as used for smolts and detailed in Section 3.3.2 of this report. Estimates for Atlantic salmon kelts passing through the propeller units were calculated for five body lengths considered representative of individuals capable of passing through 3.5 in trash racks (16, 20, 23, 27, and 30 inches). Two correlation factors (λ) were used in this analysis (0.1 and 0.2). Survival estimates for Brunswick units 1-3 were modeled using the peak turbine discharge (cfs) and the associated efficiency.

Model runs for five body lengths, two correlation factors and three *r* values resulted in a total of 30 survival estimates which likely bracket the actual survival for Atlantic salmon kelts passing through the propeller units at Brunswick (Units 1-3). The three *r* values represent the point along the runner radius that the fish enters the turbine. Values for *r* used in this assessment were 0.1, 0.5, and 0.9% of the runner radius.

Predicted survival values for salmon kelts capable of passing through the 3.5 in trash racks screening the Brunswick propeller units ranged from a high of 95.8% for a 16 inch kelt to a low of 17.7% for a 30 inch kelt (Table 31). Predicted survival probabilities increased as kelt body length and entry point proximity to the turbine hub decreased. The average survival of salmon kelts passing through the propeller units at Brunswick was determined by averaging the 30 modeled survival estimates for each combination of fish length, entry point and λ. Average survival of salmon kelts passing Brunswick via Unit 1 was 82.9% and Units 2 and 3 was 72.3%. The calculated mean survival for Atlantic salmon kelts passing through the Brunswick propeller units was 75.9%.

7.0 Estimated Project Impact on Outmigrating Atlantic Salmon Kelts

7.1 Modeled Estimate of Whole Station Survival for Kelts

Whole station survival for outmigrating kelts at the Weston Project was estimated by integrating Androscoggin River flows, Project operating flows, the proportion of kelts diverted towards the spillway and powerhouse, spillway survival rate (as estimated from empirical data for smolts), screening effectiveness of turbine trash racks, turbine passage survival rates (as estimated by modeled data), bypass guidance efficiency, and fish bypass passage survival rate (as estimated from empirical data for smolts). The following values for each of the above parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in the calculations of whole station survival for salmon kelts at the Brunswick Project:

7.1.1 Modeled Estimate of Whole Station Survival for Kelts

Whole station kelt survival was modeled using delayed (48-hr) smolt survival rates for spill obtained from empirical data collected at other hydroelectric projects and model derived estimates for turbine passed fish. The following values for each of the necessary model parameters and the sources (site-specific, empirical from similar projects, or available literature information) were used in this calculation of whole station survival for salmon kelts at the Brunswick Project:

- Androscoggin River Flow – 13,466 cfs (April), 8,816 cfs (May), 3,820 cfs (October), 6,670 cfs (November) and 6,400 cfs (December);
- Project operating flow – 7,800 cfs;
- Proportion of kelts diverted – utilized a ratio of 1:1 fish to river flow;
- Project spillway survival – 96.3% (based on review of delayed (48-hr) empirical survival data for smolts from other hydroelectric projects);
- Fish bypass guidance efficiency – as determined on a monthly basis based on the relationship of bypass discharge (60 cfs) and Project operating flow;
    - April: (60 cfs / 7,800 cfs)*100 = 0.8%
    - May: (60 cfs / 7,800 cfs)*100 = 0.8%
    - October: (60 cfs / 3,820 cfs)*100 = 1.6%
    - November: (60 cfs / 6,670 cfs)*100 = 0.9%
    - December: (60 cfs / 6,400 cfs)*100 = 0.9%
- Entrainment rate through turbines – as determined on a monthly basis as 100% - fish bypass guidance efficiency
    - April: 100% - 0.8% = 99.2%
    - May: 100% - 0.8% = 99.2%
    - October: 100% - 1.6% = 98.4%
    - November: 100% - 0.9% = 99.1%
    - December: 100% - 0.9% = 99.1%
- Proportion of kelts screened from passage through turbines – based on Penobscot River length-frequency data and derived FL-width relationship
- Propeller turbine passage survival – 75.9% (based on modeled values generated using site-specific turbine parameters);

- Fish bypass system survival – 96.3% (based on review of delayed (48-hr) empirical survival data for smolts from other hydroelectric projects).

The integration of the above values is provided in Table 32 for a hypothetical case of 100 Atlantic salmon kelts approaching the Brunswick Project during the kelt outmigration period (April-May, October-December). The whole station survival estimate for Atlantic salmon kelts passing the Brunswick Project generated using delayed (48-hr) empirical data for spillway survival and modeled estimates for turbine survival is 85%.

7.1.1.1 Impacts to Estimated Kelt Survival Associated with Bypass Efficiency Assumption

The model for estimating whole station survival for outmigrating kelts at Brunswick can be manipulated to provide insight into potential impacts to whole station survival based on modifying the various input parameters. NextEra, in consultation with resource agency personnel is presently evaluating options to further enhance downstream fish passage measures at the project. At the request of the resource agencies, NextEra in the summer of 2011, contracted with a consultant to evaluate various downstream fish passage options using Computational Fluid Dynamics (CFD) modeling. The initial model runs using various floating fish guidance boom locations and surface sluices have been completed and were presented to resource agency personnel in December 2011. Additional model runs to refine the existing ones are scheduled for the first quarter of 2012. The resultant data will be used in consultation with the resource agencies, to propose new downstream fish passage enhancements at the project. Installation of a downstream facility at the Brunswick Project should reduce the impact of turbine passage on outmigrating smolts. Table 33 provides whole station survival estimates for a range of theoretical downstream facility efficiency rates. Theoretical downstream facility effectiveness rates between 25 and 100% were modeled and produced a range of whole station survival estimates for outmigrating Atlantic salmon kelts between 88% and 96%.

7.1.1.2 Impacts to Estimated Kelt Survival Associated with Seasonal Distribution Assumption

In cases with no site-specific data, spillways are typically assumed to have a 1:1 ratio of percent total fish to percent total river flow passed (e.g., spilling 50% of total river flow results in 50% of fish passing via the spillway). A basic implication of the deviation from the 1:1 assumption is that if a proportionally smaller percentage of kelts relative to the river flow enter the Project powerhouse area then the calculated station-related kelt survival would be higher. Under these conditions, a greater percentage of kelts would pass the project via spill and would avoid impacts associated with turbine passage. Alternatively, if a proportionally higher percentage of kelts are entering the Project powerhouse area than the calculated station related kelt survival would be lower. Under these conditions, a lower percentage of kelts would pass the project via spill and a greater number would be entrained through the Project turbines.

The sensitivity of the model estimating whole station kelt survival associated with deviation from the assumed 1:1 ratio of fish to flow at the Brunswick Project is presented in Table 34. A range of spill effectiveness rates for Atlantic salmon kelts from 10% (0.2:1) to 90% (4.2:1) was evaluated. For conditions where a proportionately lower percentage of kelts relative to river flow entered the powerhouse area (i.e. spill effectiveness rates of 30% and higher), the estimates for whole station survival were greater than that observed under the assumption of 1:1 spill effectiveness and ranged from 86% to 95%. For conditions where a proportionately higher percentage of kelts relative to river flow entered the powerhouse area (i.e. spill effectiveness rate of 10%), the estimate for whole station survival was lower (84%) than that observed under the assumption of 1:1 spill effectiveness.

7.1.1.3 Impacts to Estimated Kelt Survival Associated with Seasonal Flow Assumption

The model for estimating whole station survival for outmigrating kelts at Brunswick was constructed using the assumption of median Androscoggin River flows (i.e. 50% exceedence) during the months of April, May, October, November, and December. Two "low flow" conditions (75 and 90% exceedence) and two "high flow" conditions (10 and 25% exceedence) were also examined. Estimated monthly Androscoggin River flows for the months of April, May, October, November, and December under the 10, 25, 75, and 90% exceedence conditions are presented in Table 35. Table 36 presents the modeled whole station survival estimates for downstream migrating Atlantic salmon kelts under the additional low and high flow conditions. Under the low flow conditions (i.e. those exceeded 75 and 90 % of the time) the estimated whole station survival for salmon kelts at the Brunswick Project decreased to 83% and 82%, respectively. Under the high flow conditions (i.e. those exceeded only 10 or 25% of the time) the estimated whole station survival for salmon kelts at the Brunswick Project increased to 91% and 88%, respectively.

7.2 Summary of Modeled Estimate of Whole Station Survival for Kelts

A single model of whole station survival of Atlantic salmon kelts at the Brunswick Project was constructed using available empirical and modeled survival rates for passage via spill and through turbine units. Where data was unavailable for the kelt lifestage, empirical data from smolt studies was used as a surrogate. The model constructed for whole station survival of Atlantic salmon kelts at the Brunswick Project generated a survival estimate of 85% with modifications during the various sensitivity analyses expanding those bounds to 82%- 96%. A percentage of kelts will over winter in freshwater and resume feeding following the fall spawn (Danie et al. 1984). Although mortality is high upon reentry to saltwater, a percentage of kelts which successfully migrate to ocean feeding grounds may become repeat spawners (Danie et al. 1984). Baum (1997) states that repeat spawners can reach weights approaching 30 pounds and contain an average of approximately 11,300 eggs. For comparison, a first time returning two sea-winter salmon will contain an average of approximately 7,500 eggs. In the National Research Council's book "Atlantic Salmon in Maine" (NRC 2007) it was stated that most Atlantic salmon are semelparous, spawning once and then dying. It was estimated that 1%-6% of anadromous Atlantic salmon are iteroparous and will survive to make a second spawning run the following year. Baum (1997) notes that data collected during the 1960's and 1970's suggested that 5-10% of the salmon run in Maine rivers was composed of repeat spawners. Baum (1997) indicates that value has declined in recent years to less than 1% due primarily to commercial fisheries during the 1960's to early 1990's. During the five year period (1992-1996) wild salmon repeat spawners in the Magaguadavic River (New Brunswick) were noted to represent an overall percentage of 6% (Carr et al. 1997). Within the Miramichi River, considered to have the largest run of Atlantic salmon in eastern North America, the proportion of repeat spawners within the annual run has ranged from a low of approximately 2% to a high of approximately 53% during the forty year period of 1970-2010 (Chaput and Douglas 2010). The proportion of repeat spawners within the Miramichi River was greater than 10% during 34 of the 40 years, greater than 20% during 22 of the 40 years, greater than 30% during 16 of the 40 years, greater than 40% during 6 of the 40 years and greater than 50% during 2 of the 40 years.

8.0 Predation

8.1 Smolt Predation

The smolt survival model presented in Section 5.0 of this report represents mortality associated directly with smolt/Project interactions and does not account for indirect mortality (such as predation). Atlantic salmon smolts are a potential food source for a number of fish (i.e. striped bass, black bass, northern pike), avian (i.e. cormorants, gulls, and osprey) and mammalian (i.e. harbor seals) predators which may frequent the Androscoggin River below the Brunswick Project. However, direct quantification of predation rates for Atlantic salmon smolts passing the Brunswick Project is not available.

Due to the lack of predation rate data for outmigrating salmon smolts in the Androscoggin River, a rate was estimated based on that used for Habitat Conservation Plans for the Rocky Reach hydroelectric project on the mid-Columbia River, Washington. Combined predation (upstream and downstream) for that project was estimated at 2.0% of smolts and was derived from site-specific empirical data as well as observations at other Columbia River hydroelectric projects (S. Hayes, personal communication). In the Columbia River, predation on juvenile salmonids by piscivorous fishes has been investigated in detail (Rieman et al 1991; Zimmerman 1999) and has resulted in an extensive management program to control smolt loss to predation by northern pikeminnow (Beamesderfer et al. 1996; Friesen and Ward 1999). It is suspected that striped bass may represent a predatory impact to outmigrating Atlantic salmon smolts within the Androscoggin River. Blackwell and Juanes (1998) noted 48% of striped bass with prey items in their stomachs contained Atlantic salmon smolts during a spring study below the Essex Dam on the Merrimack River. As striped bass densities would be expected to be lower towards the northern portion of their range, it is not expected that predation by that species would be as high in the Androscoggin River. Anecdotal observations from fishway personnel indicated that striped bass arrive at the nearby Lockwood tailwater during late May and early June which is during the latter part of the smolt outmigration.

Given the absence of site-specific data, an estimate of 1.0% loss was used to represent predation that may occur in the tailwater area. This was based on the absence of a major controlling predator, such as the northern pikeminnow on the Columbia River for the duration of the outmigration season in the Androscoggin River. Based on observations from the Merrimack River, striped bass most likely do represent a predation threat once they reach the Brunswick tailwater during the latter part of the spring.

In addition to predation in the hydroelectric project tailwaters, outmigrating Atlantic salmon smolts are also subjected to predation within the impounded river portions located upstream of hydroelectric projects (Ruggles 1980; Blackwell et al. 1997; Jepsen et al. 1998). Although not intended to directly assess predation rates, the release of radio-tagged smolts into impounded portions of the Kennebec River upstream of the Lockwood and Hydro-Kennebec (owned and operated by Brookfield Power) Projects can be used in an attempt to estimate impoundment predation. During May and June, 2011, a total of 98 radio-tagged smolts were released into the impoundment approximately 0.6 miles upstream of the Hydro-Kennebec Project. Of those smolts, only 3 individuals (3.1%) did not pass the Project and may have been predated. Similarly, a total of 60 radio-tagged smolts were released into the impoundment approximately 0.5 miles upstream of the Lockwood Project. Of those smolts, only 1 individual (1.6%) did not pass the Project and may have been predated. A total of 22 radio-tagged smolts were released into the impoundment approximately 0.5 miles upstream of the Lockwood Project during the 2007 (Normandeau 2008) bypass efficiency evaluation. During that study, no individuals released in the impoundment above

Lockwood were reported to have not passed the Project. It should be noted that these telemetry studies were not intended to directly assess natural predation rates and other factors such as tag retention, desmoltification, or behavioral differences associated with having been hatchery-reared may factor into the lack of downstream movement observed for some smolts. Based on the limited rates of loss for radio-tagged smolts in Kennebec River impoundments (3.1%, 1.6%, and 0.0%) a mean average rate of 1.6% was estimated for predation on Atlantic salmon smolts that may occur in the impoundment area.

8.2 Adult Predation

Sea-run returning adult Atlantic salmon potentially delayed by the presence of the Brunswick Project may be exposed to predation risks. Atlantic salmon adults are a potential food source for a limited number of fish (i.e. northern pike) and mammalian (i.e. harbor seals) predators which may frequent the Androscoggin River below the Brunswick Project. The frequency of seal bites on returning Penobscot River salmon increased from less that 0.5% to greater than 3.0% between the early 1980's and mid 1990's (NRC 2004). However, there are no data available to estimate the number of adult salmon captured and consumed by seals (NRC 2004). Additionally, mortality associated with catch and release angling injuries or poaching may also impact adult salmon in the Project tailwater. At this point, absent any data, it is unreasonable to assign a predation rate to adult salmon in the Brunswick tailrace.

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FIGURES

Figure 1. Design plan and physical layout of the Brunswick Project.

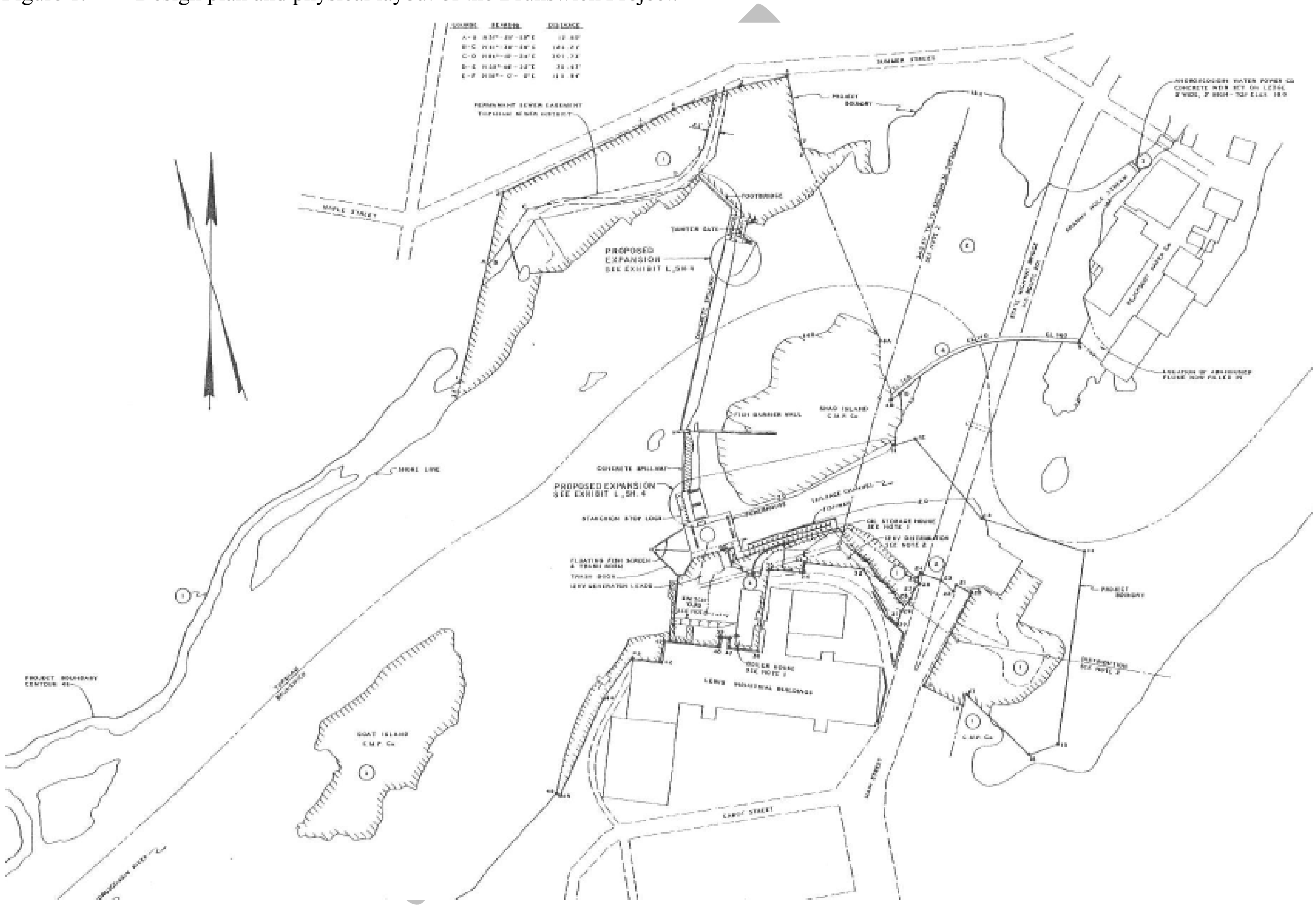


Figure 2. Potential downstream passage routes at the Brunswick Project.

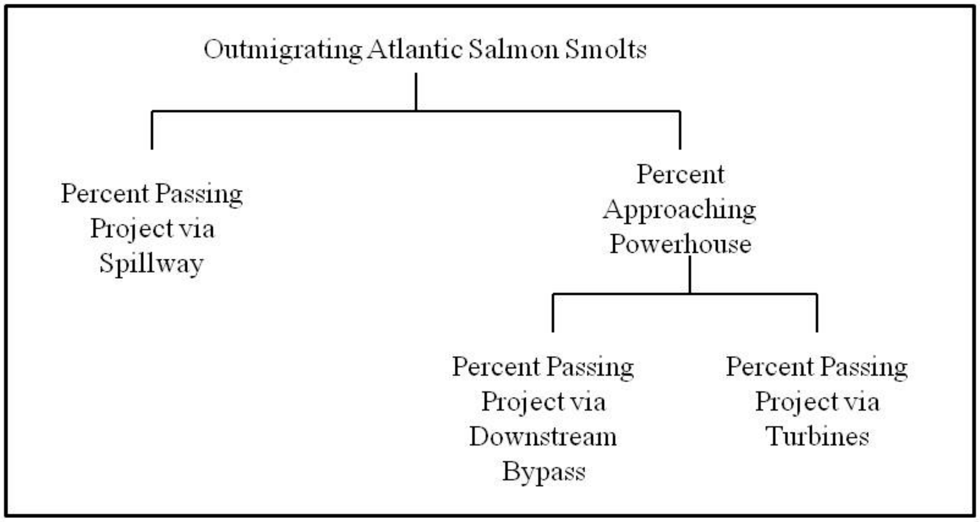


Figure 3. Androscoggin River (Brunswick Project) flow duration curve for April.

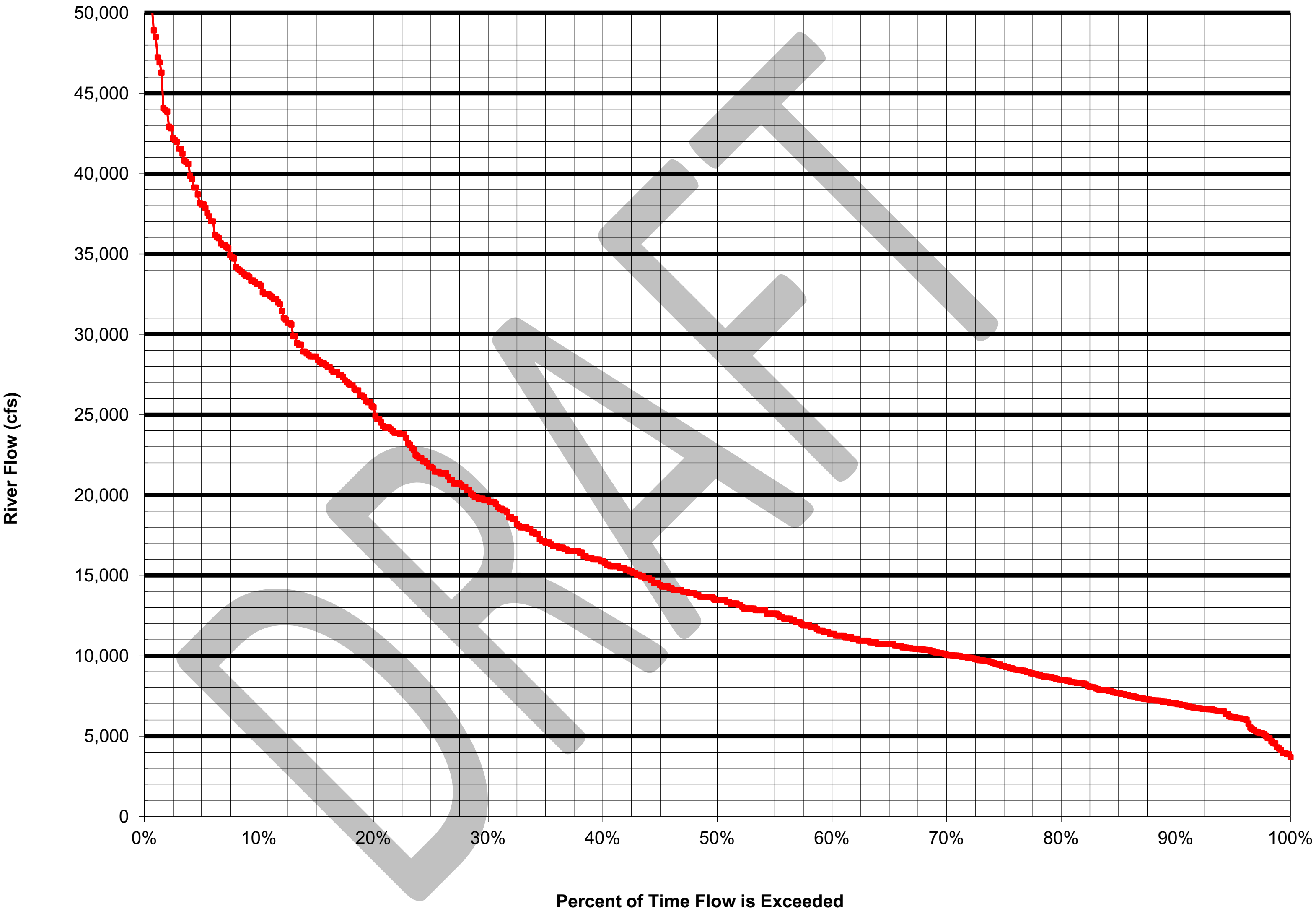


Figure 4. Androscoggin River (Brunswick Project) flow duration curve for May.

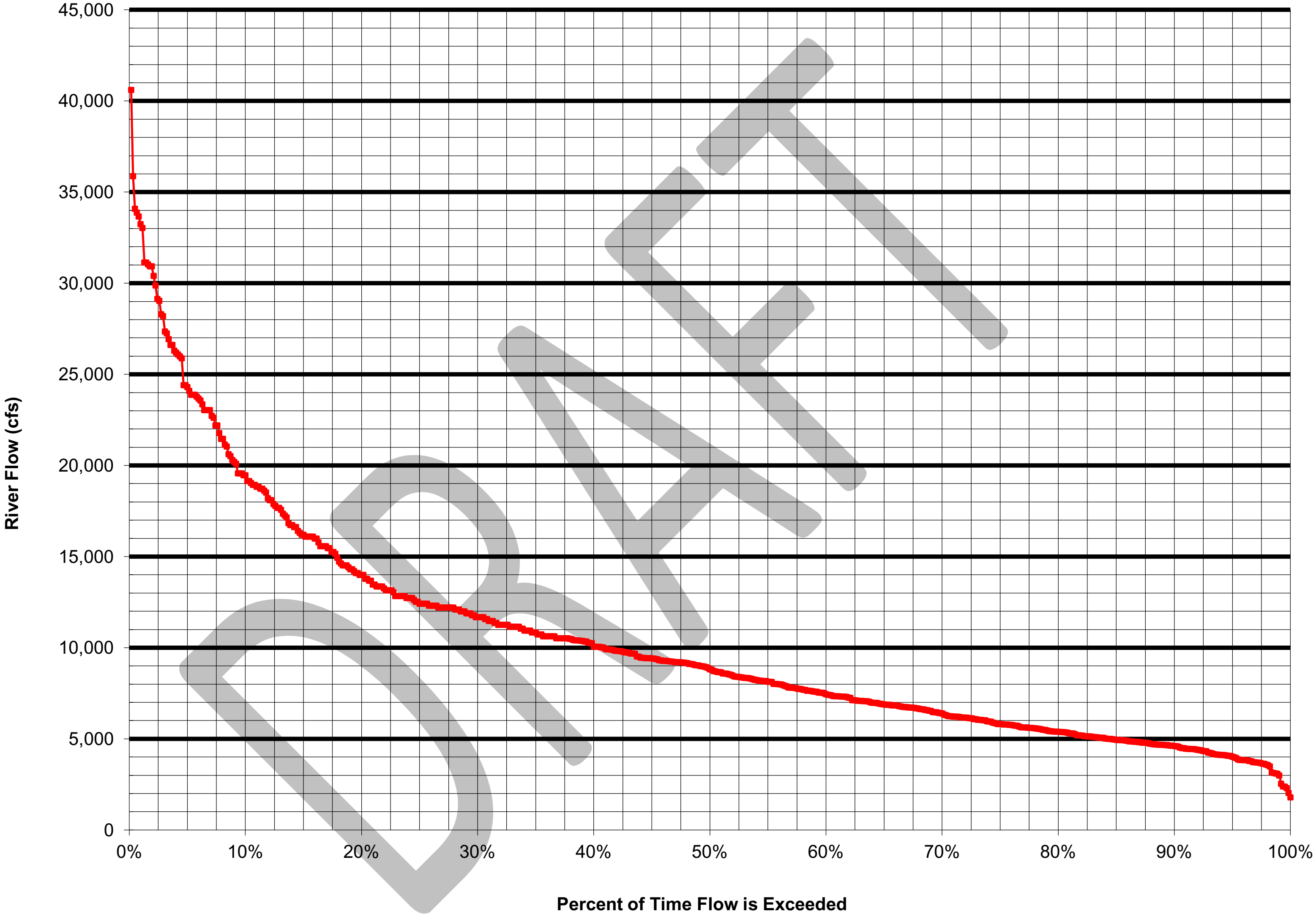


Figure 5. Androscoggin River (Brunswick Project) flow duration curve for June.

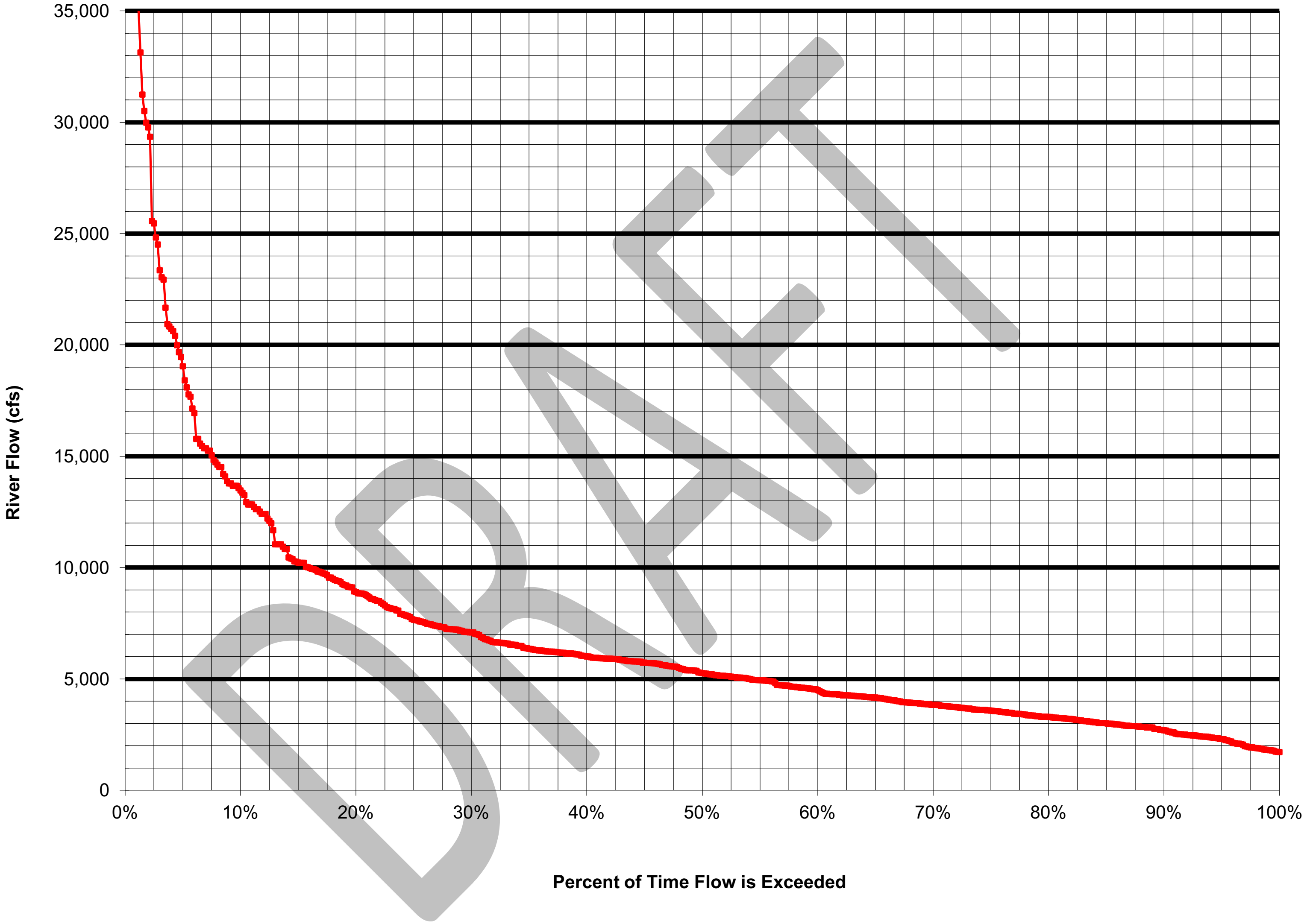


Figure 6. Smolt capture data from 2004 for the Narraguagus, Pleasant and Penobscot Rivers, Maine. Reprinted from USASAC 2005 Annual Report.

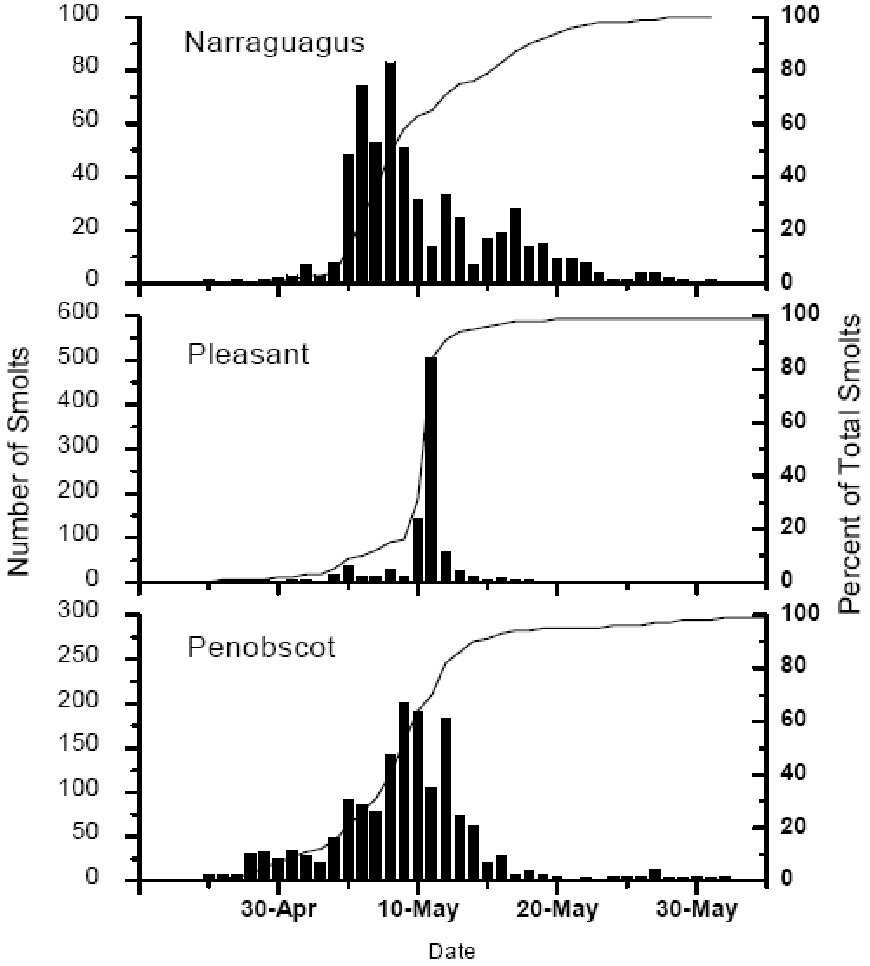


Figure 7. Androscoggin River (Brunswick Project) flow duration curve for October.

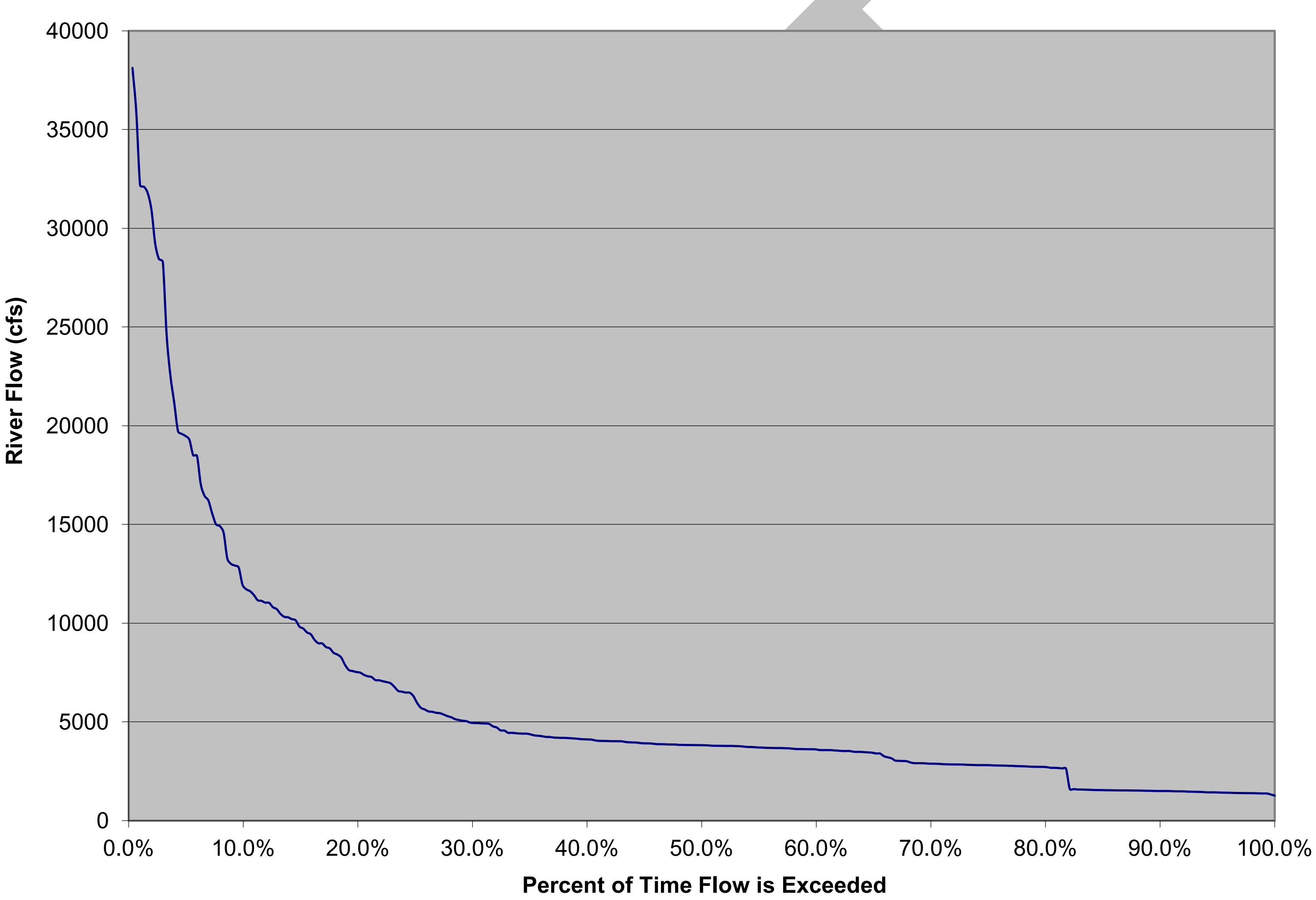


Figure 8. Androscoggin River (Brunswick Project) flow duration curve for November.

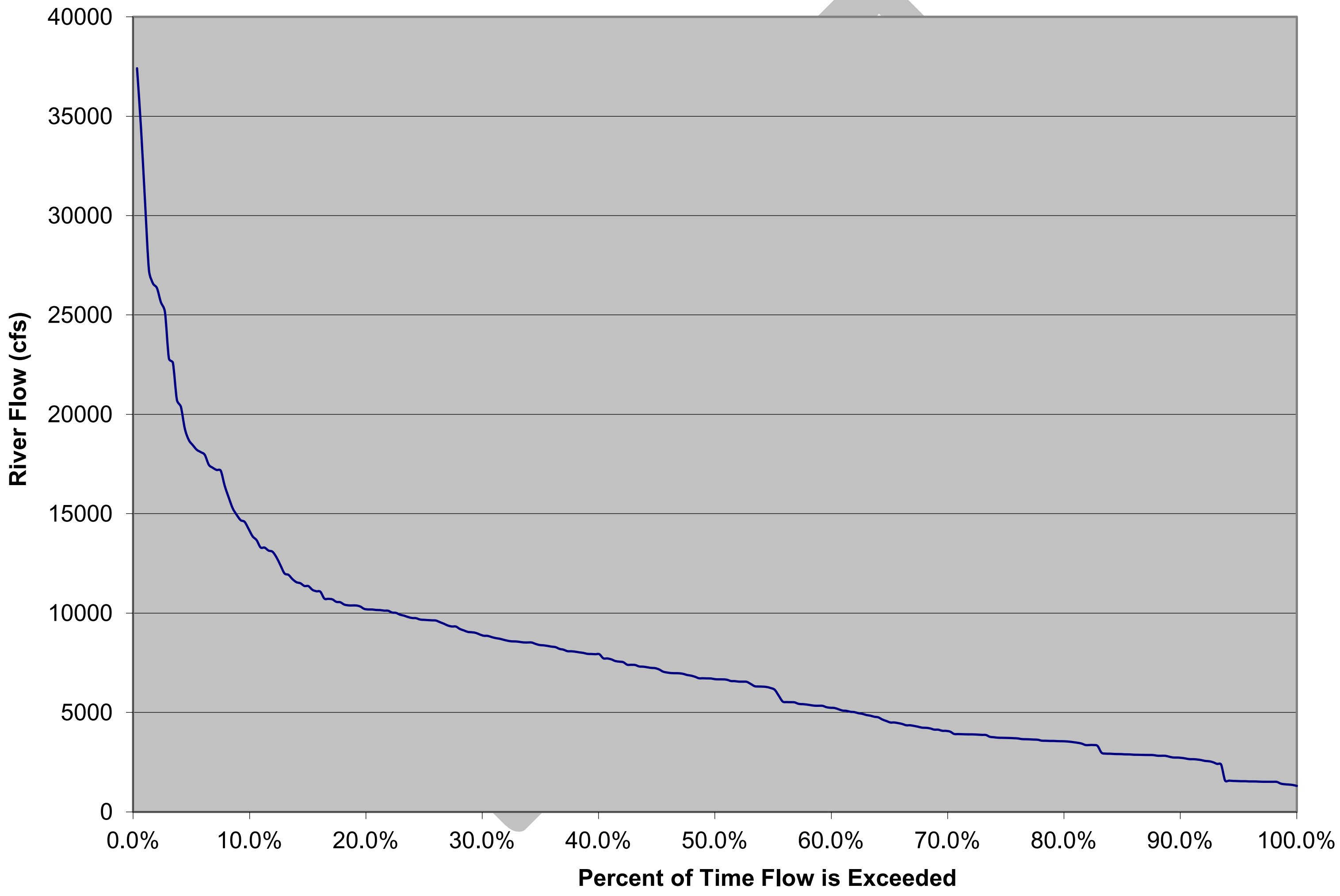
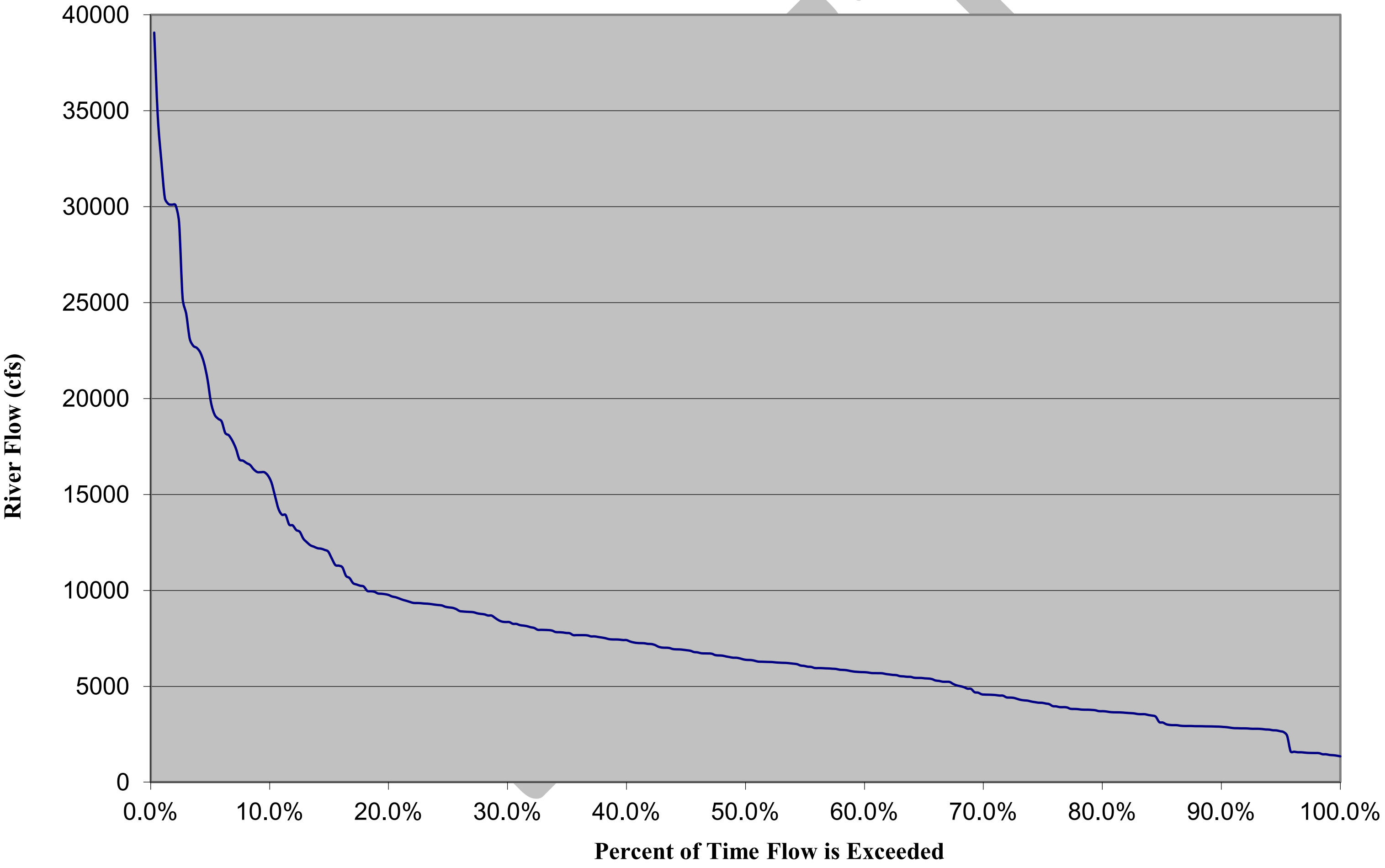


Figure 9. Androscoggin River (Brunswick Project) flow duration curve for December.



TABLES

Table 1. Number of individuals collected and seasonal timing of downstream migration of Atlantic salmon smolts at the Mattaceunk Project (Weldon Dam) on the Penobscot River. Note: NS = no sample; data is reprinted from GNP 1997.

3-Days Starting	Sample Year					
	1995	1994	1993	1990	1989	1988
1-Apr	NS	0	0	0	NS	0
4-Apr	NS	0	0	0	NS	0
7-Apr	NS	0	0	0	NS	0
10-Apr	NS	0	0	0	NS	0
13-Apr	NS	0	0	0	NS	0
16-Apr	NS	0	0	0	0	0
19-Apr	NS	0	0	0	0	1
22-Apr	NS	0	0	0	0	0
25-Apr	0	0	1	1	0	0
28-Apr	1	0	0	1	0	0
1-May	3	0	0	2	0	0
4-May	15	3	13	1	3	0
7-May	33	1	46	27	9	15
10-May	130	6	189	27	19	43
13-May	238	9	133	33	11	214
16-May	975	7	179	79	38	113
19-May	2,123	32	290	76	267	152
22-May	298	309	699	40	671	262
25-May	264	37	873	25	233	202
28-May	211	620	642	33	294	529
31-May	172	517	81	14	171	208
3-Jun	108	673	30	44	357	106
6-Jun	51	256	38	15	192	16
9-Jun	21	126	16	3	109	12
12-Jun	16	61	25	4	559	21
15-Jun	15	31	5	7	89	9
18-Jun	8	5	3	4	68	NS
21-Jun	9	0	2	1	33	NS
24-Jun	NS	1	0	NS	NS	NS
27-Jun	NS	0	0	NS	NS	NS
30-Jun	NS	1	0	NS	NS	NS

Table 2. Seasonal distributions for smolt downstream migration used for assessment of whole station survival at the Brunswick Project.

River System	Year	Percent of Migration			Reference
		April	May	June	
Penobscot	1988	0.1	80.4	19.5	GNP 1997
Penobscot	1989	0.0	49.5	50.5	GNP 1997
Penobscot	1990	0.5	78.5	21.1	GNP 1997
Penobscot	1993	0.0	93.8	6.1	GNP 1997
Penobscot	1994	0.0	38.0	62.0	GNP 1997
Penobscot	1995	0.0	91.5	8.5	GNP 1997
Penobscot	2004	10.0	88.0	2.0	USASAC 2005
Narraguagus	2004	4.0	96.0	0.0	USASAC 2006
Average		**1.8**	**77.0**	**21.2**	

Table 3. Estimated percentage of smolts entering the Brunswick Project powerhouse or passing via spillway.

Month	Discharge (cfs)			Percent of River Discharge		Smolt Run Distribution[4]	Project Smolt Distribution[5]	
	River Discharge[1]	Brunswick [2]	Calculated Spill [3]	Spill	Powerhouse		Spill	Powerhouse
April	13,466	7,800	5,666	42.1%	57.9%	1.8%	0.8%	1.0%
May	8,816	7,800	1,016	11.5%	88.5%	77.0%	8.9%	68.1%
June	5,260	5,260	0	0.0%	100.0%	21.2%	0.0%	21.2%
TOTAL	-	-	-	-	-	-	**9.6%**	**90.4%**

1 - Monthly median condition as obtained from Project flow duration curves (50% exceedence)

2 - Project capacity or total inflow

3 - Equal to River discharge - Project capacity

4 - Monthly distribution of Atlantic salmon smolt run for the Penobscot River (GNP 1997; USASAC2005) and Narraguagus River (USASAC 2005)

5 - Based on 1:1 assumption of spill effectiveness

Table 4. **Initial (1-hr) and delayed (48-hr) injury/scale loss rates for Atlantic salmon smolts passed through spillways and sluices at various hydroelectric projects. All tests conducted using the Hi-Z Turb'N Tag**.

			Initial (1hr) Rates		Delayed (48hr) Rates		
Site Name	**Passage Route**	**Normal head (ft)**	**Test Fish Injury Rates (%)**	**Control Fish Injury Rates (%)**	**Test Fish Injury Rates (%)**	**Control Fish Injury Rates (%)**	**Reference**
Garvins Falls, NH	Bypass	30	0.0	0.0	0.0	0.0	Normandeau 2005
Amoskeag, NH	Bypass	46	3.0	0.0	0.0	0.0	Normandeau 2006a
Bellows Falls, VT	Sluice	59	2.0	0.0	18.0	18.0	RMC 1991
Wilder, VT	Sluice	52	59.0	0.6	-	-	RMC 1992
Wilder, VT	Sluice	52	36.0	0.6	-	-	RMC 1992
Wilder, VT	Sluice	52	26.0	0.6	-	-	RMC 1992
Vernon, VT	Sluice	27	2.9	4.0			Normandeau 1995

Table 5. **Summary of injury types and frequency of occurrence (among injured and all smolts examined) for Atlantic salmon smolts passed through spillways and sluices at various hydroelectric projects. All tests conducted using the Hi-Z Turb'N Tag.**

Interval	Site Name	# of Individuals Examined	# of Individuals with Injuries	Injury Type			
				Minor scale loss, <25%	Major scale loss, >25%	Laceration(s), tear(s)	Hemorrhaging, bruised
Initial (1hr)	Garvins Falls, NH	30	0	0	0	0	0
	Amoskeag, NH	30	1	0	0	0	1
	Bellows Falls, VT	95	3	1	0	0	2
	Wilder, VT	100	59	22	20	7	24
	Wilder, VT	44	16	9	0	2	10
	Wilder, VT	99	26	11	4	0	14
	Vernon, VT	70	2	2	0	0	0
	All Projects	468	107	45	24	9	51
	Percent Occurrence for Smolts with Injuries			**42.1%**	**22.4%**	**8.4%**	**47.7%**
	Percent Occurrence for All Smolts Examined			**9.6%**	**5.1%**	**1.9%**	**10.9%**
Delayed (48 hr)	Garvins Falls, NH	30	0	0	0	0	0
	Amoskeag, NH	30	0	0	0	0	0
	Bellows Falls, VT	38	7	6	0	0	1
	All Projects	98	7	6	0	0	1
	Percent Occurrence for Smolts with Injuries			**85.7%**	**0.0%**	**0.0%**	**14.3%**
	Percent Occurrence for All Smolts Examined			**6.1%**	**0.0%**	**0.0%**	**1.0%**

Table 6. Initial (1-hr) and delayed (48-hr) survival and associated test parameters for Atlantic salmon smolts passed through spillways and sluices at various hydroelectric projects. All tests conducted using the Hi-Z Turb'N Tag.

Site Name	Normal head (ft)	Test Discharge (cfs)	Water Temperature (°C)	Test Fish Size (mm)			Control Fish Size (mm)			No. of Fish Released		Immediate Survival (1-hr)	48-hr Survival	Reference
				Min.	Max.	Avg.	Min.	Max.	Avg.	T	C			
Garvins Falls, NH	30	80	13.0	174	208	190	155	203	185	30	20	100.0	100.0	Normandeau 2005
Amoskeag, NH	46	149	14.0	176	226	207.8	178	229	203.8	30	30	100.0	100.0	Normandeau 2006a
Bellows Falls, VT	59	275-340	10.0-11.5	145	358	-	-	-	-	100	100	96.0	96.0	RMC 1991
Wilder, VT	52	200	8.5-15.5	180	245	212	185	240	211.4	245	145	99.0	97.0	RMC 1992
Wilder, VT	52	300	8.5-15.6	180	245	212	185	240	211.4	245	145	93.3	91.1	RMC 1992
Wilder, VT	52	500	8.5-15.7	180	245	212	185	240	211.4	245	145	98.0	97.0	RMC 1992
Vernon, VT	27	40	16.0-17.5	115	216	156	119	200	149	75	25	93.3	93.3	Normandeau 1995

Table 7. Turbine characteristics for Units 1, 2, and 3 at the Brunswick Project.

Parameter	Brunswick Turbines		
	Unit 1	**Unit 2**	**Unit 3**
Turbine Type	Vertical Propeller	Horizontal Propeller	Horizontal Propeller
Number blades	5	5	5
Max turbine discharge (cfs)	5,400	1,200	1,200
Efficiency at max discharge	0.83	[a]	[a]
Peak turbine discharge (cfs)*	4,519	1,336	1,336
Efficiency at peak discharge	0.91	0.76	0.76
Runner diameter (ft)	15.0	8.2	8.2
RPM	90	211.8	211.8
Rated head (ft)	33	33	33

*Peak turbine discharge is the maximum efficiency for a particular unit.

[a] - Value not available

Table 8. **Initial (1-hr) injury/scale loss rates for Atlantic salmon smolts passed through Kaplan and propeller units at various hydroelectric projects. All tests conducted using the Hi-Z Turb'N Tag.**

Site Name	Unit Type	Normal head (ft)	RPM	Unit Flow (cfs)	No. of Blades	Runner Diameter (ft)	Test Fish Injury Rates (%)	Control Fish Injury Rates (%)	Reference
Briar Rolfe, NH	Kaplan	35	150	-	5	9.84	7.1	0.0	Normandeau 2004
Bar Mills, ME [1]	Propeller	19.5	120	960 & 1,560	5	11.2	6.3, 12.2	0.0	Normandeau and FPL 2002
Lairg, Scotland	Kaplan	-	167	-	4	8.5	3.2	-	Normandeau and Fishtrack 1998
Cliff, Ireland	Kaplan	32.8	115.3	-	5	14.1	4.0	2.0	Normandeau and Fishtrack 2002
Cathleens Falls, Ireland	Kaplan	93.5	187.5	-	5	12.6	7.0	0.0	Normandeau and Fishtrack 2002
Ardnacrusha, Ireland [1]	Kaplan	93	167	-	5	16.4	10.6, 8.8	0.0	Normandeau and Fishtrack 2004
Wilder, VT-NH	Kaplan	51	112.5	-	5	9.0	4.8	0.0	Normandeau 1994
Vernon, VT [1]	Kaplan	34	144	1,250 & 1,600	5	10.2	9.4, 11.5	0.1	Normandeau 2009
West Buxton, ME	Propeller	26.8	120	1,360 & 1,800	6	11.1	13.7	-	Normandeau 1999
McIndoes, NH [1]	Propeller	26	150	800 & 1,600	4	10.0	0.6, 6.4	1.0	Normandeau 2006b

1 - Tested two different settings

Table 9. Summary of injury types and frequency of occurrence for Atlantic salmon smolts passed through Kaplan and propeller units at various hydroelectric projects. All tests conducted using the Hi-Z Turb'N Tag.

				Injury Type									
Site Name	**Unit Type**	**# of Individuals Examined**	**# of Individuals with Injuries**	**Loss of Equilibrium**	**Minor scale loss, <25%**	**Major scale loss, >25%**	**Operculum/gill damage**	**Severed body/ back bone**	**Ruptured/ hemorrhaged eye**	**Bruised head or body**	**Cut/tear on head or body**	**Internal Injuries**	**Other**
				2		2		1					
Bar Mills, ME	Propeller	96	9	1			2	5				1	
Lairg, Scotland	Kaplan	94	3					1	1		1	1	
Cliff, Ireland	Kaplan	75	3					3					
Cathleens Falls, Ireland	Kaplan	71	5				1	4					1
Ardnacrusha, Ireland	Kaplan	185	18	10			4	4	2				
Wilder, VT-NH	Kaplan	120	6	1		1		2		2	2		
Vernon, VT	Kaplan	259	27	4		4	6	3	2	11	1	4	
West Buxton, ME	Propeller	73	10	4	1					6	3		
McIndoes, NH	Propeller	310	11	3			2	5	2	1	1		
All Projects		1,353	97	25	1	7	15	28	7	20	8	6	1
Percent Occurrence for Smolts with Injuries				**25.8%**	**1.0%**	**7.2%**	**15.5%**	**28.9%**	**7.2%**	**20.6%**	**8.2%**	**6.2%**	**1.0%**
Percent Occurrence for All Smolts Examined				**1.8%**	**0.1%**	**0.5%**	**1.1%**	**2.1%**	**0.5%**	**1.5%**	**0.6%**	**0.4%**	**0.1%**

Table 10. Immediate (1 hr) and delayed (48 hr) survival for Atlantic salmon smolts passed through Kaplan/propeller turbines at various hydroelectric projects. Note: All studies conducted using the Hi-Z Turb'N Tag.

Site Name	Unit Type	Normal head (ft)	RPM	Unit Flow (cfs)	No. of Blades	Runner Diameter (ft)	Immediate Survival (1-hr)	Delayed Survival (48-hr)	Reference
Briar Rolfe, NH	Kaplan	35	150	-	5	9.84	95.7	95.7	Normandeau 2004
Bar Mills, ME [1]	Propeller	19.5	120	960 & 1,560	5	11.2	88.0 & 94.0	88.0 & 88.0 [2]	Normandeau and FPL 2002
Lairg, Scotland	Kaplan	-	167	-	4	8.5	91.0	91.0	Normandeau and Fishtrack 1998
Cliff, Ireland	Kaplan	32.8	115.3	-	5	14.1	92.3	92.2	Normandeau and Fishtrack 2002
Cathleens Falls, Ireland	Kaplan	93.5	187.5	-	5	12.6	89.3	88.0	Normandeau and Fishtrack 2002
Ardnacrusha, Ireland [1]	Kaplan	93	167	-	5	16.4	96.3 & 95.2	96.3 & 87.5	Normandeau and Fishtrack 2004
Wilder, VT-NH	Kaplan	51	112.5	-	5	9.0	96.0	94.3	Normandeau 1994
Vernon, VT [1]	Kaplan	34	120	1,250 & 1,600	5	10.2	94.7 & 98.5	92.3 & 89.3	Normandeau 2009
West Buxton, ME [1]	Propeller	26.8	120	1,360 & 1,800	6	11.1	100.0 & 94.0	100.0 & 94.0 [3]	Normandeau 1999
McIndoes, NH [1]	Propeller	26	150	800 & 1,600	4	10.0	100.0 & 96.1	100.0 & 94.8	Normandeau 2006b

1 - Tested two different settings

2 - These values represent 24 hour survival

3 - These values represent 72 hour survival

Table 11. Predicted survival rates for salmon smolts passed through propeller Units 1, 2, and 3 at the Brunswick Project under peak turbine operating conditions.

Unit	Turbine Type	Peak Efficiency (%)	Discharge (cfs) at Peak Efficiency	Correlation Factor	Fish Entry Point (ft)	Percent Survival at Smolt Length (in)						Unit Average
						5	6	7	8	9	Range	
1	Vertical Propeller	0.91	4,519	0.1	blade tip	95.4	94.5	93.6	92.7	91.8	91.8 - 95.4	94.9
					mid-blade	98.5	98.2	97.9	97.6	97.3	97.3 - 98.5	
					near hub	98.7	98.4	98.2	97.9	97.7	97.7 - 98.7	
				0.2	blade tip	90.9	89.1	87.3	85.4	83.6	83.6 - 90.9	
					mid-blade	97.2	96.6	96.1	95.5	95.0	95.0 - 97.2	
					near hub	97.6	97.1	96.7	96.2	95.7	95.7 - 97.6	
2	Horizontal Propeller	0.76	1,336	0.1	blade tip	93.1	91.8	90.4	89.0	87.7	87.7 - 93.1	91.6
					mid-blade	97.4	96.8	96.3	95.8	95.2	95.2 - 97.4	
					near hub	97.6	97.1	96.6	96.1	95.6	95.6 - 97.6	
				0.2	blade tip	86.3	83.5	80.8	78.0	75.3	75.3 - 86.3	
					mid-blade	94.7	93.6	92.6	91.5	90.5	90.5 - 94.7	
					near hub	95.1	94.2	93.2	92.2	91.3	91.3 - 95.1	
3	Horizontal Propeller	0.76	1,336	0.1	blade tip	93.1	91.8	90.4	89.0	87.7	87.7 - 93.1	91.6
					mid-blade	97.4	96.8	96.3	95.8	95.2	95.2 - 97.4	
					near hub	97.6	97.1	96.6	96.1	95.6	95.6 - 97.6	
				0.2	blade tip	86.3	83.5	80.8	78.0	75.3	75.3 - 86.3	
					mid-blade	94.7	93.6	92.6	91.5	90.5	90.5 - 94.7	
					near hub	95.1	94.2	93.2	92.2	91.3	91.3 - 95.1	

Table 12. Initial Survival Rate Model (Model A) for whole station survival of Atlantic salmon smolts passing the Brunswick Project under median (50% occurrence) river conditions.

		BASE MODEL
Theoretical Number of Smolts		1000
Proportion of Smolts to Spillway		0.096
Number of Smolts Passed via Spillway		96
Spillway/Bypass Survival Rate		0.971
Number Smolts Surviving Spill		93
Proportion of Smolts to Powerhouse		0.904
Total Number of Smolts to Powerhouse		904
Number of Smolts to Powerhouse by Month	April (1.8% of smolt run)	16
	May (77% of smolt run)	696
	June (21.2% of smolt run)	192
Bypass Effectiveness Rate	April	0.008
	May	0.008
	June	0.011
Number of Smolts Passed via Bypass	April	0
	May	5
	June	2
Total Number of Smolts Passed via Bypass		8
Number of Smolts Surviving Bypass	April	0
	May	5
	June	2
Total Number of Smolts Surviving Bypass		7
Proportion of Smolts to Propeller	April	0.992
	May	0.992
	June	0.989
Total Number of Smolts Passed via Propeller		896
Number of Smolts Passed via Propeller	April (1.8% of smolt run)	14
	May (77% of smolt run)	690
	June (21.2% of smolt run)	190
Propeller Turbine Survival Rate		0.947
Number of Smolts Surviving Propeller	April	14
	May	654
	June	180
Total Number of Smolts Surviving Propeller		847
TOTAL SMOLT SURVIVAL		**948**
WHOLE STATION ESTIMATE		**95%**

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 13. Impacts to the whole station smolt survival estimate obtained using the Initial Survival Rate Model (Model A) for theoretical downstream bypass effectiveness rates.

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.096*	0.096	0.096	0.096	0.096	0.096
Number of Smolts Passed via Spillway		*96*	96	96	96	96	96
Spillway/Bypass Survival Rate		*0.971*	0.971	0.971	0.971	0.971	0.971
Number Smolts Surviving Spill		*93*	93	93	93	93	93
Proportion of Smolts to Powerhouse		*0.904*	0.904	0.904	0.904	0.904	0.904
Total Number of Smolts to Powerhouse		*904*	904	904	904	904	904
Number of Smolts to Powerhouse by Month	April	*16*	16	16	16	16	16
	May	*696*	696	696	696	696	696
	June	*192*	192	192	192	192	192
Bypass Effectiveness Rate	April	*0.008*	0.250	0.450	0.650	0.850	1.000
	May	*0.008*	0.250	0.450	0.650	0.850	1.000
	June	*0.011*	0.250	0.540	0.650	0.850	1.000
Number of Smolts Passed via Bypass	April	*0*	4	7	11	14	16
	May	*5*	174	313	452	592	696
	June	*2*	48	103	125	163	192
Total Number of Smolts Passed via Bypass		*8*	226	424	588	768	904
Number of Smolts Surviving Bypass	April	*0*	4	7	10	13	16
	May	*5*	169	304	439	575	676
	June	*2*	47	100	121	158	186
Total Number of Smolts Surviving Bypass		*7*	219	412	571	746	878
Proportion of Smolts to Propeller	April	*0.992*	0.750	0.550	0.350	0.150	0.000
	May	*0.992*	0.750	0.550	0.350	0.150	0.000
	June	*0.989*	0.750	0.460	0.350	0.150	0.000
Total Number of Smolts Passed via Propeller		*896*	678	480	316	136	0
Number of Smolts Passed via Propeller	April	*14*	11	8	5	2	0
	May	*690*	522	370	244	104	0
	June	*190*	144	102	67	29	0
Propeller Turbine Survival Rate		*0.947*	0.947	0.947	0.947	0.947	0.947
Number of Smolts Surviving Propeller	April	*14*	10	7	5	2	0
	May	*654*	494	350	231	99	0
	June	*180*	136	96	64	27	0
Total Number of Smolts Surviving Propeller		*847*	641	454	299	128	0
TOTAL SMOLT SURVIVAL		***948***	**953**	**959**	**963**	**967**	**971**
WHOLE STATION ESTIMATE		***95%***	**95%**	**96%**	**96%**	**97%**	**97%**

Italics indicates the base model constructed using median flow conditions in the Androscoggin River

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 14. Impacts to the whole station smolt survival estimate obtained using the Initial Survival Rate Model (Model A) for theoretical spill effectiveness rates.

		Evaluated Spill Effectiveness Rates					
		1:1	**0.5:1**	**3.1:1**	**5.2:1**	**7.3:1**	**9.4:1**
		0.096	**0.05**	**0.3**	**0.5**	**0.7**	**0.9**
Proportion of River Flow to Spillway		*0.096*	0.096	0.096	0.096	0.096	0.096
Proportion of River Flow to Powerhouse		*0.904*	0.904	0.904	0.904	0.904	0.904
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.096*	0.05	0.3	0.5	0.7	0.9
Number of Smolts Passed via Spillway		*96*	50	300	500	700	900
Spillway/Bypass Survival Rate		*0.971*	0.971	0.971	0.971	0.971	0.971
Number Smolts Surviving Spill		*93*	49	291	486	680	874
Proportion of Smolts to Powerhouse		*0.904*	0.95	0.7	0.5	0.3	0.1
Total Number of Smolts to Powerhouse		*904*	950	700	500	300	100
Number of Smolts to Powerhouse by Month	April	*16*	17	13	9	5	2
	May	*696*	732	539	385	231	77
	June	*192*	201	148	106	64	21
Bypass Effectiveness Rate	April	*0.008*	0.008	0.008	0.008	0.008	0.008
	May	*0.008*	0.008	0.008	0.008	0.008	0.008
	June	*0.011*	0.011	0.011	0.011	0.011	0.011
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0	0
	May	*5*	6	4	3	2	1
	June	*2*	2	2	1	1	0
Total Number of Smolts Passed via Bypass		*8*	8	6	4	3	1
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0	0
	May	*5*	5	4	3	2	1
	June	*2*	2	2	1	1	0
Total Number of Smolts Surviving Bypass		*7*	8	6	4	2	1
Proportion of Smolts to Propeller	April	*0.992*	0.992	0.992	0.992	0.992	0.992
	May	*0.992*	0.992	0.992	0.992	0.992	0.992
	June	*0.989*	0.989	0.989	0.989	0.989	0.989
Total Number of Smolts Passed via Propeller		*896*	942	694	496	297	99
Number of Smolts Passed via Propeller	April	*14*	15	11	8	5	2
	May	*690*	725	534	382	229	76
	June	*190*	200	147	105	63	21
Propeller Turbine Survival Rate		*0.947*	0.947	0.947	0.947	0.947	0.947
Number of Smolts Surviving Propeller	April	*14*	14	11	8	5	2
	May	*654*	687	506	362	217	72
	June	*180*	189	139	100	60	20
Total Number of Smolts Surviving Propeller		*847*	890	656	469	281	94
TOTAL SMOLT SURVIVAL		***948***	**947**	**953**	**958**	**963**	**968**
WHOLE STATION ESTIMATE		***95%***	**95%**	**95%**	**96%**	**96%**	**97%**

Italics indicates model estimate is based 1:1 spill effectiveness ratio

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 15. Approximate river discharge (cfs) for Androscoggin River at Brunswick during April, May and June for low (i.e. 75 and 90% exceedence) and high (10 and 25% exceedence) conditions.

Percent of Time Flow is Exceeded	River Discharge (cfs)		
	April	May	June
10	33,138	19,462	13,466
25	21,776	12,414	7,659
50	*13,466*	*8,816*	*5,260*
75	9,373	5,807	3,577
90	7,027	4,608	2,693

Italics indicates values used for primary model

Table 16. Impacts to the whole station smolt survival estimate obtained using the Initial Survival Rate Model (Model A) for theoretical seasonal flow conditions.

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.096*	0.564	0.298	0.003	0.000
Number of Smolts Passed via Spillway		*96*	564	298	3	0
Spillway/Bypass Survival Rate		*0.971*	0.971	0.971	0.971	0.971
Number Smolts Surviving Spill		*94*	548	289	3	0
Proportion of Smolts to Powerhouse		*0.904*	0.436	0.702	0.997	1.000
Total Number of Smolts to Powerhouse		*904*	436	702	997	1,000
Number of Smolts to Powerhouse by Month*	April	*16*	8	13	18	18
	May	*696*	335	541	768	770
	June	*192*	92	149	211	212
Bypass Effectiveness Rate	April	*0.008*	0.008	0.008	0.008	0.009
	May	*0.008*	0.008	0.008	0.010	0.013
	June	*0.011*	0.008	0.008	0.017	0.022
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0
	May	*5*	3	4	8	10
	June	*2*	1	1	4	5
Total Number of Smolts Passed via Bypass		*8*	3	5	12	15
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0
	May	*5*	3	4	8	10
	June	*2*	1	1	3	5
Total Number of Smolts Surviving Bypass		*7*	3	5	11	14
Proportion of Smolts to Propeller	April	*0.992*	0.992	0.992	0.992	0.991
	May	*0.992*	0.992	0.992	0.990	0.987
	June	*0.989*	0.992	0.992	0.983	0.978
Total Number of Smolts Passed via Propeller		*896*	432	697	985	985
Number of Smolts Passed via Propeller	April	*14*	7	11	16	16
	May	*690*	333	537	759	759
	June	*190*	92	148	209	209
Propeller Turbine Survival Rate		*0.947*	0.947	0.947	0.947	0.947
Number of Smolts Surviving Propeller	April	*14*	7	11	15	15
	May	*653*	315	508	719	718
	June	*180*	87	140	198	198
Total Number of Smolts Surviving Propeller		*847*	409	659	931	931
TOTAL SMOLT SURVIVAL		***948***	**960**	**953**	**945**	**945**
WHOLE STATION ESTIMATE		***95%***	**96%**	**95%**	**95%**	**95%**

Italics indicates model estimate is based on median discharge conditions

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 17. Delayed Survival Rate Model (Model B) for whole station survival of Atlantic salmon smolts passing the Brunswick Project under median (50% occurrence) river conditions.

		BASE MODEL
Theoretical Number of Smolts		1000
Proportion of Smolts to Spillway		0.096
Number of Smolts Passed via Spillway		96
Spillway/Bypass Survival Rate		0.963
Number Smolts Surviving Spill		92
Proportion of Smolts to Powerhouse		0.904
Total Number of Smolts to Powerhouse		904
Number of Smolts to Powerhouse by Month	April (1.8% of smolt run)	16
	May (77% of smolt run)	696
	June (21.2% of smolt run)	192
Bypass Effectiveness Rate	April	0.008
	May	0.008
	June	0.011
Number of Smolts Passed via Bypass	April	0
	May	5
	June	2
Total Number of Smolts Passed via Bypass		8
Number of Smolts Surviving Bypass	April	0
	May	5
	June	2
Total Number of Smolts Surviving Bypass		7
Proportion of Smolts to Propeller	April	0.992
	May	0.992
	June	0.989
Total Number of Smolts Passed via Propeller		896
Number of Smolts Passed via Propeller	April (1.8% of smolt run)	14
	May (77% of smolt run)	690
	June (21.2% of smolt run)	190
Propeller Turbine Survival Rate		0.928
Number of Smolts Surviving Propeller	April	13
	May	640
	June	176
Total Number of Smolts Surviving Propeller		830
TOTAL SMOLT SURVIVAL		**930**
WHOLE STATION ESTIMATE		**93%**

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 18. Impacts to the whole station smolt survival estimate obtained using the Delayed Survival Rate Model (Model B) for theoretical downstream bypass effectiveness rates.

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.096*	0.096	0.096	0.096	0.096	0.096
Number of Smolts Passed via Spillway		*96*	96	96	96	96	96
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963	0.963
Number Smolts Surviving Spill		*92*	92	92	92	92	92
Proportion of Smolts to Powerhouse		*0.904*	0.904	0.904	0.904	0.904	0.904
Total Number of Smolts to Powerhouse		*904*	904	904	904	904	904
Number of Smolts to Powerhouse by Month	April	*16*	16	16	16	16	16
	May	*696*	696	696	696	696	696
	June	*192*	192	192	192	192	192
Bypass Effectiveness Rate	April	*0.008*	0.250	0.450	0.650	0.850	1.000
	May	*0.008*	0.250	0.450	0.650	0.850	1.000
	June	*0.011*	0.250	0.540	0.650	0.850	1.000
Number of Smolts Passed via Bypass	April	*0*	4	7	11	14	16
	May	*5*	174	313	452	592	696
	June	*2*	48	103	125	163	192
Total Number of Smolts Passed via Bypass		*8*	226	424	588	768	904
Number of Smolts Surviving Bypass	April	*0*	4	7	10	13	16
	May	*5*	168	302	436	570	670
	June	*2*	46	100	120	157	185
Total Number of Smolts Surviving Bypass		*7*	218	408	566	740	871
Proportion of Smolts to Propeller	April	*0.992*	0.750	0.550	0.350	0.150	0.000
	May	*0.992*	0.750	0.550	0.350	0.150	0.000
	June	*0.989*	0.750	0.460	0.350	0.150	0.000
Total Number of Smolts Passed via Propeller		*896*	678	480	316	136	0
Number of Smolts Passed via Propeller	April	*14*	11	8	5	2	0
	May	*690*	522	370	244	104	0
	June	*190*	144	102	67	29	0
Propeller Turbine Survival Rate		*0.928*	0.928	0.928	0.928	0.928	0.928
Number of Smolts Surviving Propeller	April	*13*	10	7	5	2	0
	May	*640*	484	343	226	97	0
	June	*176*	133	94	62	27	0
Total Number of Smolts Surviving Propeller		*830*	628	445	293	126	0
TOTAL SMOLT SURVIVAL		***930***	**938**	**945**	**951**	**958**	**963**
WHOLE STATION ESTIMATE		***93%***	**94%**	**95%**	**95%**	**96%**	**96%**

Italics indicates the base model constructed using median flow conditions in the Androscoggin River

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 19. Impacts to the whole station smolt survival estimate obtained using the Delayed Survival Rate Model (Model B) for theoretical spill effectiveness rates.

		Evaluated Spill Effectiveness Rates					
		1:1	**0.5:1**	**3.1:1**	**5.2:1**	**7.3:1**	**9.4:1**
		0.096	**0.05**	**0.3**	**0.5**	**0.7**	**0.9**
Proportion of River Flow to Spillway		*0.096*	0.096	0.096	0.096	0.096	0.096
Proportion of River Flow to Powerhouse		*0.904*	0.904	0.904	0.904	0.904	0.904
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.096*	0.05	0.3	0.5	0.7	0.9
Number of Smolts Passed via Spillway		*96*	50	300	500	700	900
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963	0.963
Number Smolts Surviving Spill		*92*	48	289	482	674	867
Proportion of Smolts to Powerhouse		*0.904*	0.95	0.7	0.5	0.3	0.1
Total Number of Smolts to Powerhouse		*904*	950	700	500	300	100
Number of Smolts to Powerhouse by Month	April	*16*	17	13	9	5	2
	May	*696*	732	539	385	231	77
	June	*192*	201	148	106	64	21
Bypass Effectiveness Rate	April	*0.008*	0.008	0.008	0.008	0.008	0.008
	May	*0.008*	0.008	0.008	0.008	0.008	0.008
	June	*0.011*	0.011	0.011	0.011	0.011	0.011
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0	0
	May	*5*	6	4	3	2	1
	June	*2*	2	2	1	1	0
Total Number of Smolts Passed via Bypass		*8*	8	6	4	3	1
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0	0
	May	*5*	5	4	3	2	1
	June	*2*	2	2	1	1	0
Total Number of Smolts Surviving Bypass		*7*	8	6	4	2	1
Proportion of Smolts to Propeller	April	*0.992*	0.992	0.992	0.992	0.992	0.992
	May	*0.992*	0.992	0.992	0.992	0.992	0.992
	June	*0.989*	0.989	0.989	0.989	0.989	0.989
Total Number of Smolts Passed via Propeller		*896*	942	694	496	297	99
Number of Smolts Passed via Propeller	April	*14*	15	11	8	5	2
	May	*690*	725	534	382	229	76
	June	*190*	200	147	105	63	21
Propeller Turbine Survival Rate		*0.928*	0.928	0.928	0.928	0.928	0.928
Number of Smolts Surviving Propeller	April	*13*	14	10	7	4	1
	May	*640*	673	496	354	213	71
	June	*176*	185	137	98	59	20
Total Number of Smolts Surviving Propeller		*830*	872	643	459	275	92
TOTAL SMOLT SURVIVAL		***930***	**928**	**937**	**945**	**952**	**959**
WHOLE STATION ESTIMATE		***93%***	**93%**	**94%**	**94%**	**95%**	**96%**

Italics indicates model estimate is based 1:1 spill effectiveness ratio

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 20. Impacts to the whole station smolt survival estimate obtained using the Delayed Survival Rate Model (Model B) for theoretical seasonal flow conditions.

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.096*	0.564	0.298	0.003	0.000
Number of Smolts Passed via Spillway		*96*	564	298	3	0
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963
Number Smolts Surviving Spill		*93*	543	287	3	0
Proportion of Smolts to Powerhouse		*0.904*	0.436	0.702	0.997	1.000
Total Number of Smolts to Powerhouse		*904*	436	702	997	1,000
Number of Smolts to Powerhouse by Month*	April	*16*	8	13	18	18
	May	*696*	335	541	768	770
	June	*192*	92	149	211	212
Bypass Effectiveness Rate	April	*0.008*	0.008	0.008	0.008	0.009
	May	*0.008*	0.008	0.008	0.010	0.013
	June	*0.011*	0.008	0.008	0.017	0.022
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0
	May	*5*	3	4	8	10
	June	*2*	1	1	4	5
Total Number of Smolts Passed via Bypass		*8*	3	5	12	15
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0
	May	*5*	2	4	8	10
	June	*2*	1	1	3	5
Total Number of Smolts Surviving Bypass		*7*	3	5	11	14
Proportion of Smolts to Propeller	April	*0.992*	0.992	0.992	0.992	0.991
	May	*0.992*	0.992	0.992	0.990	0.987
	June	*0.989*	0.992	0.992	0.983	0.978
Total Number of Smolts Passed via Propeller		*896*	432	697	985	985
Number of Smolts Passed via Propeller	April	*14*	7	11	16	16
	May	*690*	333	537	759	759
	June	*190*	92	148	209	209
Propeller Turbine Survival Rate		*0.928*	0.928	0.928	0.928	0.928
Number of Smolts Surviving Propeller	April	*13*	6	10	15	15
	May	*640*	309	498	704	704
	June	*176*	85	137	194	194
Total Number of Smolts Surviving Propeller		*830*	400	645	913	912
TOTAL SMOLT SURVIVAL		***930***	**947**	**937**	**927**	**927**
WHOLE STATION ESTIMATE		***93%***	**95%**	**94%**	**93%**	**93%**

Italics indicates model estimate is based on median discharge conditions

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 21. Delayed/Calculated Survival Rate Model (Model C) for whole station survival of Atlantic salmon smolts passing the Brunswick Project under median (50% occurrence) river conditions.

		BASE MODEL
Theoretical Number of Smolts		1000
Proportion of Smolts to Spillway		0.096
Number of Smolts Passed via Spillway		96
Spillway/Bypass Survival Rate		0.971
Number Smolts Surviving Spill		93
Proportion of Smolts to Powerhouse		0.904
Total Number of Smolts to Powerhouse		904
Number of Smolts to Powerhouse by Month	April (1.8% of smolt run)	16
	May (77% of smolt run)	696
	June (21.2% of smolt run)	192
Bypass Effectiveness Rate	April	0.008
	May	0.008
	June	0.011
Number of Smolts Passed via Bypass	April	0
	May	5
	June	2
Total Number of Smolts Passed via Bypass		8
Number of Smolts Surviving Bypass	April	0
	May	5
	June	2
Total Number of Smolts Surviving Bypass		7
Proportion of Smolts to Propeller	April	0.992
	May	0.992
	June	0.989
Total Number of Smolts Passed via Propeller		896
Number of Smolts Passed via Propeller	April (1.8% of smolt run)	14
	May (77% of smolt run)	690
	June (21.2% of smolt run)	190
Propeller Turbine Survival Rate		0.927
Number of Smolts Surviving Propeller	April	13
	May	640
	June	176
Total Number of Smolts Surviving Propeller		829
TOTAL SMOLT SURVIVAL		**930**
WHOLE STATION ESTIMATE		**93%**

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 22. Impacts to the whole station smolt survival estimate obtained using the Delayed/Calculated Survival Rate Model (Model C) for theoretical downstream bypass effectiveness rates.

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.096*	0.096	0.096	0.096	0.096	0.096
Number of Smolts Passed via Spillway		*96*	96	96	96	96	96
Spillway/Bypass Survival Rate		*0.971*	0.971	0.971	0.971	0.971	0.971
Number Smolts Surviving Spill		*93*	93	93	93	93	93
Proportion of Smolts to Powerhouse		*0.904*	0.904	0.904	0.904	0.904	0.904
Total Number of Smolts to Powerhouse		*904*	904	904	904	904	904
Number of Smolts to Powerhouse by Month	April	*16*	16	16	16	16	16
	May	*696*	696	696	696	696	696
	June	*192*	192	192	192	192	192
Bypass Effectiveness Rate	April	*0.008*	0.250	0.450	0.650	0.850	1.000
	May	*0.008*	0.250	0.450	0.650	0.850	1.000
	June	*0.011*	0.250	0.540	0.650	0.850	1.000
Number of Smolts Passed via Bypass	April	*0*	4	7	11	14	16
	May	*5*	174	313	452	592	696
	June	*2*	48	103	125	163	192
Total Number of Smolts Passed via Bypass		*8*	226	424	588	768	904
Number of Smolts Surviving Bypass	April	*0*	4	7	10	13	16
	May	*5*	169	304	439	575	676
	June	*2*	47	100	121	158	186
Total Number of Smolts Surviving Bypass		*7*	219	412	571	746	878
Proportion of Smolts to Propeller	April	*0.992*	0.750	0.550	0.350	0.150	0.000
	May	*0.992*	0.750	0.550	0.350	0.150	0.000
	June	*0.989*	0.750	0.460	0.350	0.150	0.000
Total Number of Smolts Passed via Propeller		*896*	678	480	316	136	0
Number of Smolts Passed via Propeller	April	*14*	11	8	5	2	0
	May	*690*	522	370	244	104	0
	June	*190*	144	102	67	29	0
Propeller Turbine Survival Rate		*0.927*	0.927	0.927	0.927	0.927	0.927
Number of Smolts Surviving Propeller	April	*13*	10	7	5	2	0
	May	*640*	484	343	226	97	0
	June	*176*	133	94	62	27	0
Total Number of Smolts Surviving Propeller		*829*	627	444	293	125	0
TOTAL SMOLT SURVIVAL		***930***	**940**	**949**	**956**	**965**	**971**
WHOLE STATION ESTIMATE		***93%***	**94%**	**95%**	**96%**	**96%**	**97%**

Italics indicates the base model constructed using median flow conditions in the Androscoggin River

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 23. Impacts to the whole station smolt survival estimate obtained using the Delayed/Calculated Survival Rate Model (Model C) for theoretical spill effectiveness rates.

		Evaluated Spill Effectiveness Rates					
		1:1	**0.5:1**	**3.1:1**	**5.2:1**	**7.3:1**	**9.4:1**
		0.096	**0.05**	**0.3**	**0.5**	**0.7**	**0.9**
Proportion of River Flow to Spillway		*0.096*	0.096	0.096	0.096	0.096	0.096
Proportion of River Flow to Powerhouse		*0.904*	0.904	0.904	0.904	0.904	0.904
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.096*	0.05	0.3	0.5	0.7	0.9
Number of Smolts Passed via Spillway		*96*	50	300	500	700	900
Spillway/Bypass Survival Rate		*0.971*	0.971	0.971	0.971	0.971	0.971
Number Smolts Surviving Spill		*93*	49	291	486	680	874
Proportion of Smolts to Powerhouse		*0.904*	0.95	0.7	0.5	0.3	0.1
Total Number of Smolts to Powerhouse		*904*	950	700	500	300	100
Number of Smolts to Powerhouse by Month	April	*16*	17	13	9	5	2
	May	*696*	732	539	385	231	77
	June	*192*	201	148	106	64	21
Bypass Effectiveness Rate	April	*0.008*	0.008	0.008	0.008	0.008	0.008
	May	*0.008*	0.008	0.008	0.008	0.008	0.008
	June	*0.011*	0.011	0.011	0.011	0.011	0.011
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0	0
	May	*5*	6	4	3	2	1
	June	*2*	2	2	1	1	0
Total Number of Smolts Passed via Bypass		*8*	8	6	4	3	1
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0	0
	May	*5*	5	4	3	2	1
	June	*2*	2	2	1	1	0
Total Number of Smolts Surviving Bypass		*7*	8	6	4	2	1
Proportion of Smolts to Propeller	April	*0.992*	0.992	0.992	0.992	0.992	0.992
	May	*0.992*	0.992	0.992	0.992	0.992	0.992
	June	*0.989*	0.989	0.989	0.989	0.989	0.989
Total Number of Smolts Passed via Propeller		*896*	942	694	496	297	99
Number of Smolts Passed via Propeller	April	*14*	15	11	8	5	2
	May	*690*	725	534	382	229	76
	June	*190*	200	147	105	63	21
Propeller Turbine Survival Rate		*0.927*	0.927	0.927	0.927	0.927	0.927
Number of Smolts Surviving Propeller	April	*13*	14	10	7	4	1
	May	*640*	672	495	354	212	71
	June	*176*	185	136	97	58	19
Total Number of Smolts Surviving Propeller		*829*	871	642	459	275	92
TOTAL SMOLT SURVIVAL		***930***	**928**	**939**	**948**	**957**	**966**
WHOLE STATION ESTIMATE		***93%***	**93%**	**94%**	**95%**	**96%**	**97%**

Italics indicates model estimate is based 1:1 spill effectiveness ratio
Shading indicates the variable assessed in this sensitivity analysis
*Monthly smolt run distribution is presented in Table 3 of this report.

Table 24. Impacts to the whole station smolt survival estimate obtained using the Delayed/Calculated Survival Rate Model (Model C) for theoretical seasonal flow conditions.

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.096*	0.564	0.298	0.003	0.000
Number of Smolts Passed via Spillway		*96*	564	298	3	0
Spillway/Bypass Survival Rate		*0.971*	0.971	0.971	0.971	0.971
Number Smolts Surviving Spill		*94*	548	289	3	0
Proportion of Smolts to Powerhouse		*0.904*	0.436	0.702	0.997	1.000
Total Number of Smolts to Powerhouse		*904*	436	702	997	1,000
Number of Smolts to Powerhouse by Month*	April	*16*	8	13	18	18
	May	*696*	335	541	768	770
	June	*192*	92	149	211	212
Bypass Effectiveness Rate	April	*0.008*	0.008	0.008	0.008	0.009
	May	*0.008*	0.008	0.008	0.010	0.013
	June	*0.011*	0.008	0.008	0.017	0.022
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0
	May	*5*	3	4	8	10
	June	*2*	1	1	4	5
Total Number of Smolts Passed via Bypass		*8*	3	5	12	15
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0
	May	*5*	3	4	8	10
	June	*2*	1	1	3	5
Total Number of Smolts Surviving Bypass		*7*	3	5	11	14
Proportion of Smolts to Propeller	April	*0.992*	0.992	0.992	0.992	0.991
	May	*0.992*	0.992	0.992	0.990	0.987
	June	*0.989*	0.992	0.992	0.983	0.978
Total Number of Smolts Passed via Propeller		*896*	432	697	985	985
Number of Smolts Passed via Propeller	April	*14*	7	11	16	16
	May	*690*	333	537	759	759
	June	*190*	92	148	209	209
Propeller Turbine Survival Rate		*0.927*	0.927	0.927	0.927	0.927
Number of Smolts Surviving Propeller	April	*13*	6	10	15	15
	May	*640*	309	497	703	703
	June	*176*	85	137	194	194
Total Number of Smolts Surviving Propeller		*829*	400	645	912	911
TOTAL SMOLT SURVIVAL		***930***	**951**	**939**	**926**	**926**
WHOLE STATION ESTIMATE		***93%***	**95%**	**94%**	**93%**	**93%**

Italics indicates model estimate is based on median discharge conditions

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 25. Initial Injury Rate Model (Model D) for whole station survival of Atlantic salmon smolts passing the Brunswick Project under median (50% occurrence) river conditions.

		BASE MODEL
Theoretical Number of Smolts		1000
Proportion of Smolts to Spillway		0.096
Number of Smolts Passed via Spillway		96
Spillway/Bypass Survival Rate		0.816
Number Smolts Surviving Spill		78
Proportion of Smolts to Powerhouse		0.904
Total Number of Smolts to Powerhouse		904
Number of Smolts to Powerhouse by Month	April (1.8% of smolt run)	16
	May (77% of smolt run)	696
	June (21.2% of smolt run)	192
Bypass Effectiveness Rate	April	0.008
	May	0.008
	June	0.011
Number of Smolts Passed via Bypass	April	0
	May	5
	June	2
Total Number of Smolts Passed via Bypass		8
Number of Smolts Surviving Bypass	April	0
	May	4
	June	2
Total Number of Smolts Surviving Bypass		6
Proportion of Smolts to Propeller	April	0.992
	May	0.992
	June	0.989
Total Number of Smolts Passed via Propeller		896
Number of Smolts Passed via Propeller	April (1.8% of smolt run)	14
	May (77% of smolt run)	690
	June (21.2% of smolt run)	190
Propeller Turbine Survival Rate		0.925
Number of Smolts Surviving Propeller	April	13
	May	638
	June	176
Total Number of Smolts Surviving Propeller		827
TOTAL SMOLT SURVIVAL		**912**
WHOLE STATION ESTIMATE		**91%**

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 26. Impacts to the whole station smolt survival estimate obtained using the Initial Injury Rate Model (Model D) for theoretical downstream bypass effectiveness rates.

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.096*	0.096	0.096	0.096	0.096	0.096
Number of Smolts Passed via Spillway		*96*	96	96	96	96	96
Spillway/Bypass Survival Rate		*0.816*	0.816	0.816	0.816	0.816	0.816
Number Smolts Surviving Spill		*78*	78	78	78	78	78
Proportion of Smolts to Powerhouse		*0.904*	0.904	0.904	0.904	0.904	0.904
Total Number of Smolts to Powerhouse		*904*	904	904	904	904	904
Number of Smolts to Powerhouse by Month	April	*16*	16	16	16	16	16
	May	*696*	696	696	696	696	696
	June	*192*	192	192	192	192	192
Bypass Effectiveness Rate	April	*0.008*	0.250	0.450	0.650	0.850	1.000
	May	*0.008*	0.250	0.450	0.650	0.850	1.000
	June	*0.011*	0.250	0.540	0.650	0.850	1.000
Number of Smolts Passed via Bypass	April	*0*	4	7	11	14	16
	May	*5*	174	313	452	592	696
	June	*2*	48	103	125	163	192
Total Number of Smolts Passed via Bypass		*8*	226	424	588	768	904
Number of Smolts Surviving Bypass	April	*0*	3	6	9	11	13
	May	*4*	142	256	369	483	568
	June	*2*	39	84	102	133	156
Total Number of Smolts Surviving Bypass		*6*	184	346	479	627	738
Proportion of Smolts to Propeller	April	*0.992*	0.750	0.550	0.350	0.150	0.000
	May	*0.992*	0.750	0.550	0.350	0.150	0.000
	June	*0.989*	0.750	0.460	0.350	0.150	0.000
Total Number of Smolts Passed via Propeller		*896*	678	480	316	136	0
Number of Smolts Passed via Propeller	April	*14*	11	8	5	2	0
	May	*690*	522	370	244	104	0
	June	*190*	144	102	67	29	0
Propeller Turbine Survival Rate		*0.925*	0.925	0.925	0.925	0.925	0.925
Number of Smolts Surviving Propeller	April	*13*	10	7	5	2	0
	May	*638*	483	342	225	97	0
	June	*176*	133	94	62	27	0
Total Number of Smolts Surviving Propeller		*827*	626	443	292	125	0
TOTAL SMOLT SURVIVAL		***912***	**889**	**867**	**850**	**831**	**816**
WHOLE STATION ESTIMATE		***91%***	**89%**	**87%**	**85%**	**83%**	**82%**

Italics indicates the base model constructed using median flow conditions in the Androscoggin River

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 27. Impacts to the whole station smolt survival estimate obtained using the Initial Injury Rate Model (Model D) for theoretical spill effectiveness rates.

		Evaluated Spill Effectiveness Rates					
		1:1	**0.5:1**	**3.1:1**	**5.2:1**	**7.3:1**	**9.4:1**
		0.096	**0.05**	**0.3**	**0.5**	**0.7**	**0.9**
Proportion of River Flow to Spillway		*0.096*	0.096	0.096	0.096	0.096	0.096
Proportion of River Flow to Powerhouse		*0.904*	0.904	0.904	0.904	0.904	0.904
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.096*	0.05	0.3	0.5	0.7	0.9
Number of Smolts Passed via Spillway		*96*	50	300	500	700	900
Spillway/Bypass Survival Rate		*0.816*	0.816	0.816	0.816	0.816	0.816
Number Smolts Surviving Spill		*78*	41	245	408	571	734
Proportion of Smolts to Powerhouse		*0.904*	0.95	0.7	0.5	0.3	0.1
Total Number of Smolts to Powerhouse		*904*	950	700	500	300	100
Number of Smolts to Powerhouse by Month	April	*16*	17	13	9	5	2
	May	*696*	732	539	385	231	77
	June	*192*	201	148	106	64	21
Bypass Effectiveness Rate	April	*0.008*	0.008	0.008	0.008	0.008	0.008
	May	*0.008*	0.008	0.008	0.008	0.008	0.008
	June	*0.011*	0.011	0.011	0.011	0.011	0.011
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0	0
	May	*5*	6	4	3	2	1
	June	*2*	2	2	1	1	0
Total Number of Smolts Passed via Bypass		*8*	8	6	4	3	1
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0	0
	May	*4*	5	3	2	1	0
	June	*2*	2	1	1	1	0
Total Number of Smolts Surviving Bypass		*6*	7	5	3	2	1
Proportion of Smolts to Propeller	April	*0.992*	0.992	0.992	0.992	0.992	0.992
	May	*0.992*	0.992	0.992	0.992	0.992	0.992
	June	*0.989*	0.989	0.989	0.989	0.989	0.989
Total Number of Smolts Passed via Propeller		*896*	942	694	496	297	99
Number of Smolts Passed via Propeller	April	*14*	15	11	8	5	2
	May	*690*	725	534	382	229	76
	June	*190*	200	147	105	63	21
Propeller Turbine Survival Rate		*0.925*	0.925	0.925	0.925	0.925	0.925
Number of Smolts Surviving Propeller	April	*13*	14	10	7	4	1
	May	*638*	671	494	353	212	71
	June	*176*	185	136	97	58	19
Total Number of Smolts Surviving Propeller		*827*	870	641	458	275	92
TOTAL SMOLT SURVIVAL		***912***	**917**	**890**	**869**	**848**	**827**
WHOLE STATION ESTIMATE		***91%***	**92%**	**89%**	**87%**	**85%**	**83%**

Italics indicates model estimate is based 1:1 spill effectiveness ratio
Shading indicates the variable assessed in this sensitivity analysis
*Monthly smolt run distribution is presented in Table 3 of this report.

Table 28. Impacts to the whole station smolt survival estimate obtained using the Initial Injury Rate Model (Model D) for theoretical seasonal flow conditions.

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Theoretical Number of Smolts		*1,000*	1,000	1,000	1,000	1,000
Proportion of Smolts to Spillway		*0.096*	0.564	0.298	0.003	0.000
Number of Smolts Passed via Spillway		*96*	564	298	3	0
Spillway/Bypass Survival Rate		*0.816*	0.816	0.816	0.816	0.816
Number Smolts Surviving Spill		*79*	461	243	2	0
Proportion of Smolts to Powerhouse		*0.904*	0.436	0.702	0.997	1.000
Total Number of Smolts to Powerhouse		*904*	436	702	997	1,000
Number of Smolts to Powerhouse by Month*	April	*16*	8	13	18	18
	May	*696*	335	541	768	770
	June	*192*	92	149	211	212
Bypass Effectiveness Rate	April	*0.008*	0.008	0.008	0.008	0.009
	May	*0.008*	0.008	0.008	0.010	0.013
	June	*0.011*	0.008	0.008	0.017	0.022
Number of Smolts Passed via Bypass	April	*0*	0	0	0	0
	May	*5*	3	4	8	10
	June	*2*	1	1	4	5
Total Number of Smolts Passed via Bypass		*8*	3	5	12	15
Number of Smolts Surviving Bypass	April	*0*	0	0	0	0
	May	*4*	2	3	6	8
	June	*2*	1	1	3	4
Total Number of Smolts Surviving Bypass		*6*	3	4	9	12
Proportion of Smolts to Propeller	April	*0.992*	0.992	0.992	0.992	0.991
	May	*0.992*	0.992	0.992	0.990	0.987
	June	*0.989*	0.992	0.992	0.983	0.978
Total Number of Smolts Passed via Propeller		*896*	432	697	985	985
Number of Smolts Passed via Propeller	April	*14*	7	11	16	16
	May	*690*	333	537	759	759
	June	*190*	92	148	209	209
Propeller Turbine Survival Rate		*0.925*	0.925	0.925	0.925	0.925
Number of Smolts Surviving Propeller	April	*13*	6	10	15	15
	May	*638*	308	496	702	702
	June	*176*	85	137	193	193
Total Number of Smolts Surviving Propeller		*827*	399	643	910	909
TOTAL SMOLT SURVIVAL		***912***	**862**	**891**	**922**	**922**
WHOLE STATION ESTIMATE		***91%***	**86%**	**89%**	**92%**	**92%**

Italics indicates model estimate is based on median discharge conditions

Shading indicates the variable assessed in this sensitivity analysis

*Monthly smolt run distribution is presented in Table 3 of this report.

Table 29. Summary of upstream passage for adult Atlantic salmon at the Brunswick Project during 1995-2010.

Passage Year	Atlantic Salmon Returns
1995	16
1996	39
1997	1
1998	4
1999	5
2000	6
2001	6
2002	2
2003	5
2004	11
2005	10
2006	7
2007	21
2008	18
2009	24
2010	10
2011	48*

*2011 total as of 12 August 2011

Table 30. Estimated percentage of kelts entering the Brunswick Project powerhouse area or passing via spillway.

Month	Discharge (cfs)			Percent of River Discharge		Kelt Run Distribution[4]	Project Kelt Distribution[5]	
	River Discharge[1]	Brunswick [2]	Calculated Spill [3]	Spill	Powerhouse		Spill	Powerhouse
April	13,466	7,800	5,666	42.1%	57.9%	40.0%	16.8%	23.2%
May	8,816	7,800	1,016	11.5%	88.5%	40.0%	4.6%	35.4%
October	3,820	3,820	0	0.0%	100.0%	5.0%	0.0%	5.0%
November	6,670	6,670	0	0.0%	100.0%	10.0%	0.0%	10.0%
December	6,400	6,400	0	0.0%	100.0%	5.0%	0.0%	5.0%
TOTAL	-	-	-	-	-	-	**21.4%**	**78.6%**

1 - Monthly median condition as obtained from Project flow duration curves (50% exceedence)

2 - Project capacity or total inflow

3 - Equal to River discharge - Project capacity

4 - Mean monthly distribution of Atlantic salmon kelt migrations based on Baum (1997)

5 - Based on 1:1 assumption of spill effectiveness

Table 31. **Predicted survival rates for salmon kelts passed through propeller Units 1-3 at the Brunswick Project under peak turbine operating conditions.**

Unit	Turbine Type	Peak Efficiency (%)	Discharge (cfs) at Peak Efficiency	Correlation Factor	Fish Entry Point (ft)	Percent Survival at Smolt Length (in)						Unit Average
						16	20	23	27	30	Range	
1	Vertical Propeller	0.91	4,519	0.1	blade tip	85.4	81.7	79.0	75.3	72.6	72.6 - 85.4	82.9
					mid-blade	95.3	94.1	93.2	92.0	91.1	91.1 - 95.3	
					near hub	95.8	94.8	94.0	93.0	92.2	92.2 - 95.8	
				0.2	blade tip	70.8	63.4	58.0	50.6	45.2	45.2 - 70.8	
					mid-blade	90.5	88.2	86.4	84.0	82.2	82.2 - 90.5	
					near hub	91.7	89.6	88.0	85.9	84.4	84.4 - 91.7	
2	Horizontal Propeller	0.76	1,336	0.1	blade tip	78.0	72.6	68.4	63.0	58.8	58.8 - 78.0	72.3
					mid-blade	91.5	89.4	87.8	85.7	84.1	84.1 - 91.5	
					near hub	92.2	90.3	88.8	86.9	85.4	85.4 - 92.2	
				0.2	blade tip	56.1	45.1	36.9	25.9	17.7	17.7 - 56.1	
					mid-blade	83.1	78.8	75.6	71.4	68.2	68.2 - 83.1	
					near hub	84.5	80.6	77.7	73.8	70.9	70.9 - 84.5	
3	Horizontal Propeller	0.76	1,336	0.1	blade tip	78.0	72.6	68.4	63.0	58.8	58.8 - 78.0	72.3
					mid-blade	91.5	89.4	87.8	85.7	84.1	84.1 - 91.5	
					near hub	92.2	90.3	88.8	86.9	85.4	85.4 - 92.2	
				0.2	blade tip	56.1	45.1	36.9	25.9	17.7	17.7 - 56.1	
					mid-blade	83.1	78.8	75.6	71.4	68.2	68.2 - 83.1	
					near hub	84.5	80.6	77.7	73.8	70.9	70.9 - 84.5	

Table 32. Model for whole station survival of Atlantic salmon kelts passing the Brunswick Project under median (50% occurrence) river conditions.

		BASE MODEL
Theoretical Number of Kelts		100
Proportion of Kelts to Spillway		0.214
Number of Kelts Passed via Spillway		21.4
Spillway/Bypass Survival Rate		0.963
Number Kelts Surviving Spill		21
Proportion of Kelts to Powerhouse		0.786
Total Number of Kelts to Powerhouse		79
Number of Kelts to Powerhouse by Month	April (40% of kelt run)	31
	May (40% of kelt run)	31
	October (5% of kelt run)	4
	November (10% of kelt run)	8
	December (5% of kelt run)	4
Bypass Effectiveness Rate	April	0.008
	May	0.008
	October	0.016
	November	0.009
	December	0.009
Number of Kelts Passed via Bypass	April	0
	May	0
	October	0
	November	0
	December	0
Total Number of Kelts Passed via Bypass		1
Number of Kelts Surviving Bypass	April	0
	May	0
	October	0
	November	0
	December	0
Total Number of Smolts Surviving Bypass		1
Proportion of Kelts to Propeller	April	0.992
	May	0.992
	October	0.984
	November	0.991
	December	0.991
Total Number of Smolts Directed to Propeller		78
Proportion of Kelts Through 3.5" Racks (Propeller)		0.709
Proportion of Kelts Screened at 3.5" Racks (Propeller) and to Spill		0.291
Number of Kelts Through 3.5" Racks (Propeller)		55
Number of Kelts Screened at 3.5" Racks (Propeller) and to Spill		23

(continued)

Table 32. (Continued)

		BASE MODEL
Number of Kelts Passed via Propeller	April	22
	May	22
	October	3
	November	6
	December	3
Number of Kelts Passed via Spill	April	9
	May	9
	October	1
	November	2
	December	1
Propeller Turbine Survival Rate		0.759
Number of Kelts Surviving Propeller	April	17
	May	17
	October	2
	November	4
	December	2
Total Number of Kelts Surviving Propeller		42
Number of Kelts Surviving Spill	April	9
	May	9
	October	1
	November	2
	December	1
Total Number of Kelts Surviving Spill		22
TOTAL KELT SURVIVAL		**85**
WHOLE STATION ESTIMATE		**85%**

*Monthly kelt run distribution is presented in Table 30 of this report.

Table 33. Impacts to the whole station kelt survival estimate for theoretical downstream bypass effectiveness rates.

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Theoretical Number of Kelts		*100*	100	100	100	100	100
Proportion of Kelts to Spillway		*0.214*	0.214	0.214	0.214	0.214	0.214
Number of Kelts Passed via Spillway		*21.4*	21.4	21.4	21.4	21.4	21.4
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963	0.963
Number Kelts Surviving Spill		*21*	21	21	21	21	21
Proportion of Kelts to Powerhouse		*0.786*	0.786	0.786	0.786	0.786	0.786
Total Number of Kelts to Powerhouse		*79*	79	79	79	79	79
Number of Kelts to Powerhouse by Month	April (40% of smolt run)	*31*	31	31	31	31	31
	May (40% of smolt run)	*31*	31	31	31	31	31
	October (5% of smolt run)	*4*	4	4	4	4	4
	November (10% of smolt run)	*8*	8	8	8	8	8
	December (5% of smolt run)	*4*	4	4	4	4	4
Bypass Effectiveness Rate	April	*0.008*	0.250	0.450	0.650	0.850	1.000
	May	*0.008*	0.250	0.450	0.650	0.850	1.000
	October	*0.016*	0.250	0.450	0.650	0.850	1.000
	November	*0.009*	0.250	0.450	0.650	0.850	1.000
	December	*0.009*	0.250	0.450	0.650	0.850	1.000
Number of Kelts Passed via Bypass	April	*0*	8	14	20	27	31
	May	*0*	8	14	20	27	31
	October	*0*	1	2	3	3	4
	November	*0*	2	4	5	7	8
	December	*0*	1	2	3	3	4
Total Number of Kelts Passed via Bypass		*1*	20	35	51	67	79
Number of Kelts Surviving Bypass	April	*0*	8	14	20	26	30
	May	*0*	8	14	20	26	30
	October	*0*	1	2	2	3	4
	November	*0*	2	3	5	6	8
	December	*0*	1	2	2	3	4
Total Number of Smolts Surviving Bypass		*1*	19	34	49	64	76
Proportion of Kelts to Propeller	April	*0.992*	0.750	0.550	0.350	0.150	0.000
	May	*0.992*	0.750	0.550	0.350	0.150	0.000
	October	*0.984*	0.750	0.550	0.350	0.150	0.000
	November	*0.991*	0.750	0.550	0.350	0.150	0.000
	December	*0.991*	0.750	0.550	0.350	0.150	0.000
Total Number of Smolts Directed to Propeller		*78*	59	43	28	12	0
Proportion of Kelts Through 3.5" Racks (Propeller)		*0.709*	0.709	0.709	0.709	0.709	0.709
Proportion of Kelts Screened at 3.5" Racks (Propeller) and to Spill		*0.291*	0.291	0.291	0.291	0.291	0.291
Number of Kelts Through 3.5" Racks (Propeller)		*55*	42	31	20	8	0
Number of Kelts Screened at 3.5" Racks (Propeller) and to Spill		*23*	17	13	8	3	0

(continued)

Table 33. (Continued)

		Evaluated Downstream Bypass Effectiveness Rates					
		BASE	**0.25**	**0.45**	**0.65**	**0.85**	**1.00**
Number of Kelts Passed via Propeller	April	*22*	17	12	8	3	0
	May	*22*	17	12	8	3	0
	October	*3*	2	2	1	0	0
	November	*6*	4	3	2	1	0
	December	*3*	2	2	1	0	0
Number of Kelts Passed via Spill	April	*9*	7	5	3	1	0
	May	*9*	7	5	3	1	0
	October	*1*	1	1	0	0	0
	November	*2*	2	1	1	0	0
	December	*1*	1	1	0	0	0
Propeller Turbine Survival Rate		*0.759*	0.759	0.759	0.759	0.759	0.759
Number of Kelts Surviving Propeller	April	*17*	13	9	6	3	0
	May	*17*	13	9	6	3	0
	October	*2*	2	1	1	0	0
	November	*4*	3	2	1	1	0
	December	*2*	2	1	1	0	0
Total Number of Kelts Surviving Propeller		*42*	32	23	15	6	0
Number of Kelts Surviving Spill	April	*9*	7	5	3	1	0
	May	*9*	7	5	3	1	0
	October	*1*	1	1	0	0	0
	November	*2*	2	1	1	0	0
	December	*1*	1	1	0	0	0
Total Number of Kelts Surviving Spill		*22*	17	12	8	3	0
TOTAL KELT SURVIVAL		***85***	**88**	**90**	**92**	**95**	**96**
WHOLE STATION ESTIMATE		***85%***	**88%**	**90%**	**92%**	**95%**	**96%**

Italics indicates the base model constructed using median flow conditions in the Androscoggin River
Shading indicates the variable assessed in this sensitivity analysis
*Monthly kelt run distribution is presented in Table 30 of this report.

Table 34. Impacts to the whole station kelt survival estimate for theoretical spill effectiveness rates.

		Evaluated Spill Effectiveness Rates					
		1:1	**0.2:1**	**1.4:1**	**2.4:1**	**3.3:1**	**4.2:1**
		0.214	**0.05**	**0.3**	**0.5**	**0.7**	**0.9**
Proportion of River Flow to Spillway		*0.214*	0.214	0.214	0.214	0.214	0.214
Proportion of River Flow to Powerhouse		*0.786*	0.786	0.786	0.786	0.786	0.786
Theoretical Number of Kelts		*100*	100	100	100	100	100
Proportion of Kelts to Spillway		*0.214*	0.05	0.3	0.5	0.7	0.9
Number of Kelts Passed via Spillway		*21.4*	5	30	50	70	90
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963	0.963
Number Kelts Surviving Spill		*21*	5	29	48	67	87
Proportion of Kelts to Powerhouse		*0.786*	0.95	0.7	0.5	0.3	0.1
Total Number of Kelts to Powerhouse		*79*	95	70	50	30	10
Number of Kelts to Powerhouse by Month	April (40% of smolt run)	*31*	38	28	20	12	4
	May (40% of smolt run)	*31*	38	28	20	12	4
	October (5% of smolt run)	*4*	5	4	3	2	1
	November (10% of smolt run)	*8*	10	7	5	3	1
	December (5% of smolt run)	*4*	5	4	3	2	1
Bypass Effectiveness Rate	April	*0.008*	0.008	0.008	0.008	0.008	0.008
	May	*0.008*	0.008	0.008	0.008	0.008	0.008
	October	*0.016*	0.016	0.016	0.016	0.016	0.016
	November	*0.009*	0.009	0.009	0.009	0.009	0.009
	December	*0.009*	0.009	0.009	0.009	0.009	0.009
Number of Kelts Passed via Bypass	April	*0*	0	0	0	0	0
	May	*0*	0	0	0	0	0
	October	*0*	0	0	0	0	0
	November	*0*	0	0	0	0	0
	December	*0*	0	0	0	0	0
Total Number of Kelts Passed via Bypass		*1*	1	1	0	0	0
Number of Kelts Surviving Bypass	April	*0*	0	0	0	0	0
	May	*0*	0	0	0	0	0
	October	*0*	0	0	0	0	0
	November	*0*	0	0	0	0	0
	December	*0*	0	0	0	0	0
Total Number of Smolts Surviving Bypass		*1*	1	1	0	0	0
Proportion of Kelts to Propeller	April	*0.992*	0.992	0.992	0.992	0.992	0.992
	May	*0.992*	0.992	0.992	0.992	0.992	0.992
	October	*0.984*	0.984	0.984	0.984	0.984	0.984
	November	*0.991*	0.991	0.991	0.991	0.991	0.991
	December	*0.991*	0.991	0.991	0.991	0.991	0.991
Total Number of Smolts Directed to Propeller		*78*	94	69	50	30	10
Proportion of Kelts Through 3.5" Racks (Propeller)		*0.709*	0.709	0.709	0.709	0.709	0.709
Proportion of Kelts Screened at 3.5" Racks (Propeller) and to Spill		*0.291*	0.291	0.291	0.291	0.291	0.291
Number of Kelts Through 3.5" Racks (Propeller)		*55*	67	49	35	21	7
Number of Kelts Screened at 3.5" Racks (Propeller) and to Spill		*23*	27	20	14	9	3

(continued)

Table 34. (Continued)

		Evaluated Spill Effectiveness Rates					
		1:1	**0.2:1**	**1.4:1**	**2.4:1**	**3.3:1**	**4.2:1**
		0.214	**0.05**	**0.3**	**0.5**	**0.7**	**0.9**
Number of Kelts Passed via Propeller	April	*22*	27	20	14	8	3
	May	*22*	27	20	14	8	3
	October	*3*	3	2	2	1	0
	November	*6*	7	5	4	2	1
	December	*3*	3	2	2	1	0
Number of Kelts Passed via Spill	April	*9*	11	8	6	3	1
	May	*9*	11	8	6	3	1
	October	*1*	1	1	1	0	0
	November	*2*	3	2	1	1	0
	December	*1*	1	1	1	0	0
Propeller Turbine Survival Rate		*0.759*	0.759	0.759	0.759	0.759	0.759
Number of Kelts Surviving Propeller	April	*17*	20	15	11	6	2
	May	*17*	20	15	11	6	2
	October	*2*	3	2	1	1	0
	November	*4*	5	4	3	2	1
	December	*2*	3	2	1	1	0
Total Number of Kelts Surviving Propeller		*42*	51	37	27	16	5
Number of Kelts Surviving Spill	April	*9*	11	8	6	3	1
	May	*9*	11	8	6	3	1
	October	*1*	1	1	1	0	0
	November	*2*	3	2	1	1	0
	December	*1*	1	1	1	0	0
Total Number of Kelts Surviving Spill		*22*	26	19	14	8	3
TOTAL KELT SURVIVAL		***85***	**83**	**86**	**89**	**92**	**95**
WHOLE STATION ESTIMATE		***85%***	**83%**	**86%**	**89%**	**92%**	**95%**

Italics indicates the base model constructed using median flow conditions in the Androscoggin River
Shading indicates the variable assessed in this sensitivity analysis
*Monthly kelt run distribution is presented in Table 30 of this report.

Table 35. Approximate river discharge (cfs) for the Androscoggin River at Brunswick during April, May, October, November and December for low (i.e. 75 and 90% exceedence) and high (10 and 25% exceedence) conditions.

Percent of Time Flow is Exceeded	River Discharge (cfs)				
	April	May	October	November	December
10	33,138	19,462	11,940	14,230	15,600
25	21,776	12,414	5,900	9,656	9,100
50	*13,466*	*8,816*	*3,820*	*6,670*	*6,400*
75	9,373	5,807	2,807	3,715	4,100
90	7,027	4,608	1,498	2,711	2,900

Italics indicates values used for 50% exceedence model

Table 36. Impacts to the whole station kelt survival estimate for seasonal flow conditions.

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Theoretical Number of Kelts		*100*	100	100	100	100
Proportion of Kelts to Spillway		*0.214*	0.633	0.432	0.067	0.000
Number of Kelts Passed via Spillway		*21.4*	63	43	7	0
Spillway/Bypass Survival Rate		*0.963*	0.963	0.963	0.963	0.963
Number Kelts Surviving Spill		*21*	61	42	6	0
Proportion of Kelts to Powerhouse		*0.786*	0.367	0.568	0.933	1.000
Total Number of Kelts to Powerhouse		*79*	37	57	93	100
Number of Kelts to Powerhouse by Month	April (40% of smolt run)	*31*	15	23	37	40
	May (40% of smolt run)	*31*	15	23	37	40
	October (5% of smolt run)	*4*	2	3	5	5
	November (10% of smolt run)	*8*	4	6	9	10
	December (5% of smolt run)	*4*	2	3	5	5
Bypass Effectiveness Rate	April	*0.008*	0.008	0.008	0.008	0.009
	May	*0.008*	0.008	0.008	0.010	0.013
	October	*0.016*	0.008	0.010	0.021	0.040
	November	*0.009*	0.008	0.008	0.016	0.022
	December	*0.009*	0.008	0.008	0.015	0.021
Number of Kelts Passed via Bypass	April	*0*	0	0	0	0
	May	*0*	0	0	0	1
	October	*0*	0	0	0	0
	November	*0*	0	0	0	0
	December	*0*	0	0	0	0
Total Number of Kelts Passed via Bypass		*1*	0	0	1	1
Number of Kelts Surviving Bypass	April	*0*	0	0	0	0
	May	*0*	0	0	0	1
	October	*0*	0	0	0	0
	November	*0*	0	0	0	0
	December	*0*	0	0	0	0
Total Number of Smolts Surviving Bypass		*1*	0	0	1	1
Proportion of Kelts to Propeller	April	*0.992*	0.992	0.992	0.992	0.991
	May	*0.992*	0.992	0.992	0.990	0.987
	October	*0.984*	0.992	0.990	0.979	0.960
	November	*0.991*	0.992	0.992	0.984	0.978
	December	*0.991*	0.992	0.992	0.985	0.979
Total Number of Smolts Passed via Propeller		*78*	36	56	92	99
Proportion of Kelts Through 3.5" Racks (Propeller)		*0.709*	0.709	0.709	0.709	0.709
Proportion of Kelts Screened at 3.5" Racks (Propeller) and to Spill		*0.291*	0.291	0.291	0.291	0.291
Number of Kelts Through 3.5" Racks (Propeller)		*55*	26	40	65	70
Number of Kelts Screened at 3.5" Racks (Propeller) and to Spill		*23*	11	16	27	29

(continued)

Table 36. (Continued)

		Percent of Time Flow is Exceeded				
		50	**10**	**25**	**75**	**90**
Number of Kelts Passed via Propeller	April	*22*	10	16	26	28
	May	*22*	10	16	26	28
	October	*3*	1	2	3	3
	November	*6*	3	4	7	7
	December	*3*	1	2	3	3
Number of Kelts Passed via Spill	April	*9*	4	7	11	11
	May	*9*	4	7	11	11
	October	*1*	1	1	1	1
	November	*2*	1	2	3	3
	December	*1*	1	1	1	1
Propeller Turbine Survival Rate		*0.759*	0.759	0.759	0.759	0.759
Number of Kelts Surviving Propeller	April	*17*	8	12	20	21
	May	*17*	8	12	20	21
	October	*2*	1	2	2	3
	November	*4*	2	3	5	5
	December	*2*	1	2	2	3
Total Number of Kelts Surviving Propeller		*42*	20	30	50	53
Number of Kelts Surviving Spill	April	*9*	4	6	10	11
	May	*9*	4	6	10	11
	October	*1*	1	1	1	1
	November	*2*	1	2	3	3
	December	*1*	1	1	1	1
Total Number of Kelts Surviving Spill		*22*	10	16	26	28
TOTAL KELT SURVIVAL		***85***	**91**	**88**	**83**	**82**
WHOLE STATION ESTIMATE		***85%***	**91%**	**88%**	**83%**	**82%**

Italics indicates the base model constructed using median flow conditions in the Androscoggin River
Shading indicates the variable assessed in this sensitivity analysis

*Monthly kelt run distribution is presented in Table 26 of this report.

APPENDIX A

Appendix Table A-1. Site characteristics and study parameters for turbine survival studies conducted using the Hi-Z Turb'N Tag method.

Site Name	Species Tested	Sampling Method	Unit Type	Normal head (ft)	RPM	Wicket Gate (%)	Unit Flow (cfs)	No. of Blades or Buckets	Runner Diameter (ft)	Water Temp. (°C)	Test Season or Month	Test Fish Size (mm)			Control Fish Size (mm)			No. of Fish Released		Immediate Survival (1-hr)	24-hr Survival	48-hr Survival	72-hr Survival	Reference
												Min	Max	Avg	Min	Max	Avg	T	C					
Briar Rolfe, NH	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	35	150	73.3-76.3	-	5	9.84	13.0	May	174	228	192.7	180	219	194.1	70	30	95.7	-	95.7	-	Normandeau 2004
Bar Mills, ME [1]	Atlantic salmon	Hi-Z Turb'N Tag	Propeller	19.5	120	50 & 100	960 & 1,560	5	11.2	14-16.5	May	177	238	204	175	238	205	100	50	88.0 & 94.0	-	-	88.0 & 88.0	Normandeau and FPL 2002
Lairg, Scotland	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	-	167	-	-	4	8.5	7.0-8.5	April	90	136	111.4	96	147	112.8	100	75	91.0	-	91.0	-	Normandeau and Fishtrack 1998
Cliff, Ireland	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	32.8	115.3	-	-	5	14.1	-	April	121	155	136	108	150	132	78	50	92.3	-	92.2	-	Normandeau and Fishtrack 2002
Cathleens Falls, Ireland	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	93.5	187.5	-	-	5	12.6	-	April	122	150	136	121	152	136	75	50	89.3	-	88.0	-	Normandeau and Fishtrack 2002
Ardnacrusha, Ireland [1]	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	93	167	-	-	5	16.4	9.5-10.1	April	148	214	181	161	225	189	190	60	96.3 & 95.2	-	96.3 & 87.5	-	Normandeau and Fishtrack 2004
Wilder, VT-NH	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	51	112.5	74-84	-	5	9.0	8.5-10.0	May	163	218	187.9	162	220	186.3	125	125	96.0	-	94.3	-	Normandeau 1994
Vernon, VT [1]	Atlantic salmon	Hi-Z Turb'N Tag	Kaplan	34	144	-	1,250 & 1,600	5	10.2	-	May	152	305	223	183	322	224	273	107	94.7 & 98.5	-	92.3 & 89.3	-	Normandeau 2009
West Buxton, ME [1]	Atlantic salmon	Hi-Z Turb'N Tag	Propeller	26.8	120	55 & 80	1,360 & 1,800	6	11.1	15.0	May	190	244	214	192	226	210	40	20	100.0 & 94.0	100.0 & 94.0	-	-	Normandeau 1999
McIndoes, NH [1]	Atlantic salmon	Hi-Z Turb'N Tag	Propeller	26	150	-	800 & 1,600	4	10.0	-	May	133	248	207	141	245	203	310	100	100.0 & 96.1	-	100.0 & 94.8	-	Normandeau 2006b

1 - Tested two different settings

Document Content(s)

ORIGINAL

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
NORTHEAST REGION
55 Great Republic Drive
Gloucester, MA 01930-2276

SECRETARY OF THE COMMISSION
2013 JUL 22 P 2:59
FEDERAL ENERGY REGULATORY COMMISSION

P-2302

JUL 19 2013

P-2574
P-2322
P-2325
P-2284

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

RE: Endangered Species Act Section 7 Formal Consultation for the for the Lockwood (2574), Shawmut (2322), Weston (2325), Brunswick (2284), and Lewiston Falls (2302) Projects

Dear Ms. Bose:

Under section 7(a)(2) of the Endangered Species Act (ESA), NOAA's National Marine Fisheries Service (NMFS) has developed a biological opinion (Opinion) regarding the subject projects. This opinion considers the Federal Energy Regulatory Commission's (FERC) authorization of FPL Energy Maine Hydro LLC's (FPL Energy) proposal to incorporate the provisions of a seven year (2013-2019) Interim Species Protection Plan (ISPP) at the Lockwood (2574), Shawmut (2322), and Weston (2325) Projects on the Kennebec River, and the Brunswick (2284) and Lewiston Falls (2302) Projects on the Androscoggin River in Maine. This Opinion is based on the FERC's March 14, 2013 Biological Assessment (BA) and other sources of information. In the Opinion, we conclude that the proposed project may adversely affect but is not likely to jeopardize the continued existence of the GOM DPS of Atlantic salmon. All of the Projects, except for Lewiston Falls, are located in designated critical habitat for the GOM DPS of Atlantic salmon. Ongoing operations of the hydroelectric facilities will continue to adversely affect essential features of this habitat over the interim period. However, the proposed action is anticipated to improve the functioning of migratory habitat by constructing three volitional upstream fishways, and by implementing an adaptive management strategy to improve downstream survival of Atlantic salmon smolts and kelts in the Kennebec and Androscoggin Rivers. We, therefore, concur with FERC that the proposed action will not lead to adverse modification or destruction of critical habitat.

FERC's May 1, 2013, addendum to the BA proposes the implementation of a Sturgeon Handling and Protection Plan at the Brunswick and Lockwood Projects, to protect listed shortnose and Atlantic sturgeon that occur downstream of these Projects. The provisions of the plan will include the survey for, and rescue of, sturgeon that become: 1) entrapped in the fishways at either of the two Projects, 2) stranded in the ledges downstream of the dams during periods of low flow, or 3) entrapped in dewatered draft tubes during maintenance activities. We concur with FERC that the implementation of the handling and protection plan may adversely affect but is not likely to jeopardize the continued existence of shortnose sturgeon or the GOM or NYB DPSs of Atlantic sturgeon.

As required by Section 7(b)(4) of the ESA, an incidental take statement (ITS) prepared by us is provided with the Opinion. The ITS exempts the incidental taking of Atlantic salmon smolts and kelts from activities associated with the ongoing operation of the hydroelectric facilities as well as upstream and downstream passage and survival studies. It also exempts the take of sturgeon that are rescued from stranding in the fishways or downstream ledges. The ITS specifies Reasonable and Prudent Measures (RPMs) and implementing Terms and Conditions necessary to minimize the impact of these activities on listed species. The take level for Atlantic salmon was estimated based on the likelihood of the species occurring in the action area during the time period proposed for the project (7 years).

The ITS specifies three RPMs necessary to minimize and monitor take of listed species. The RPMs and their implementing terms and conditions outlined in the ITS are non-discretionary, and must be undertaken so that they become binding conditions for the exemption in section 7(o)(2) to apply. Failure to implement the terms and conditions through enforceable measures may result in a lapse of the protective coverage of section 7(o)(2). Annual reporting that is required by the ITS will continue to supply information on the level of take resulting from the proposed action. The RPMs and the Terms and Conditions have been reviewed by your staff and no objections have been raised.

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. To further reduce adverse effects of the proposed project, we provide four conservation recommendations for endangered Atlantic salmon. While these recommendations are discretionary, we strongly urge FERC to carry out this program.

This Opinion concludes consultation for the FERC's proposed authorization to amend the licenses of the Lockwood, Shawmut, Weston, Brunswick, and Lewiston Falls Projects. Reinitiation of consultation is required and shall be requested by FERC or by 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; or (4) a new species is listed or critical habitat designated that may be affected by the identified action. In 2020, this Opinion will no longer be valid and consultation under section 7 will need to be reinitiated by FERC. Please contact Dan Tierney of my staff at (207) 866-3755 or Dan.Tierney@noaa.gov for any questions involving this consultation.

Sincerely,

John K. Bullard
Regional Administrator

Cc: Tierney, F/NER
Damon-Randall, F/NER
Collins, GCNE

File Code: Sec 7 FPL Energy ISPP
PCTS: NER/2013/9613

NATIONAL MARINE FISHERIES SERVICE

ENDANGERED SPECIES ACT
BIOLOGICAL OPINION

Agency:	Federal Energy Regulatory Commission (FERC) US Army Corps of Engineers, New England District
Activity Considered:	**Amendment of the Licenses for the Lockwood (2574), Shawmut (2322), Weston (2325), Brunswick (2284), and Lewiston Falls (2302) Projects** NER/2013/9613
Conducted by:	National Marine Fisheries Service Northeast Region
Date Issued:	7/19/2013
Approved by:	

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1. INTRODUCTION AND BACKGROUND

This constitutes the biological opinion (Opinion) of NOAA's National Marine Fisheries Service (NMFS) 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) approval of applications to amend the licenses for the construction of new upstream fishways at the Lockwood (P-2574), Shawmut (P-2322), and Weston (P-2325) Projects, as well as the incorporation of an Interim Species Protection Plan (ISPP) for Atlantic salmon at the Lockwood, Shawmut Weston, Brunswick (P-2284), and Lewiston Falls (P-2302) Projects. Additionally, this consultation will address the effects of a proposed Atlantic and Shortnose Sturgeon Handling and Protection Plan at the Lockwood and Brunswick Projects.

By an application filed with FERC on February 21, 2013, FPL Energy Maine Hydro LLC (FPL Energy), representing Merimil Limited Partnership (Merimil) and itself (licensee), requested that the licenses for the Lockwood, Shawmut, Weston, Brunswick, and Lewiston Falls Projects be amended to incorporate provisions from a proposed seven year ISPP for Atlantic salmon (2013-2019). This Opinion only considers the effects of these Projects on salmon for the duration of this interim period; therefore, take authorization for Atlantic salmon expires in 2019. In addition, the licensee filed an application on March 29, 2013 to implement an Atlantic and Shortnose Sturgeon Handling and Protection Plan at the Lockwood and Brunswick Projects. The Sturgeon Handling and Protection Plans would become part of the project licenses and, therefore, this Opinion considers the effects to sturgeon between 2013 and the license expiration dates (2029 at Brunswick and 2036 at Lockwood). In letters dated February 7, 2013 and March 25, 2013, the FERC designated the licensee as their non-federal representative to conduct informal ESA consultation with us.

This Opinion is based on information provided in the FERC's March 14, 2013 (Atlantic salmon) and May 1, 2013 (shortnose and Atlantic sturgeon) Biological Assessments, as well as the ISPP and Sturgeon Handling and Protection Plan. A complete administrative record of this consultation will be maintained at our Maine Field Office in Orono, Maine. Formal consultation was initiated on March 14, 2013.

In addition to FERC, another federal agency, the U.S. Army Corps of Engineers (ACOE), may take action to authorize the construction of the new fishways at the Lockwood, Shawmut, 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. Pursuant to the section 7 regulations (50 CFR §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.

1.1. Consultation History

- July 30, 2009 – FPL Energy submitted a letter to us stating their intention to take measures to protect Atlantic salmon.

- May 21, 2010 – FPL Energy submitted a letter to us indicating their intent to obtain an Incidental Take Permit through a Habitat Conservation Plan under section 10 of the ESA.

- September 23, 2010 – FPL Energy met with us to discuss the section 10 process and to review the content requirements of a Habitat Conservation Plan.
- October 2010 – FPL Energy initiated the section 10 process and formed technical advisory and steering committees that met several times in 2011 and 2012.

- February 2012 – FPL Energy submitted a draft Habitat Conservation Plan to us for review.

- November 2012 – FPL Energy met with us to discuss the section 7 process and the species protection plan process.

- January 30, 2013 – FPL Energy met with us and indicated their intention to proceed with developing a interim species protection plan, and that they would request that FERC modify the project licenses to incorporate the proposed provisions.

- January 31, 2013 – FPL Energy submitted a letter to FERC requesting designation as a non-federal representative for the purposes of informal consultation on Atlantic salmon.

- February 7, 2013 – FERC designated FPL Energy to act as its non-federal representative in conducting informal consultation under section 7 of the ESA regarding federally listed Atlantic salmon at the Lockwood, Shawmut, Weston, Brunswick, and Lewiston Falls Projects.

- February 21, 2013 - FPL Energy submitted a draft BA to FERC.

- March 14, 2013 – FERC adopted the BA and submitted a letter to NMFS requesting the initiation of formal consultation.

- March 25, 2013 - FERC designated FPL Energy to act as its non-federal representative in conducting informal consultation under section 7 of the ESA regarding federally listed shortnose and Atlantic sturgeon at the Lockwood and Brunswick Projects.

- March 29, 2013 – FPL Energy submitted a draft BA for Atlantic and shortnose sturgeon to FERC as an addendum.

- May 1, 2013 - FERC adopted the BA and submitted a letter to NMFS requesting the initiation of formal consultation for Atlantic and shortnose sturgeon at the Lockwood and Brunswick Projects.

- May 10, 2013 – NMFS submitted a letter to FERC indicating that all of the information required to initiate a formal consultation for Atlantic salmon, shortnose sturgeon, and Atlantic sturgeon had been received. In this letter NMFS noted that the date that the original initiation request was received (March 14, 2013) will serve as the commencement of the formal consultation process.

1.2. Relevant Documents

The analysis in this Opinion is based on a review of the best available scientific and commercial information. Specific sources are listed in Section 13 and are cited directly throughout the body of the document. Primary sources of information include: 1) information provided in FERC's March 14, 2013 initiation letter and attached BA and ISPP in support of formal consultation under the ESA; 2) information provided in the draft BA submitted to FERC by the licensees describing the effects of the sturgeon handling and protection plan; 3) Determination of Endangered Status for the Gulf of Maine Distinct Population Segment of Atlantic salmon; Final Rule (74 FR 29345; June 19, 2009); 4) Status Review for Anadromous Atlantic Salmon (*Salmo salar*) in the United States (Fay *et al.* 2006); 5) Designation of Critical Habitat for Atlantic salmon Gulf of Maine Distinct Population Segment (74 FR 29300; June 19, 2009); 6) Final Recovery Plan for Shortnose Sturgeon (December, 1998); and 7) Final listing determinations for the five distinct population segments of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). On February 6, 2012, we published notice in the *Federal Register* listing the Atlantic sturgeon as endangered in the New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs, and as threatened in the Gulf of Maine DPS (77 FR 5880 and 77 FR 5914).

1.3. 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 CFR §402.02 (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. In conducting analyses of actions under section 7 of the ESA, we take the following steps, as directed by the consultation regulations:

- Identifies the action area based on the action agency's description of the proposed action (Section 2);
- Evaluates the current status of the species with respect to biological requirements indicative of survival and recovery and the essential features of any 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 any 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 CFR §402.02). In making these determinations, we must rely on the best available scientific and commercial data.

The critical habitat analysis determines whether the proposed action will destroy or adversely modify designated or proposed critical habitat for ESA-listed species by examining any change in the conservation value of the primary constituent elements of that critical habitat. This analysis focuses on statutory provisions of the ESA, including those in section 3 that define "critical habitat" and "conservation", in section 4 that describe the designation process, and in section 7 that set forth the substantive protections and procedural aspects of consultation. Although some "properly functioning" habitat parameters are generally well known in the fisheries literature (e.g., thermal tolerances), for others, the effects of any adverse impacts are considered in more qualitative terms. The analysis presented in this Opinion does not rely on the regulatory definition of "adverse modification or destruction" of critical habitat at issue in the 9th Circuit Court of Appeals (Gifford Pinchot Task Force *et al.* v. U.S. Fish and Wildlife Service, No. 03-35279, August 6, 2004).

2. PROJECT DESCRIPTION AND PROPOSED ACTION

FERC is proposing to amend the licenses held by the licensee for the Lockwood, Shawmut, Weston, Brunswick, and Lewiston Falls Projects to incorporate the provisions of an ISPP for Atlantic salmon. The Lockwood, Shawmut, and Weston Projects are, respectively, the first, third, and fourth dams on the Kennebec River; while the Brunswick and Lewiston Falls Projects are the first and fourth dams on the Androscoggin River (Figure 1). The provisions of the ISPP include the installation of new upstream fishways at the Lockwood, Shawmut, and Weston Projects in the Kennebec River, and the implementation of upstream and downstream passage and survival studies for Atlantic salmon. These studies are to be conducted as part of an adaptive management strategy designed to achieve high passage and survival rates for Atlantic salmon through the Lockwood, Shawmut, Weston, and Brunswick Projects. Although no new measures or structures are being proposed for the Lewiston Falls Project, FERC is proposing to amend the license to require the licensee to meet with us every five years to ensure that operation of the Project is consistent with the recovery objectives for Atlantic salmon and other listed fish species. The licensee will also cooperate with NMFS, USFWS, and MDMR on the installation and operation of a rotary screw trap (RST) in the Sandy River, for a period of up to three years (2013-2015). The purpose of the RST is to improve knowledge and to identify the period of downstream migration of Atlantic salmon smolts on the Kennebec River. In addition, the licensee proposes to implement a Sturgeon Handling and Protection Plan at the Brunswick and Lockwood Projects.

This Opinion considers effects of the operation of Lockwood, Shawmut, Weston, Brunswick, and Lewiston Falls Projects by the licensees between 2013 and 2019 under the terms of the revised operating licenses as proposed by FERC (Table 1).

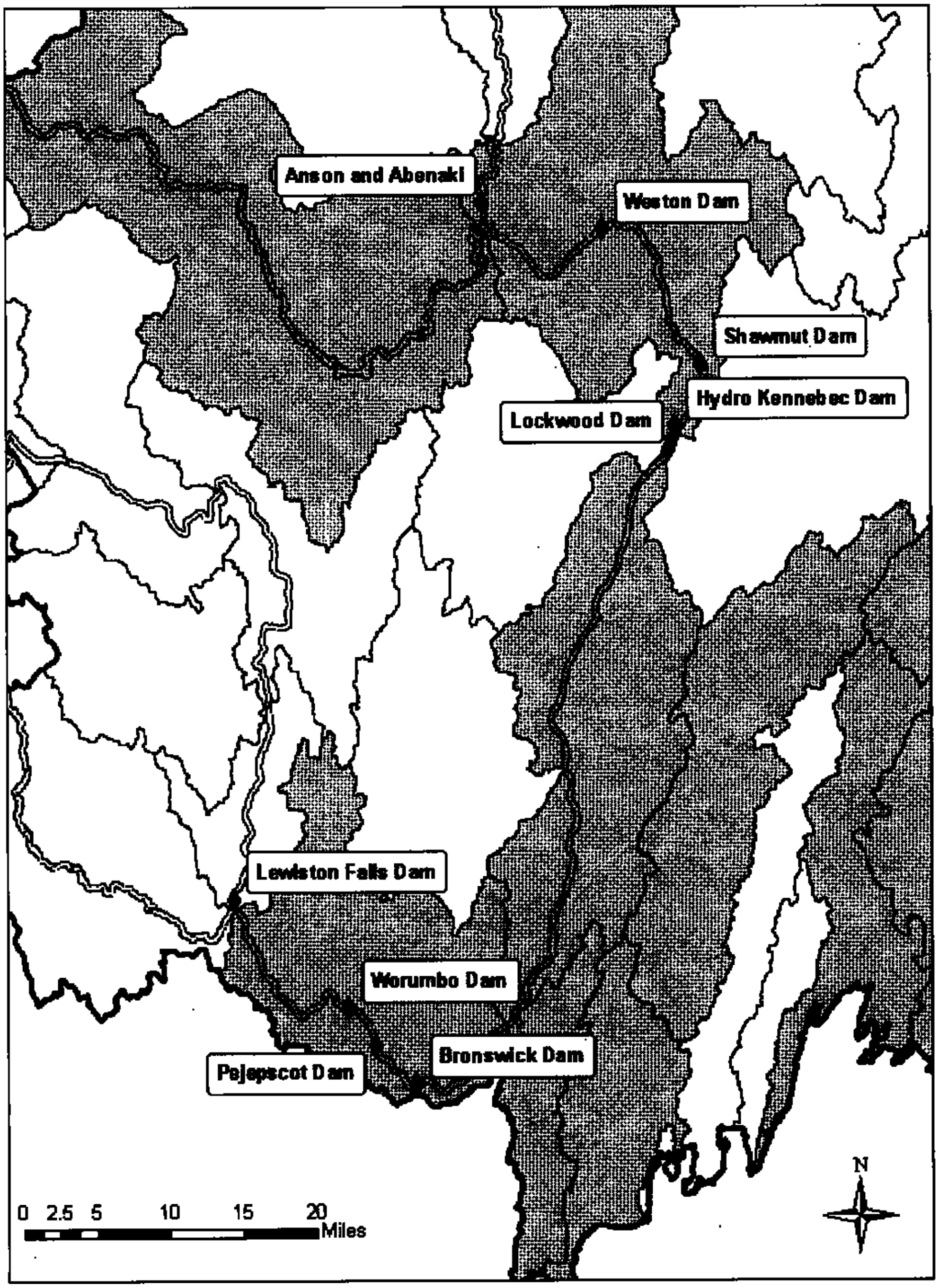

Figure 1. The lower Kennebec and Androscoggin River watersheds with mainstem dams and Atlantic salmon critical habitat (in gray) indicated.

Table 1. The licensee's proposed schedule for the implementation of the interim species protection plan for Atlantic salmon and the Atlantic and shortnose sturgeon handling and protection plan.

Year	Activity
2013	• Licensee develops Atlantic salmon ISPP and draft BA and file them with FERC • Licensee files a Sturgeon Handling and Protection Plan for Atlantic sturgeon and shortnose sturgeon as an addendum • FERC issues BA • Assuming the proposed action does not jeopardize the continued existence of any listed species or destroy/adversely modify designated critical habitat, NMFS will issue a BO and ITS covering Lockwood, Shawmut, Weston, Brunswick, and Lewiston Falls projects for the period 2013 – 2019 • FERC issues license amendments for the Lockwood, Shawmut, Weston, Brunswick and Lewiston Falls projects • Licensee conducts Atlantic salmon smolt downstream passage survival studies (paired release) at Lockwood, Shawmut, Weston, and Brunswick projects (year 1)* • Licensee extends period that upstream and downstream bypass facilities are operated at Brunswick Project • Licensee conducts Atlantic salmon adult upstream passage effectiveness monitoring studies at Brunswick Project, in cooperation with licensees for the Pejepscot and Worumbo projects (year 1) • Licensee operates rotary screw trap in cooperation with NMFS and MDMR to collect smolt out-migration data in Sandy River (year 1)* • Licensees implement the provisions of the Sturgeon Handling Protection Plan at the Lockwood and Brunswick Projects. These plans will be implemented throughout the terms of the existing licenses.
2014	• Licensee conducts Atlantic salmon smolt downstream passage survival studies (paired release) at Lockwood, Shawmut, Weston and Brunswick projects (year 2) • Licensee conducts Atlantic salmon kelt downstream passage survival studies at Lockwood, Shawmut, Weston and Brunswick projects, in cooperation with upstream projects (year 1) • Licensee operates rotary screw trap to collect smolt out-migration data in Sandy River (year 2) • Licensee designs new upstream volitional fish passage component for the existing Lockwood fishway and investigates upstream passage improvement opportunities at the development • Licensee conducts Atlantic salmon adult upstream passage effectiveness monitoring studies at Brunswick Project, in cooperation with licensees for the Pejepscot and Worumbo projects (year 2)

Year	Activity
2015	• Licensee conducts Atlantic salmon smolt downstream passage survival studies (paired release) at Lockwood, Shawmut, Weston and Brunswick projects (year 3) • Licensee conducts Atlantic salmon kelt downstream passage survival studies at Lockwood, Shawmut, Weston and Brunswick projects, in cooperation with upstream projects (year 2) • Licensee operates rotary screw trap to collect smolt out-migration data in Sandy River (year 3) • Licensee constructs new upstream volitional fish passage component for existing Lockwood fishway • Licensee conducts Atlantic salmon adult upstream passage effectiveness monitoring studies at Brunswick Project, in cooperation with licensces for the Pejepscot and Worumbo projects (year 3)
2016	• Licensee operates new volitional upstream fishway at Lockwood** • Licensee conducts Atlantic salmon adult upstream passage effectiveness monitoring studies at Lockwood (year 1) • Licensee conducts Atlantic salmon kelt downstream passage survival studies at Lockwood, Shawmut, Weston and Brunswick, in cooperation with upstream projects (year 3) • Licensee designs new upstream fish passage facility for Shawmut Project • Licensee initiates FERC relicensing process for Shawmut Project
2017	• Licensee constructs new upstream fish passage facility at Shawmut • Licensee conducts Atlantic salmon adult upstream passage effectiveness monitoring studies at Lockwood (year 2)
2018	• Licensee operates new upstream fish passage facility at Shawmut** • Licensee conducts Atlantic salmon adult upstream passage effectiveness monitoring studies at Lockwood (year 3) • Licensee designs new upstream fish passage facility for Weston Project • Licensee and FERC reinitiate Section 7 consultation
2019	• Licensee constructs new upstream fish passage facility at Weston Project • Licensee develops final SPP covering the period from 2020 to issuance of new FERC project licenses, including additional Atlantic salmon enhancement/protection measures, if determined necessary, based on interim SPP monitoring results • Licensee files final SPP with FERC in 2019 • NMFS issues a BO and ITS to cover period of subsequent SPP (through FERC license expiration date), assuming the proposed action does not jeopardize the continued existence of any listed species or destroy/adversely modify designated critical habitat

* Take from these activities will be authorized under a section 10 research and recovery permit with USFWS

** In accordance with the KHDG Agreement and license requirements, the licensee will begin operating permanent downstream fish passage facilities at the time that upstream passage facilities become operational.

The licensee is committed to an adaptive management approach to implementing this ISPP. The agreed upon fish passage measures and activities are laid out within an adaptive management framework, with integration of management and research in order to provide feedback and the ability to adapt measures, as necessary, for further protection and enhancement of Atlantic salmon. As the proposed interim process is intended to be adaptive, the licensees will be coordinating and consulting with us throughout the seven year period (2013-2019). If early downstream passage study results indicate that the study design is not adequately measuring survival, the licensee will work with us to correct it. Likewise, if the early study results indicate that the downstream fishway is not highly efficient at passing Atlantic salmon, they will coordinate with us and modify operations at the Projects as appropriate to avoid and minimize effects to Atlantic salmon to the extent practicable. To that end, we will meet with the licensee annually to discuss study results, potential modifications to the study design and/or potential changes to the operation of the facility that may be necessary to reduce adverse effects to the species.

In 2020, the new upstream fishway at Weston will be operational. At that time, we expect that Atlantic salmon will be passed volitionally upstream of the Lockwood, Shawmut, Hydro-Kennebec, and Weston Projects. Although not proposed as part of the ISPP, the licensee is committed to meeting their obligations under the 1998 Kennebec Hydro Developers Group (KHDG) Agreement and the terms of their licenses, which require them to have permanent downstream passage facilities operating no later than the date when the new upstream fishways become operational. The proposed studies will be conducted prior to the installation of permanent facilities as required by the KHDG Agreement "to determine the effectiveness of various downstream passage techniques in preparation for the design and installation of permanent downstream facilities" (KHDG 1998). The design of the downstream facilities will be based on the results of the proposed survival studies and will be conducted in consultation with state and federal resource agencies.

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

2.1. Lockwood Project - FERC No. 2574

2.1.1. Existing Hydroelectric Facilities and Operations

The Lockwood Project, owned by the Mcrimil Limited Partnership (Mcrimil), is a 6.8 MW hydroelectric project located at river mile 63 and is the first dam on the mainstem Kennebec River (Figure 1). The Lockwood Project includes an 81.5-acre reservoir, an 875 foot long and 17 foot high dam with two spillway sections and a 160 foot long forebay headworks section, a 450 foot long forebay canal, and two powerhouses. The dam and forebay headworks span the Kennebec River at or near the U.S. Route 201 bridge along a site known as Ticonic Falls. The east spillway section begins at the east abutment of the dam and extends about 225 feet in a westerly direction to a small island. The west spillway extends about 650 feet from the small island in a southwesterly direction to the forebay canal headworks, which extend to the west bank of the river. Each spillway is equipped with 15 inch high flashboards.

From the headworks, the forebay canal directs water to two powerhouses located on the west bank of the Kennebec River. The original powerhouse contains six generating units, each with a hydraulic capacity of 660 cfs, and the second powerhouse contains one generating unit with a hydraulic capacity of 1,700 cfs (Table 2). At maximum flow efficiencies for these turbines range from 82 to 86 percent, and at minimum flow efficiencies range from 10 to 51 percent.

Table 2. Lockwood Project Generating Unit Summary

Unit	Turbine Design/Type	Capacity (cfs)	RPM	*Max Flow*		*Peak Efficiency*		*Min Flow*	
				CFS	Effic. (%)	CFS	Effic. (%)	CFS	Effic. (%)
1	Francis/vertical	660 cfs	133	721	86	600	90	266	25
2	Francis/vertical	660 cfs	133	679	85	607	90	297	10
3	Francis/vertical	660 cfs	133	710	84	597	90	266	26
4	Francis/vertical	660 cfs	133	666	82	607	90	239	32
5	Francis/vertical	660 cfs	133	676	86	578	90	289	51
6	Francis/vertical	660 cfs	133	670	82	599	90	314	51
7	Kaplan/horizontal	1,700 cfs	144	1,689	86	775	90	111	35

The Lockwood Project impoundment is 1.2 miles long encompassing a surface area of 81.5 acres and a gross storage volume of only 250 acre-feet. The Lockwood impoundment is riverine in nature and has no significant embayments or shoal areas. The impoundment width is nearly uniform throughout. The substrate of the impoundment consists of a mixture of bedrock, cobble, and rubble with gradual accumulations of silt deposits moving from upstream to downstream. A few shallow littoral areas with gravel or finer substrate and scattered submerged aquatic vegetation beds exist, but much of the shoreline is steep, with depths of five feet only a few feet from the shoreline (FERC 2005).

The Lockwood Project operates as run-of-river. Impoundment drawdowns are generally limited to no more than six inches below the top of the spillway flashboards when the flashboards are in place, and no more than one foot below the spillway crest when the flashboards are being replaced.

The Lockwood Project is operated to provide a minimum flow of 2,114 cfs, or inflow, whichever is less. In addition, three orifices, each three feet long by eight inches high, are annually placed along the spillway. The purpose of the orifices is to pass a 50 cfs minimum flow into the bypass reach. The orifices also provide downstream passage routes along the spillway even when the project is not spilling over the top of the flashboards. During periods of no spillage (approximately 30 percent of the time on an annual basis), the bypassed reach receives leakage plus orifice flows, which range from approximately 50 cfs at full headpond level to approximately 30 cfs at a drawdown of six inches below the top of the flashboards. During flashboard installation, the reach receives only leakage flows.

2.1.1.1. Upstream Fish Passage

In accordance with the FERC license and the 1998 KHDG Agreement, the licensee completed construction of a fish lift, trap, sort, and transport system in 2006. The system was completed and became operational in May 2006. In consultation with resource agencies, the licensee developed operational and effectiveness study plans for the new fish lift. These plans were filed with FERC on January 30, 2006, and approved on April 26, 2006.

The Lockwood fish lift facility is located on the west side of the powerhouse adjacent to Unit 7. The lift operates with an attraction flow of up to150 cfs, and entrance water velocities are four to six feet per second (fps). The lift has an approximate ten minute cycle time.

The attraction flow attracts the fish through the fish lift entrance gate into the lower flume of the fish lift. The fish then swim through a vee-gate crowder and remain in the lower flume of the lift. During the cycling process, the vee-gate crowder closes to hold the fish in the hopper area. The 1,800 gallon water-filled hopper lifts the fish to the holding tank elevation and the fish are sluiced into the 2,500 gallon round discharge tank. Liquid oxygen is introduced into all tanks via carbon micro porous stones to reduce stress and mortality. Two auxiliary water pumps provide a constant flow of ambient river water to all the tanks, and they provide ambient river water to the stocking trucks. The fish lift operates to accommodate all target species, and attraction flows are passed continuously during lift operation. The fish lift is designed to pass up to 164,640 alewives, 228,470 American shad and 4,750 Atlantic salmon per year.

The sorting and trucking portion of the facility includes: one 2,500 gallon, 12 foot diameter, round discharge tank, which collects fish discharged from the 1,800 gallon fish lift hopper; two 1,250 gallon, ten foot diameter, round holding tanks that sluice fish into MDMR stocking trucks; and one 250 gallon, rectangular holding tank for Atlantic salmon. The 2,500 gallon discharge tank is also equipped with piping that can discharge fish back into the tailrace.

The Lockwood upstream fish passage facility operates between May 1 and October 31 to pass anadromous fish. Under a cooperative agreement, the Project owner is responsible for capturing shad, river herring and Atlantic salmon, and the Maine Department of Marine Resources (MDMR) is responsible for collecting biological data and trucking fish to upstream spawning locations. MDMR's role in handling fish at the Lockwood Project is expected to continue through the term of this ISPP, and authorization for that handling will be covered under a section 10 research permit issued by USFWS to MDMR.

During the fish lift operation season, the licensee coordinates daily with the MDMR regarding sorting, counting and trucking operations. During the river herring, American shad and Atlantic salmon migration season (approximately May through mid-July), the fish lift is generally staffed seven days per week, as necessary, to meet resource agency trap and truck requirements. During the run, the fish lift is generally operated from early morning to late afternoon. During other times of the year, the fish lift is generally operated three to five times per day, seven days per week for Atlantic salmon capture. The licensee determines the precise timing of the fish lift operation, in consultation with the MDMR, based on factors such as the number of migrating fish, water temperature, time of year, and river flow. As outlined in the ISPP, the licensee proposes to increase the fish lift cycle to five to eight times per day from approximately mid-July to October 31.

During periods of fish lift operation, personnel routinely monitor four underwater cameras that are connected to a monitor and DVD recorder. The monitor and DVD recorder are located in the control room of the fish lift and typically record from dawn until dusk. The cameras are also used in real time to help determine the presence of fish in the lift and maximize fishing effectiveness. Camera 1 is located just downstream of the vee-gates and provides a good view of fish moving through the vee-gates into the hopper area. Camera 2 is located just upstream of the entrance gate and provides a good view of fish swimming towards and into the fish lift. Camera 3 is located in the river just downstream of the fish lift entrance gate. This location provides a view of the tailrace area below the entrance gate. Camera 4 is positioned between the entrance gate and the sorting tank sluice pipe on the edge of the river. This camera offers another good view of the fish lift entrance gate vicinity. Since all four cameras show good detail, fishway personnel are able to identify species, obtain an approximate number of fish, and initiate the lift cycle manually, when appropriate.

2.1.1.2. Downstream Fish Passage

In accordance with the KHDG Agreement, the licensee is also providing interim measures for downstream Atlantic salmon passage at Lockwood. In addition to the adult salmon trucked to the Sandy River, the MDMR has been stocking Atlantic salmon eggs in the Sandy River above the Weston Project since 2003. Therefore, Atlantic salmon smolts and kelts migrate past the Project every spring.

In 2009, the licensee installed a downstream fish passage facility in the Lockwood power canal. This facility consisted of a ten foot deep floating boom leading to a new seven foot wide by nine foot deep fish sluice and associated mechanical over-flow gate. Maximum flow through the gate is 6% of station capacity or 340 cfs. The sluice is located on the river side of the power canal just upstream of the Unit 1 trash rack and discharges directly into the river. To enhance use of the sluice gate, a guidance boom is seasonally installed in the power canal. The boom is approximately 300 feet long, is secured on the land side of the canal, and angles downstream to the new sluice gate. The boom has flotation, and is suspended in the water column.

The 2009 shakedown period and associated evaluation of the new floating guidance boom and surface sluice gate indicated that the boom was not buoyant and strong enough to handle existing unit flows. In the winter of 2009/2010, the licensee reviewed the available floating boom products on the market and subsequently selected a product manufactured by "Tuffboom."

In early April 2010, the licensee developed a new guidance boom design and consulted with resource agency personnel. The new design consists of two ten foot long plastic cylindrical "Tuffboom" brand floats per section (i.e., 30 sections which equate to 300 feet long) with a four foot deep section of 5/16-inch metal punch plate located in between the floats. Attached to the punch plate is six feet of the 5/16-inch dynema netting used in the 2009 system. All gaps between the panels are covered by rubber flanges. The new boom was installed in May of 2010 and then evaluated using Atlantic salmon smolts and PIT tags. The results of the PIT tag tests were suspect due to issues associated with PIT tag antenna interference, limited PIT tag antenna range, and non-detection of fish.

The licensee subsequently conducted another evaluation using radio telemetry techniques in the spring of 2011. Based upon the 2011 study results, a number of recommendations for enhancing the downstream bypass for Atlantic salmon smolts at Lockwood were developed. These modifications, which were implemented in the spring of 2012, included the replacement of 32 feet of the downstream section of the boom with ten foot deep metal punch plate panels (to replace the vulnerable portion of the existing netting). The modification also included a new flexible attachment point and new larger floats. Finally, the existing trash rack exclusion bars at the entrance of the bypass, which were causing noise and vibration, were removed.

The licensee completed a second Atlantic salmon smolt radio telemetry downstream passage study at Lockwood in the spring of 2012 in order to evaluate the effectiveness of the guidance boom modification completed earlier that spring. During the study, five groups of radio-tagged smolts were released upstream of the Weston Project and their passage routes and bypass usage were recorded at Weston, Shawmut and Lockwood. Two groups of radio-tagged smolts were released upstream of Lockwood, and their passage routes and bypass usage were recorded. Additional data on smolt passage routes and bypass usage at Lockwood were collected from four groups of smolts radio-tagged and released upstream of the Hydro-Kennebec Project, located about one mile upstream from Lockwood. Kennebec River flow conditions during the 2012 study did not allow for all turbine units to run at a 100% gate setting; however, river conditions did allow for the evaluation of passage routes under limited to no spill conditions at Weston, Shawmut and Lockwood, as well as the assessment of downstream passage effectiveness at the Weston and Lockwood Projects. Kennebec River flows during smolt releases were low (exceeded 94% of the time based on the May flow duration curve for the Lockwood Project).

Results of the 2012 study at Lockwood indicate that when smolts from all releases are combined, the bypass effectiveness rate of radio-tagged individuals entering the Lockwood forebay canal (n =128) was 66.4%. This was a significant improvement over the 2011 bypass effectiveness (20.9% at 6% of powerhouse flow), which indicates that the modifications completed during spring 2012 improved downstream passage conditions for smolts. Data was also collected on how many smolts passed through all available passage routes. Individual smolts detected passing Lockwood were originally released upstream of the Weston (n =42), Hydro-Kennebec (n = 72) and Lockwood (n = 39) Projects. Of the 153 smolts that passed the Lockwood Project, 55.6% (85 of 153) passed through the downstream bypass, 13.7% (21 of 153) passed through the Kaplan turbine, 14.4% (22 of 153) passed through the Francis turbines, and 15.7% (24 of 153) passed on spill.

In addition to the new surface sluice gate and associated guidance boom, downstream passage is also provided through the three orifices (three foot long by eight inches high) cut into the flashboards along the spillway. The orifices pass approximately 50 cfs, and provide downstream passage routes along the spillway even when the Project is not spilling over the top of the flashboards. In addition, river flows exceed the turbine capacity for much of the time period that downstream fish migrations occur; thus, providing passage capability via spill over the dam.

2.1.2. Proposed Action

2.1.2.1. Interim Species Protection Plan

The ISPP is valid for a seven-year period (2013- 2019) to allow the licensee to study existing and proposed measures to protect migrating Atlantic salmon. Provisions of the ISPP require the licensee to undertake the following activities:

- Upstream Passage
    - Increase the number of lifts per day from three to five to five to eight between mid-July and the end of October;
    - Construct a volitional upstream fishway (operational in 2016);
    - Continue to use underwater cameras in and around the fish lift to observe Atlantic salmon behavior and identify any issues with Atlantic salmon movement into the fish lift;
    - Monitor areas of the tailrace that can be visually observed for the presence of holding Atlantic salmon and collect information on numbers and time periods;
    - Monitor angler activity near the fish lift and collect available information on numbers of Atlantic salmon accidentally captured or observed;
    - Monitor the bypass reach ledge area during flashboard replacement. With MDMR assistance, collect adult Atlantic salmon for transfer to Sandy River or release back into the Kennebec depending on fish condition and water temperature;
    - Collaborate with Hydro Kennebec Project personnel to gather visual observation data on Atlantic salmon that may migrate to the Hydro Kennebec Project via the Lockwood spillway section; and
    - Conduct Atlantic salmon adult upstream passage effectiveness monitoring studies (2016-2018).

- Downstream Passage
    - Extend period that downstream bypass facilities operate from April 1 to June 15 and November 1 to December 15 to April 1 to December 31, as river and ice conditions allow;
    - Ensure that the bypass gate is open and operating to pass the maximum flow through the gate, which is 6% of station unit flow;
    - 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; and
- Conduct downstream survival studies for outmigrating smolts (2013-2015) and kelts (2014-2016).

At the end of the seven year period (2019), the licensee will file a final SPP for Atlantic salmon in consultation with FERC. The final SPP will reinitiate formal section 7 consultation under the ESA.

The licensee has proposed to conduct upstream passage studies at the Lockwood Project using pre-spawn Atlantic salmon between 2016 and 2018 as part of the ISPP. Given that few salmon return to the Kennebec River every year, the licensee will need to conduct the studies in such a way that salmon would not be released upriver of the Lockwood Project. If released, they would face a dead end in their migration to suitable spawning and rearing habitat in the Sandy River due to barriers at the Shawmut and Weston Projects.

The ISPP indicates that the new volitional upstream fishway at Lockwood will be designed in 2014, constructed in 2015, and operational in 2016. Although the fishway has yet to be designed, the licensee has indicated that the construction of the fishway will involve a modification to the existing fishway and that the project will not involve any in-water work (R. Richter, Brookfield Renewable Power, pers. comm., 2013).

2.1.2.2. Sturgeon Handling and Protection Plan

Atlantic and shortnose sturgeon have been documented using the habitat downstream of the Lockwood Project. The Lockwood Project has an existing FERC-approved handling plan for shortnose sturgeon, which was updated in March, 2013 (BWPH 2013). On January 12, 2005, we issued an Opinion that considered the effects of the handling plan on shortnose sturgeon. In the Incidental Take Statement (ITS), we exempted the take of up to two shortnose sturgeon annually at the Lockwood Project. The handling plan outlines the procedures that the Project licensees use for handling sturgeon and documenting such interactions at the Lockwood Project. The existing handling plan envisions possible interaction between sturgeon and the project under two scenarios: 1) sturgeon that may find their way into the upstream fish lift, and 2) sturgeon that may become stranded in pools below the Lockwood Dam. The plan outlines measures to be undertaken by the licensee in the event of these two occurrences. The current handling plan is approved for shortnose sturgeon, but identical procedures and measures are appropriate for Atlantic sturgeon, as well. As part of the proposed Sturgeon Handling and Protection Plan amendment, the licensee has updated the Lockwood handling plan for both shortnose and Atlantic sturgeon.

Fish Lift Operations

Atlantic and shortnose sturgeon will not be passed upstream of the Lockwood Project as the dam location is thought to be the historical limit of upstream migration for sturgeon on the Kennebec River (Houston *et al.* 2007), and because of concerns regarding the safety of downstream passage for shortnose and Atlantic sturgeon. The handling plan requires that if sturgeon are found in the fish lift, the following procedures will be implemented:

- For each sturgeon detected, the licensees shall record the weight, length, and condition of the fish. Fish will also be scanned for PIT tags. River flow, bypass reach minimum flow, and water temperature will be recorded.
- If alive and uninjured, the sturgeon will be immediately returned downstream. A long handled net outfitted with non-abrasive knotless mesh will be used to place the sturgeon back into the river downstream of the dam. The fish should be properly supported during transport in the net to ensure that it is not injured. The licensees will report to us within 24 hours any live, uninjured sturgeon that are removed and relocated back to the river.
- If any injured sturgeon are found, the licensees shall report it to us immediately. Injured fish must be photographed and measured, if possible, and the reporting sheet must be submitted to us within 24 hours. If the fish is badly injured, the fish should be retained by the licensees until notified by NMFS with instructions regarding potential rehabilitation.
- If any dead sturgeon are found, the licensees will report it to us within 24 hours. Any dead specimens or body parts should be photographed, measured, scanned for tags and all relevant information should be recorded. Specimens should be stored in a refrigerator by the licensees until we can obtain them for analysis.

Sturgeon Stranding

Annually, 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 this time, fish could become stranded in isolated pools in the bypass reach. In May 2003, an adult sturgeon, believed to be a shortnose sturgeon, was rescued from a pool at the base of Lockwood Dam during the annual flashboard replacement. The handling plan includes measures to ensure safe handling of any sturgeon stranded during this period. If shortnose or Atlantic sturgeon become stranded, the licensees will return them to the river downstream. The handling plan requires that they follow this protocol:

- Designated employees and fish lift operation staff must monitor the pools below the dam while the flashboards at the project are replaced.
- For each fish removed from the pool, the licensees will record the weight, length, and condition. Fish should also be scanned for PIT tags. River flow, bypass reach minimum flow and water temperature will be recorded.
- If stranded but alive and uninjured, the sturgeon will be moved to the river below the Ticonic Falls that will provide egress out of the area. The licensees shall report to us within 24 hours any live, uninjured sturgeon that are removed and relocated back to the river.
- If any injured sturgeon are found, the licensees will report it to us immediately. Injured fish must be photographed and measured, if possible, and a reporting sheet must be submitted to us within 24 hours. If the fish is badly injured, the fish should be retained by the licensees, if possible, until obtained by a NMFS recommended facility for potential rehabilitation.

- If any dead sturgeon are found, the licensees will report it to us within 24 hours. Any dead specimens or body parts should be photographed, measured, scanned for tags and all relevant information should be recorded. Specimens should be stored in a freezer by the licensees until we can obtain them for analysis.

2.2. Shawmut Project - FERC No. 2322

2.2.1. Existing Hydroelectric Facilities and Operations

The Shawmut Project is located at river mile 66 and is the third dam on the mainstem of the Kennebec River (Figure 1). The Shawmut Project includes a 1,310-acre reservoir, a 1,135 foot long dam with an average height of about 24 feet, headworks and intake structure, enclosed forebay, and two powerhouses. The crest of the dam has a 380 foot section of four foot high hinged flashboards serviced by a steel bridge with a gantry crane; a 730 foot long section of dam topped with an inflatable bladder composed of three sections, each 4.46 feet high when inflated; a 25 foot wide by eight foot deep log sluice equipped with a timber and steel gate; and a surface sluice (four feet wide by 22 inches deep), next to Unit # 7, which discharges into a three foot deep man-made plunge pool.

The headworks and intake structure are integral to the dam and the powerhouse. The forebay intake section contains 11 headgates and two filler gates. A non-overflow concrete gravity section of dam connects the west end of the 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 1912 powerhouse located to the east, and the 1982 powerhouse located to the south. Located at the south end of the forebay between the two powerhouses is a ten foot wide by seven foot deep Taintor gate and a six foot wide by six foot deep gate. The 1912 powerhouse contains six generating units, and the 1982 powerhouse contains two generating units (Table 3).

Table 3. Shawmut Project Generating Unit Summary

Unit	Turbine Design/Type	Capacity (cfs)	RPM	Max Flow		Peak Efficiency		Min Flow	
				CFS	Effic. (%)	CFS	Effic. (%)	CFS	Effic. (%)
1	Francis/ horizontal	650	200	648	78	581	83	400	52
2	Francis/ horizontal	650	200	645	80	583	84	438	41
3	Francis/ horizontal	650	200	641	82	581	84	453	40
4	Francis/ horizontal	650	200	672	71	539	81	367	67
5	Francis/ horizontal	650	200	742	71	520	84	326	55
6	Francis/ horizontal	650	200	667	78	575	83	264	37
7	Propeller/horizontal	1,200	160	N/A	N/A	1,312	82	N/A	N/A
8	Propeller/horizontal	1,200	160	N/A	N/A	1,347	85	N/A	N/A

The Shawmut Project typically operates as run-of river, with a target reservoir elevation near the full pond elevation of 112.0 feet during normal conditions. The maximum hydraulic capacity of the turbines is 6,755 cfs. After maximum flow to the turbines has been achieved, excess water is spilled through the existing log sluice. When flows exceed the capacity of the log sluice, sections of the rubber dam are deflated to pass additional water.

2.2.1.1. Upstream Fish Passage

The Shawmut Project has used the Lockwood fish lift and transport system as its means of interim upstream fish passage since 2006. The MDMR capture Atlantic salmon (and other anadromous species) at the Lockwood lift and transport the fish in trucks to areas of suitable habitat, primarily the Sandy River, which is upstream of the Shawmut Project.

2.2.1.2. Downstream Fish Passage

Interim downstream passage for Atlantic salmon at Shawmut is provided through a sluice located on the right-hand side of the intake structure next to Unit 6. The sluice, which is manually adjusted and contains three stoplogs, is four feet wide by 22 inches deep. With all stoplogs removed, this sluice passes flows between 30 and 35 cfs. Flows from this sluice discharge over the face of the dam and drain into a man-made three feet deep plunge pool connected to the river. In addition, there is a Taintor gate located next to this sluice that measures seven feet high by ten feet wide and can pass 600 cfs. This gate is used to pass debris and excess flows, which also discharge over the face of the dam into a shallow plunge pool connected to the river.

In 2009, FPL Energy engineers, operations personnel, and biologists investigated options to resolve both ongoing debris issues and downstream anadromous and catadromous fish passage needs at Shawmut. It was agreed that options for debris resolution could be designed to also address downstream fish passage needs. In 2010, the licensee subsequently hired a team of consultants, including Wright Pierce Engineers, Alden Research Labs and Blue Hill Hydraulics, to design a new facility at the Shawmut Project that would address both the debris and fish passage needs.

In 2011, the licensee, in consultation with resource agencies, developed designs for a new combined intake structure and downstream fish bypass facility at the Project. At that time, the proposed facility included the use of new full depth one inch angled trashracks and a new surface sluice and flume leading to the river. The proposed location and design of this facility, which resulted from significant efforts in hydraulic modeling and evaluation of alternatives by both the licensee and resource agencies, was just upstream of the existing intake structure. However, the need for this proposed facility is being re-evaluated in light of results from a 2012 downstream smolt study conducted at Shawmut. This study indicated that the majority of study smolts (over 80%) used the existing forebay Taintor gate for downstream passage. The licensee will continue evaluations of downstream smolt passage at Shawmut and discussions with the resource agencies regarding how to provide safe and efficient passage to downstream migrants at the Shawmut Project.

The licensee completed an Atlantic salmon smolt radio telemetry downstream passage study involving the Shawmut Project in the spring of 2012. The primary focus of the study was on the Lockwood and Weston projects, but the study also provided information on bypass effectiveness at Shawmut. Five groups of radio-tagged smolts were released upstream of the Weston Project and their passage routes and bypass usage were recorded at Weston, Shawmut and Lockwood. The Shawmut Taintor gate, which was fully opened to simulate a surface sluice, passed approximately 600 cfs for the duration of the study. Relative to the total flows observed during 2012, 600 cfs represented from 9-17% of actual powerhouse flow. When all smolts entering the Shawmut forebay canal are considered (n = 64), 82.8% of smolts passing Shawmut used the downstream bypass. When examined by setting, 100% (15 of 15) of smolts passed Shawmut with the bypass releasing 9-11% of powerhouse flow, 80.0% (24 of 30) of smolts passed Shawmut with the bypass releasing 12-13% of powerhouse flow, and 73.7% (14 of 19) of smolts passed Shawmut with the bypass releasing 15-17% of powerhouse flow. Of the 65 smolts which passed the Shawmut Project, 81.5% (53 of 65) passed through the Taintor gate, 16.9% (11 of 65) passed through the propeller turbines, and 1.5% (1 of 65) passed on spill.

2.2.2. Proposed Action

2.2.2.1.Interim Species Protection Plan

The ISPP is valid for a seven-year period (2013- 2019) to allow the licensee time to implement species protection measures and to study their ability to protect migrating Atlantic salmon. Provisions of the ISPP will require the licensee to undertake the following activities at the Shawmut Project:

- Upstream Passage
    - Construct an upstream fishway facility (operational in 2018).

- Downstream passage
    - Extend period that downstream bypass facilities operate from April 1 to June 15 and November 1 to December 15 to the current period of April 1 to December 31, as river and ice conditions allow;
    - The bypass gate will be operated to maintain an interim flow of 6% of station unit flow through the gate during evening passage hours. Modifications to the bypass flow will be considered as part of the adaptive management approach to the ISPP, based on results of radio telemetry studies and consultation with the agencies; and
    - Conduct downstream survival studies for outmigrating smolts (2013-2015) and kelts (2014-2016).

At the end of the seven year period (2019), the licensee will file a final SPP for Atlantic salmon in consultation with FERC. The final SPP will reinitiate formal section 7 consultation under the ESA.

The ISPP indicates that the new volitional upstream fishway at Shawmut will be designed in 2016, constructed in 2017, and operational in 2018. Although the project has yet to be designed, the licensee has indicated that the construction of the fishway will likely involve a small amount of permanent impact associated with ledge removal and the placement of fill (R. Richter, Brookfield Renewable Power, pers. comm.). It is anticipated that less than 500 square feet of riverine habitat will be temporarily or permanently affected by the construction of cofferdams and the placement of fill. In-water work will occur outside of the smolt and kelt outmigration periods and within the confines of a dewatered cofferdam.

2.3. Weston Project - FERC No. 2534

2.3.1. Existing Hydroelectric Facilities and Operations

The Weston Project is located at river mile 82 in the Town of Skowhegan and is the fourth dam on the mainstem of the Kennebec River (Figure 1). The Weston Project includes a 930-acre reservoir, 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. U.S. Route 2 crosses the island, spanning the South Channel impoundment above South Channel Dam and the North Channel bypass section located below the North Channel Dam.

The North Channel Dam is a concrete gravity and buttress dam 38 feet high, with a crest elevation of 156.0 feet. The dam extends about 529.5 feet 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 North Channel Dam consists of four sections: a 22.5 foot long concrete non-overflow section; a 244 foot long stanchion section with five bays; a 160.5 foot long pneumatic gate section with 7.5 feet high steel panels; and a 93 foot long gated section (located next to the island) containing two steel Taintor gates. The normal full pond elevation of the impoundment is 156.0 feet.

The South Channel Dam is a concrete gravity and buttress dam 51 feet high, with a crest elevation of 156.0 feet. The dam extends about 391.5 feet between abutment walls from the island to the south riverbank and consists of five sections: a 125 foot long powerhouse/intake section; a 33 foot long concrete spillway section; a 24 foot long sluice section; a 188 foot long stanchion section with five bays; and a 21.5 foot long concrete non-overflow section. The powerhouse/intake section of the dam, located adjacent to the north abutment and integral to the project dam, includes the headworks and four intake bays, one for each of the four turbine generator units. Each bay houses three reinforced concrete gates that can isolate flow to the individual turbines; the hydraulic capacity for each turbine is 1,450 cfs (Table 4). The trashracks, which are situated in front of the gate slots, are cleaned using a motor-operated trash rake. The concrete spillway section has a permanent crest elevation of 154.0 foot and is topped by two foot high stoplogs. A 14 foot high Taintor gate controls flows through the sluice section, which extends 69.5 feet downstream.

Table 4. Weston Project Generating Unit Summary

Unit	Turbine Design/Type	Hydraulic Capacity (cfs)	RPM	Max Flow		Peak Efficiency		Min Flow	
				CFS	Effic. (%)	CFS	Effic. (%)	CFS	Effic. (%)
1	Francis/vertical	1750	100	1,750	82	1,614	90	434	49
2	Francis/vertical	1500	100	1,498	83	1,207	88	426	73
3	Francis/vertical	1750	100	1,750	84	1,614	90	434	49
4	*Francis/vertical*	*1700*	*100*	*1,710*	*81*	*1,428*	*87*	*634*	*63*
4 planned	Francis/vertical	1900	100	1,900	87	1,688	90	TBD	

The Weston Project operates as run-of-river by maintaining the impoundment water surface elevation within one foot of the full pond elevation of 156.0 foot msl, during normal operations. The existing FERC license requires the project to provide an instantaneous minimum flow of 1,947 cfs or inflow, whichever is less.

The hydraulic capacity of the Weston Project is currently 6,075 cfs. When river flow exceeds the hydraulic capacity of the turbines, excess water is passed downstream through the South Channel sluice, and/or Taintor gates. The south channel sluice gate is capable of passing up to 2,500 cfs, and each of the Taintor gates are capable of passing up to 5,000 cfs. If after opening the south channel sluice and Taintor gates the elevation of the impoundment is 156.0 feet and still rising, then additional water is released via hinged flashboards, top boards, and north and south channel stanchions.

2.3.1.1. Upstream Fish Passage

The Weston Project has used the Lockwood fish lift and transport system as its means of interim upstream fish passage since 2006. Atlantic salmon (and other anadromous species) are captured at the Lockwood lift and transported in trucks by the MDMR to areas of suitable habitat, primarily the Sandy River, which is upstream of the Weston Project.

2.3.1.2. Downstream Fish Passage

Interim downstream passage at the Weston Project is provided through a sluice gate and associated concrete flume located on the South Channel Dam. The gate and flume were formerly used as a log sluice during river log drives and both are located near the Unit 4 intake. The sluice is 18 feet wide by 14 feet high and discharges into a deep plunge pool. Maximum flow through the gate at full pond is 2,250 cfs.

In 2011, the licensees enhanced the existing downstream passage facility by installing a guidance boom consisting of a 300 foot long floating boom with suspended ten feet deep sections of 5/16 inch metal punch plate screens. The boom leads to the existing log sluice gate, which in turn discharges via an existing concrete flume to a deep pool in the river. The licensees had previously (in 2010) made some major structural repairs to the existing sluice gate structure, which included resurfacing of the concrete flume.

During the downstream migration period, the gate is opened to pass 6% of station unit flow. The sluice has been opened for smolt and kelt passage generally from April 1 through June 15 and between November 1 and December 31, if river and ice conditions allow. As part of the proposed action, the licensee initially proposed to expand the operation of downstream passage facilities to April 1 to December 31. This was proposed for all four of the Projects to account for the downstream migration of juvenile river herring. As river herring are not stocked upstream of the Weston Project, the licensee has requested to maintain the existing schedule of operation. As detailed in the ISPP, studies to evaluate the effectiveness of the bypass with the new guidance boom will be undertaken after resource agency consultation and approval of a study plan.

On the North Channel side of the Weston Project, there are two Taintor gates, an inflatable rubber dam section, and stanchion gate sections. Interim passage is provided on the North Channel side via spillage.

The licensee completed an Atlantic salmon smolt radio telemetry downstream passage study at the Weston Project in the spring of 2012. During the study, five groups of radio-tagged smolts were released upstream of the Weston Project and their passage routes and bypass usage were recorded at Weston, Shawmut and Lockwood. Downstream bypass usage data were collected for smolts at the Weston Project at 6%, 4% and 2% of actual powerhouse flows during 2012. When examined by setting, 68.4% (26 of 38) of smolts used the downstream bypass with the bypass set at 6%, 45.5% (15 of 33) of smolts used it with the bypass set at 4%, and 43.8% (7 of 16) of the smolts used the downstream bypass with the bypass set at 2%. Of the 89 smolts that passed the Weston Project with known routes, 54.0% (48 of 89) passed through the downstream bypass, 43.8% (39 of 89) passed through the turbines, and 2.2% (2 of 89) passed on spill.

2.3.2. Proposed Action

2.3.2.1. Interim Species Protection Plan

The ISPP is valid for a seven-year period (2013- 2019) to allow the licensee time to implement species protection measures and to study their ability to protect migrating Atlantic salmon. Provisions of the ISPP will require the licensee to undertake the following activities at the Weston Project:

- Upstream Passage
    - Construct upstream fishway facility (operational in 2020).

- Downstream Passage
    - The passage facility will be operated to maintain an interim flow of 6% of station unit flow through the sluice gate during evening passage hours. Modifications to the bypass flow will be considered as part of the adaptive management approach to the ISPP, based on results of radio telemetry studies and consultation with the agencies;
    - The Licensee will undertake measures necessary to keep the guidance boom in place and in good operating condition. If the guidance boom becomes dislodged or damaged, the licensee will repair or replace the guidance boom as soon as can be safely and reasonably done; and
    - Conduct downstream survival studies for outmigrating smolts (2013-2015) and kelts (2014-2016).

At the end of the seven year period (2019), the licensee will file a final SPP for Atlantic salmon in consultation with FERC. With the submission of the final SPP, FERC will reinitiate formal section 7 consultation under the ESA.

The ISPP indicates that the new volitional upstream fishway at Weston will be designed in 2018, constructed in 2019, and operational in 2020. Although the project has yet to be designed, the licensee has indicated that the construction of the fishway will likely involve a small amount of permanent impact associated with ledge removal and the placement of fill (R. Richter, Brookfield Renewable Power, pers. comm., 2013). It is anticipated that less than 500 square feet of riverine habitat will be temporarily or permanently affected by the construction of cofferdams and the placement of fill. In-water work will occur outside of the smolt and kelt outmigration periods and within the confines of a dewatered cofferdam.

2.4. Brunswick Project - FERC No. 2600

2.4.1. Existing Hydroelectric Facilities and Operations

The Brunswick Project is located at river mile 6 at the head of tide, and is the first dam on the mainstem of the Androscoggin River. The dam and powerhouse span the Androscoggin River immediately above the U.S. Route 201 bridge connecting Topsham and Brunswick, at a site originally known as Brunswick Falls. The Brunswick Project includes a 300-acre reservoir; a 605 foot long and 40 foot high concrete gravity dam; a gate section containing two Taintor gates and an emergency spillway; and a powerhouse and intake. The Project also has vertical slot fishway, a 21 foot high fish barrier wall between the dam and Shad Island, and a three foot high by 20 foot long concrete fish barrier weir across Granney Hole Stream in Topsham.

The concrete gravity dam consists of two ogee overflow spillway sections separated by a pier and barrier wall. The right spillway section, about 128 foot long, is topped with wooden flashboards that are 2.6 feet high. The left section does not have flashboards. The intake structure and powerhouse are integral with the dam and located adjacent to the Brunswick shoreline. The powerhouse contains three vertical propeller turbine generators. Unit 1 has a hydraulic capacity of 4,400 cfs, and units 2 and 3 have a hydraulic capacity of 1,200 cfs (Table 5).

Table 5. Brunswick Project Generating Unit Summary

Unit	Turbine Design/Type	Hydraulic Capacity (cfs)	RPM	Max Flow		Peak Efficiency		Min Flow	
				CFS	Effic. (%)	CFS	Effic. (%)	CFS	Effic. (%)
1	Propeller/ vertical	4,400	90	5,075	83	4,519	93	2,741	57
2	Propeller/ horizontal	1,200	211.8	N/A	N/A	1,336	88	N/A	N/A
3	Propeller/ Horizontal	1,200	211.8	N/A	N/A	1,336	88	N/A	N/A

The Brunswick Project normally operates as run-of-river. Due to the on/off nature of the units and the small pond available, the pond fluctuates to allow the units to operate efficiently; however, the pond is too small to store water for any significant amount of peaking. Thus, the station is considered run of river. Impoundment drawdowns are generally limited to less than two feet below the top of the spillway.

Downstream of the dam's spillway, the riverbed consists of broad ledges interspersed with one large pool and a few smaller pools. Immediately to the south of the spillway is a concrete retaining wall that separates the tailwater area from the spillway ledge area. Along the downstream end of the spillway area is a naturally occurring rock ledge that acts as a natural barrier to fish. In the 1980s, concrete caps were added to portions of the ledge to create an even more effective barrier to fish access. The ledge is approximately 520 feet long, 15 feet wide, and six feet high (at high tide). This substantial barrier serves to prevent fish from being drawn up into the ledges near the spillway portion of the dam during periods of large spill.

2.4.1.1. Upstream Fish Passage

Upstream passage at Brunswick is provided via a vertical slot fishway and associated trap, sort, and truck facility that were installed in 1983. The fishway is 570 feet long and consists of 42 individual pools, with a one-foot drop between each. The trapping facility, located at the upstream end of the fishway, provides biologists the opportunity to collect data on migratory and resident fish species that use the fishway. As fish swim to the top of the fishway, fixed grating guides them past a viewing window and into a 500 gallon capacity fish hoist (trap). The hoist elevates the fish to overhead sorting tanks where staff sort and pass fish upstream. Atlantic salmon pass upstream above the 40-foot dam after biological data are collected. The fishway is currently operated between May 1 and October 31, but has been proposed to be extended to April 15 to October 31 as part of the proposed ISPP. During the period of fishway operation, an attraction flow of 100 cfs is provided.

The Brunswick fishway facility is maintained by the licensee; however, since its construction, MDMR personnel have operated the fishway each season under prior agreement. According to the annual fishway reports, in some years the upstream fishway is shutdown for several weeks in August and September due to maintenance needs, low staff availability, as well as the harm associated with sampling adult salmon during warm water periods (MDMR 2009, 2012).

The Brunswick Project also has a fish barrier wall located between the dam and Shad Island and a concrete cap over the ledges at the southern end of the spillway section. These structures were installed in the 1980s in an effort to prevent fish from accessing the spillway section and to prevent spill from entering the tailrace and interfering with fish attraction to the fishway.

2.4.1.2. Downstream Fish Passage

Downstream passage is provided at the Brunswick Project via a surface sluice and associated 18-inch pipe that discharges fish into the project tailrace. The existing sluice gate and pipe were installed in 1983. The sluice is located along the face of the powerhouse between units one and two.

2.4.2. Proposed Action

2.4.2.1. Interim Species Protection Plan

The ISPP is valid for a seven-year period (2013- 2019) to allow the licensee time to implement species protection measures and to study their ability to protect migrating Atlantic salmon. Provisions of the ISPP will require the licensee to undertake the following activities at the Brunswick Project:

- Upstream Passage
    - Extend period that upstream passage facilities are operated from May 1 – October 31 to April 15 – November 15;
    - MDMR will trap and sort all fish species, including Atlantic salmon. All Atlantic salmon will be released to Brunswick headpond to continue their upstream migration;
    - The licensee will undertake measures necessary to keep the fishway in good operating condition. If the fishway malfunctions or becomes inoperable during the critical months, they will repair the fishway and restore it to normal operation as soon as can be safely and reasonably done;
    - MDMR will maintain records of all fish moved via the fishway. MDMR will maintain detailed records of Atlantic salmon moved via the fish lift, including an assessment of size, age, and condition; and
    - Conduct Atlantic salmon adult upstream passage effectiveness monitoring studies at Brunswick Project (2013-2015). The upstream passage studies will be conducted in coordination with upstream dam owners.

- Downstream Passage
    - Extend period that downstream bypass facilities operate from April 1 to June 15 and November 1 to December 15 to the period of April 1 to December 31, as river and ice conditions allow; and
    - Conduct downstream survival studies for outmigrating smolts (2013-2015) and kelts (2014-2016).

At the end of the seven year period (2019), the licensee will file a final SPP for Atlantic salmon in consultation with FERC. The final SPP will reinitiate formal section 7 consultation under the ESA.

2.4.2.2. Sturgeon Handling and Protection Plan

Atlantic and shortnose sturgeon have been documented using the habitat downstream of the Brunswick Project. Currently, there is no formally approved handling plan for shortnose or Atlantic sturgeon at the Brunswick Project. The proposed handling plan envisions possible interaction between sturgeon and the project under three scenarios: 1) sturgeon that may find their way into the upstream fishway, 2) sturgeon that may become stranded in pools below the Brunswick Project, and 3) sturgeon may be attracted into portions of Unit #1 when it is shut down for annual inspection. The existing plan spells out measures to be undertaken by the licensee in the event of any one of these three occurrences.

Fishway and Trap Operations

Atlantic and shortnose sturgeon will not be passed upstream of the Brunswick Project as the dam location is thought to be the historical limit of upstream migration for sturgeon on the Androscoggin River (Houston *et al.* 2007), and because of concerns regarding the safcty of downstream passage for shortnose and Atlantic sturgeon. The handling plan requires that if sturgeon are found in the fishway, the following procedures will be implemented:

- For each sturgeon detected, the licensees shall record the weight, length, and condition of the fish. Fish will also be scanned for PIT tags. River flow, bypass reach minimum flow, and water temperature will be recorded.
- If alive and uninjured, the sturgeon will be immediately returned downstream. A long handled nct outfitted with non-abrasive knotless mesh will be used to place the sturgeon back into the river downstream of the dam. The fish should be properly supported during transport in the net to ensure that it is not injured. The licensees will report to us within 24 hours any live, uninjured sturgeon that are removed and relocated back to the river.
- If any injured sturgeon are found, the licensees shall report it to us immediately. Injured fish must be photographed and measured, if possible, and the reporting sheet must be submitted to us within 24 hours. If the fish is badly injured, the fish should be retained by the licensees until notified by NMFS with instructions regarding potential rehabilitation.
- If any dead sturgcon are found, the licensees will report it to us immediately (within 24 hours). Any dead specimens or body parts should be photographed, measured, scanned for tags and all relevant information should be recorded. Specimens should be stored in a refrigerator by the licensees until we can obtain them for analysis.

Sturgeon Stranding

Annually, the impoundment of the Brunswick 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. The boards are typically installed prior to May 1. As described above, there is a ledge outcrop at the outlct of the large pool downstream of the spillway that was augmented with concrete in the 1980's to keep fish from entering the ledge areas downstream of the spillway. At high tide the falls has a six foot drop (approximately nine feet at low tide) that would likely preclude all life stages of sturgeon from being near the spillway. Additionally, the ledge outcrop controls the depth of the water in the large pool downstream of the spillway, which keeps it from dewatcring at periods of low flow. Although it is possible, it is unlikely that sturgeon would have access to the area that would be affected by the lowering of the impoundment.

The handling plan includes measures to ensure safe handling of any sturgeon should stranding occur. If shortnose or Atlantic sturgeon become stranded, the licensce will return them to the river downstream. The handling plan requires that they follow this protocol:

- Designated employees and fish lift operation staff must monitor the pools below the dams while the flashboards at the project are replaced.
- For each fish removed from the pool, the licensees will record the weight, length, and condition. Fish should also be scanned for PIT tags. River flow, bypass reach minimum flow and water temperature will be recorded.

- If stranded but alive and uninjured, the sturgeon will be moved downriver of the dam. The licensees shall report to us within 24 hours any live, uninjured sturgeon that are removed and relocated back to the river.
- If any injured sturgeon are found, the licensees will report it to us immediately. Injured fish must be photographed and measured, if possible, and a reporting sheet must be submitted to us within 24 hours. If the fish is badly injured, the fish should be retained by the licensees, if possible, until obtained by a NMFS recommended facility for potential rehabilitation.
- If any dead sturgeon are found, the licensees will report it to us immediately (within 24 hours). Any dead specimens or body parts should be photographed, measured, scanned for tags and all relevant information should be recorded. Specimens should be stored in a refrigerator by the licensees until we can obtain them for analysis.

Unit Inspection and Maintenance

The Brunswick Project units are shut down annually for routine inspection and maintenance, which may require dewatering all or portions of the units. For routine inspections and maintenance, the licensee will reduce the potential for sturgeon interaction with the Project by scheduling such activities to occur outside the sturgeon spawning season (May to July). If unit maintenance is of an emergency nature, they shall immediately notify us of the nature of the emergency and the maintenance required. For both scheduled and emergency unit inspection or repairs that require dewatering of any of the three project generating units, they will implement the following measures:

- Prior to dewatering, areas upstream of the turbine tailrace tail logs and inside the scroll case that are accessible to the maintenance crew and/or divers, will be inspected. Divers with lights will inspect the tailrace area upstream of the tail logs before they are lowered into place. The tail logs may need to be alternately raised or lowered depending on sturgeon encountered. Flexible fencing may need to be deployed to corral the sturgeon out of the tailraces. Upon lowering the tail logs, an inspection inside of the tail logs will be conducted to confirm that no sturgeon are present prior to dewatering.
- After the tail logs are in place and the unit dewatered, the scroll case will be inspected by maintenance crews for sturgeon. If sturgeon are found to be present, fish rescue operation procedures will be implemented:
  - Removal of individuals from scroll case via dip net or other appropriate equipment;
  - For each fish removed from the scroll case, the handlers will record the weight, length, and condition. Fish will be scanned for PIT tags. River flow, bypass reach minimum flow, and water temperature will be recorded. All relevant information will be recorded on the reporting sheet.
- Any live, uninjured sturgeon will immediately be returned to the Androscoggin River safely downstream of the project. The licensees shall report to us within 24 hours any live, uninjured sturgeon that are removed and relocated back to the river.
- If any injured sturgeon are found, the licensees will report it to us immediately. Injured fish must be photographed and measured, if possible, and a reporting sheet must be submitted to us within 24 hours. If the fish is badly injured, the fish should be retained

by the licensees, if possible, until obtained by a NMFS recommended facility for potential rehabilitation.

- If any dead sturgeon are found, the licensees will report it to us within 24 hours. Any dead specimens or body parts should be photographed, measured, scanned for tags and all relevant information should be recorded. Specimens should be stored in a refrigerator by the licensees until we can obtain them for analysis.

2.5. Lewiston Falls Project - FERC No. 2302

2.5.1. Existing Hydroelectric Facilities and Operations

The Lewiston Falls Project includes a dam consisting of several distinct dam sections. There are four stone-masonry dam sections (Dams 1-4), each of which support four foot high flashboards. A fifth dam section (Dam 5) is four feet high and supports 1.34 foot high flashboards. The island spillway is a concrete section located on a small island between Dams 3 and 4 and it is fitted with flashboards. the licensee is in the process of replacing approximately 681 feet of flashboards over four sections of the spillway (Dams #1, #2, #3, & #4) with inflatable rubber dams. The work includes resurfacing the cap and upstream face of the dam to provide a base for the new bladder system; and resurfacing and modifying the end piers on either end of the spillways to support the inflatable bladders that will be required to span the flashboard sections. There are two sections of approximately 154 feet of operational rubber dam (Dam #4) currently installed. There will be three more sections (Dams #1, #2, and #3), approximately 578 feet installed in 2013. It is anticipated that the project will be completed by the end of 2013.

The Project also includes a canal system that originally served to deliver water to small generating facilities located in several mills. The Project was redeveloped in 1990 when a new powerhouse (Monty Station) was added to the project. The Canal generating units are currently out of service and are awaiting final disposition. As detailed in Table 6, the Monty Station units (Units1 and 2) are vertical Kaplan units each with a generating capacity of 12,500 kW when passing 3,300 cfs under a 54 foot gross head. After satisfying a 150 cfs minimum flow requirement for the Lewiston Canal system, all additional river flow goes to Monty Station up to the capacity of the turbines (6,600 cfs). Units 1 and 2 are remotely controlled.

Table 6. Lewiston Falls Project Generating Unit Summary

	Units	Turbine Design/Type	Generator Rating (MW)	Hydraulic Capacity (cfs)	Rotation Speed (rpm)
Monty Station	Unit 1	Kaplan/vertical	12.5	3,300	150
	Unit 2	Kaplan/vertical	12.5	3,300	150
Bates Weave Shed	Unit 1	Francis/horizontal	1.2	650	257
	Unit 2	Francis/horizontal	1.5	650	257
	Unit 3	Francis/horizontal	1.2	650	257
Hill Mill	Unit 1	Francis/vertical	0.36	205	180
	Unit 2	Francis/vertical	0.36	205	180
	Unit 3	Francis/vertical	0.36	205	180

	Unit 4	Francis/vertical	0.36	205	180
	Unit 5	Francis/vertical	0.36	205	180
	Unit 6	Francis/vertical	0.36	205	180
Lower Androscoggin	Unit 1	Leffel/vertical	0.27	340	164
Continental Mills	Unit 1	Hercules/vertical	0.4	325	120
	Unit 2	Hercules/vertical	0.4	325	120
	Unit 3	Hercules/vertical	0.4	325	120
	Unit 5	Hercules/vertical	0.192	150	164
	Unit 6	Hercules/vertical	0.192	150	164

The Lewiston Falls Project is licensed to operate with up to four feet of impoundment fluctuation to allow for peaking under normal conditions. The Project currently cycles in response to the cycling of the Gulf Island Project upriver, which was designed as a weekly cycle station, generally pulling during the week while cycling daily and filling during the weekend. Once the rubber dams at Lewiston Falls are commissioned to operate as minimum flow gates, the Project will be able to cycle independently of Gulf Island. Post commissioning, Lewiston Falls will be available to cycle the four feet available in the pond. Cycling will be predicated on the flows provided by Gulf Island and will likely operate as a daily cycle station. Flows during cycling will likely range between about 1,800 – 6,600 cfs. The station has a minimum flow requirement of 1,430 cfs at Lewiston Falls, with a minimum flow of 1,280 cfs required at Monty Station and 150 cfs through the canal.

The Lewiston Canal is typically operated at a minimum flow of 150 cfs, which is contractually required to supply Androscoggin Upper, a small generating facility owned and operated by the City of Lewiston under a separate license. The City may be considering retirement of this facility in the future. Since the Androscoggin Lower generating facility cannot operate at this low flow, flows are spilled there and released back to the river.

2.5.1.1.Upstream Fish Passage

There are no upstream fish passage facilities at the Lewiston Falls Project.

2.5.1.2.Downstream Fish Passage

There are no downstream fish passage facilities at the Lewiston Falls Project.

2.5.2. Proposed Action

The licensee is not proposing any changes to the physical components of the Project as part of the proposed action. As there are no fish passage facilities at the Project, the licensee is not proposing that any passage studies be conducted at the Lewiston Falls Project. The licensee will meet with us annually, as part of the adaptive management strategy, to ensure that the operations of all five Projects (including Lewiston Falls) are consistent with the recovery objectives for Atlantic salmon.

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 CFR 402.02). The action area must encompass all areas where both the direct and indirect effects of the proposed action would affect listed species and critical habitat.

Operation of the Lockwood, Shawmut, Weston, Brunswick, and Lewiston Falls Projects pursuant to the revised licenses proposed to be approved by FERC, will affect much of the Kennebec and Androseoggin River watersheds, the estuary, and associated waters. Therefore, these watersheds represent the action area for this consultation (Figure 1).

3. STATUS OF AFFECTED SPECIES AND CRITICAL HABITAT RANGEWIDE

We have determined that the following endangered or threatened species may be affected by the proposed action:

Fish	
Gulf of Maine DPS of Atlantic salmon	Endangered
Shortnose sturgeon	Endangered
Gulf of Maine DPS of Atlantic sturgeon	Threatened
New York Bight DPS of Atlantic sturgeon	Endangered
Chesapeake Bay DPS of Atlantic sturgeon	Endangered
South Atlantic DPS of Atlantic sturgeon	Endangered
Carolina DPS of Atlantic sturgeon	Endangered

Critical Habitat
Designated for the Gulf of Maine DPS of Atlantic salmon

This section will focus on the status of the various species within the action area, summarizing information necessary to establish the environmental baseline and to assess the effects of the proposed action.

3.1. Gulf of Maine DPS of Atlantic Salmon

3.1.1. Species Description

The Atlantic salmon is an anadromous fish species that spends most of its adult life in the ocean but returns to freshwater to reproduce. The Atlantic salmon is native to the North Atlantic Ocean, from the Arctic Circle to Portugal in the eastern Atlantic, from Iceland and southern Greenland, and from the Ungava region of northern Quebec south to the Housatonic River (Bigelow and Schroeder 1953). In the United States, Atlantic salmon historically ranged from Maine south to Long Island Sound. However, the Central New England DPS and Long Island Sound DPS have both been extirpated (65 FR 69459; November 17, 2000).

The GOM DPS of anadromous Atlantic salmon was initially listed jointly by the USFWS and

NMFS (collectively, the Services) as an endangered species on November 17, 2000 (65 FR 69459). In 2009 the Services finalized an expanded listing of Atlantic salmon as an endangered species (74 FR 29344; June 19, 2009). The decision to expand the range of the GOM DPS was largely based on the results of a Status Review (Fay *et al.* 2006) completed by a Biological Review Team consisting of Federal and State agencies and Tribal interests. Fay *et al.* (2006) conclude that the DPS delineation in the 2000 listing designation was largely appropriate, except in the case of large rivers that were partially or wholly excluded in the 2000 listing determination. Fay *et al.* (2006) conclude that the salmon currently inhabiting the larger rivers (Androscoggin, Kennebec, and Penobscot) are genetically similar to the rivers included in the GOM DPS as listed in 2000, have similar life history characteristics, and occur in the same zoogeographic region. Further, the salmon populations inhabiting the large and small rivers from the Androscoggin River northward to the Dennys River differ genetically and in important life history characteristics from Atlantic salmon in adjacent portions of Canada (Spidle *et al.* 2003; Fay *et al.* 2006). Thus, Fay *et al.* (2006) conclude that this group of populations (a "distinct population segment") met both the discreteness and significance criteria of the Services' DPS Policy (61 FR 4722; February 7, 1996) and, therefore, recommend the geographic range included in the new expanded GOM DPS.

The current GOM DPS includes 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 following impassable falls delimit the upstream extent of the freshwater range: Rumford Falls in the town of Rumford on the Androscoggin River; Snow Falls in the town of West Paris on the Little Androscoggin River; Grand Falls in Township 3 Range 4 BKP WKR on the Dead River in the Kennebec Basin; the un-named falls (impounded by Indian Pond Dam) immediately above the Kennebec River Gorge in the town of Indian Stream Township on the Kennebec River; Big Niagara Falls on Nesowadnehunk Stream in Township 3 Range 10 WELS in the Penobscot Basin; Grand Pitch on Webster Brook in Trout Brook Township in the Penobscot Basin; and Grand Falls on the Passadumkeag River in Grand Falls Township in the Penobscot Basin. 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 Hatchery (CBNFH), both operated by the USFWS. Excluded from the GOM DPS are landlocked Atlantic salmon and those salmon raised in commercial hatcheries for the aquaculture industry (74 FR 29344; June 19, 2009).

Atlantic salmon have a complex life history that includes territorial rearing in rivers to extensive feeding migrations on the high seas. During their life cycle, Atlantic salmon go through several distinct phases that are identified by specific changes in behavior, physiology, morphology, and habitat requirements.

Adult Atlantic salmon return to rivers from the sea and migrate to their natal stream to spawn; a small percentage (1-2%) of returning adults in Maine will stray to a new river. Adults ascend the rivers within the GOM DPS beginning in the spring. The ascent of adult salmon continues into the fall. Although spawning does not occur until late fall, the majority of Atlantic salmon in Maine enter freshwater between May and mid-July (Meister 1958; Baum 1997). Early migration is an adaptive trait that ensures adults have sufficient time to effectively reach spawning areas despite the occurrence of temporarily unfavorable conditions that naturally occur within rivers (Bjornn and 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.

In the fall, female Atlantic salmon select sites for spawning in rivers. 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, water velocity is increasing (McLaughlin and Knight 1987, White 1942), and hydraulic head allows for permeation of water through the redd (a gravel depression where eggs are deposited). Female salmon use their caudal fin to scour or dig redds. The digging behavior also serves to clean the substrate of fine sediments that can embed the cobble and gravel substrates needed for spawning and consequently reduce egg survival (Gibson 1993). One or more males fertilize the eggs that the female deposits in the redd (Jordan and Beland 1981). The female then continues digging upstream of the last deposition site, burying the fertilized eggs with clean gravel.

A single female may create several redds before depositing all of her eggs. Female anadromous Atlantic salmon 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 (2SW) female (an adult female that has spent two winters at sea before returning to spawn) (Baum and Meister 1971). After spawning, Atlantic salmon may either return to sea immediately or remain in fresh water until the following spring before returning to the sea (Fay *et al.* 2006). From 1996 to 2011, approximately 1.3 percent of the "naturally-reared" adults (fish originating from natural spawning or hatchery fry) in the Penobscot River were repeat spawners (USASAC 2012).

Embryos develop in redds for a period of 175 to 195 days, hatching in late March or April (Danie *et al.* 1984). Newly hatched salmon, referred to as larval fry, alevin, or sac fry, remain in the redd for approximately six weeks after hatching and are nourished by their yolk sac (Gustafson-Greenwood and Moring 1991). Survival from the egg to fry stage in Maine is estimated to range from 15 to 35 percent (Jordan and Beland 1981). Survival rates of eggs and larvae are a function of stream gradient, overwinter temperatures, interstitial flow, predation, disease, and competition (Bley and Moring 1988). Once larval fry emerge from the gravel and begin active feeding, they are referred to as fry. The majority of fry (>95 percent) emerge from redds at night (Gustafson-Marjanen and Dowse 1983).

When fry reach approximately four centimeters in length, the young salmon are termed parr (Danie *et al.* 1984). Parr have eight to eleven pigmented vertical bands on their sides that are believed to serve as camouflage (Baum 1997). A territorial behavior, first apparent during the fry stage, grows more pronounced during the parr stage, as the parr actively defend territories (Allen 1940; Kalleberg 1958; 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." First year parr are often characterized as being small parr or 0+ parr (four to seven centimeters long), whereas second and third year parr are characterized as large parr (greater than seven cm long) (Haines 1992). Parr growth is a function of water temperature (Elliott 1991); parr density (Randall 1982); photoperiod (Lundqvist 1980); interaction with other fish, birds, and mammals (Bjornn and Reiser 1991); and food supply (Swansburg *et al.* 2002). Parr movement may be quite limited in the winter (Cunjak 1988; Heggenes 1990); however, movement in the winter does occur (Hiscock *et al.* 2002) and is often necessary, as ice formation reduces total habitat availability (Whalen *et al.* 1999). Parr have been documented using riverine, lake, and estuarine habitats; incorporating opportunistic and active feeding strategies; defending territories from competitors including other parr; and working together in small schools to actively pursue prey (Gibson 1993, Marschall *et al.* 1998, Pepper 1976, Pepper *et al.* 1984, Hutchings 1986, Erkinaro *et al.* 1998, O'Connell and Ash 1993, Erkinaro *et al.* 1995, Dempson *et al.* 1996, Halvorsen and Svenning 2000, Klemetsen *et al.* 2003).

In a parr's second or third spring (age 1 or age 2, respectively), when it has grown to 12.5 to 15 cm in length, a series of physiological, morphological, and behavioral changes occur (Schaffer and Elson 1975). This process, called "smoltification," prepares the parr for migration to the ocean and life in salt water. In Maine, the vast majority of naturally reared parr remain in fresh water for two years (90 percent or more) with the balance remaining for either one or three years (USASAC 2005). In order for parr to undergo smoltification, they must reach a critical size of ten centimeters total length at the end of the previous growing season (Hoar 1988). During the smoltification process, parr markings fade and the body becomes streamlined and silvery with a pronounced fork in the tail. Naturally reared smolts in Maine range in size from 13 to 17 centimeters, and most smolts enter the sea during May to begin their first ocean migration (USASAC 2004). During this migration, smolts must contend with changes in salinity, water temperature, pH, dissolved oxygen, pollution levels, and various predator assemblages. The physiological changes that occur during smoltification prepare the fish for the dramatic change in osmoregulatory needs that come with the transition from a fresh to a salt water habitat (Ruggles 1980, Bley 1987, McCormick and Saunders 1987, McCormick *et al.* 1998). The transition of smolts into seawater is usually gradual as they pass through a zone of fresh and saltwater mixing that typically occurs in a river's estuary. Given that smolts undergo smoltification while they are still in the river, they are pre-adapted to make a direct entry into seawater with minimal acclimation (McCormick *et al.* 1998). This pre-adaptation to seawater is necessary under some circumstances where there is very little transition zone between freshwater and the marine environment.

The spring migration of post-smolts out of the coastal environment is generally rapid, within several tidal cycles, and follows a direct route (Hyvarinen *et al.* 2006, Lacroix and McCurdy 1996, Lacroix *et al.* 2004). Post-smolts generally travel out of coastal systems on the ebb tide and may be delayed by flood tides (Hyvarinen *et al.* 2006, Lacroix and McCurdy 1996, Lacroix *et al.* 2004, Lacroix and Knox 2005). 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 that post-smolts aggregate together and move near the coast in "common corridors" and that post-smolt movement is closely related to surface currents in the bay (Hyvarinen *et al.* 2006; Lacroix and McCurdy 1996; Lacroix *et al.* 2004). European post-smolts tend to use the open ocean for a nursery zone, while North American post-smolts appear to have a more near-shore distribution (Friedland *et al.* 2003). Post-smolt distribution may reflect water temperatures (Reddin and Shearer 1987) or the major surface-current vectors (Lacroix and Knox 2005). Post-smolts live mainly on the surface of the water column and form shoals, possibly of fish from the same river (Shelton *et al.* 1997).

During the late summer and autumn of the first year, North American post-smolts are concentrated in the Labrador Sea and off of the west coast of Greenland, with the highest concentrations between 56°N. and 58°N. (Reddin 1985, Reddin and Short 1991, Reddin and Friedland 1993). The salmon located off Greenland are composed of both 1SW fish and fish that have spent multiple years at sea (multi-sea winter fish or MSW) and also includes immature salmon from both North American and European stocks (Reddin 1988, Reddin *et al.* 1988). The first winter at sea regulates annual recruitment, and the distribution of winter habitat in the Labrador Sea and Denmark Strait may be critical for North American populations (Friedland *et al.* 1993). In the spring, North American post-smolts are generally located in the Gulf of St. Lawrence, off the coast of Newfoundland, and on the east coast of the Grand Banks (Reddin 1985, Dutil and Coutu 1988, Ritter 1989, Reddin and Friedland 1993, and Friedland *et al.* 1999). Some salmon may remain at sea for another year or more before maturing. After their second winter at sea, the salmon over-winter in the area of the Grand Banks before returning to their natal rivers to spawn (Reddin and Shearer 1987). Reddin and Friedland (1993) found immature adults located along the coasts of Newfoundland, Labrador, and Greenland, and in the Labrador and Irminger Sea in the later summer and autumn.

3.1.2 Status and Trends of Atlantic Salmon in the GOM DPS

The abundance of Atlantic salmon within the range of the GOM DPS has been generally declining since the 1800s (Fay *et al.* 2006). Data sets tracking adult abundance are not available throughout this entire time period; however, a comprehensive time series of adult returns to the GOM DPS dating back to 1967 exists (Fay *et al.* 2006, USASAC 2001-2012) (Figure 2). It is important to note that 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 (1869) estimated that roughly 100,000 adult salmon returned to the Penobscot River alone before the river was dammed, whereas contemporary 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 2010).

Contemporary abundance estimates are informative in considering the conservation status of the GOM DPS today. After a period of slow population growth between the 1970s and the early 1980s, adult returns of salmon in the GOM DPS peaked between approximately 1984 and 2001 before declining during the 2000s. Adult returns have been increasing again over the last few years. The population growth observed in the 1970s is likely attributable to favorable marine survival and increases in hatchery capacity, particularly from GLNFH that was 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 observed throughout 1990s and early 2000s. The increase in the abundance of returning adult salmon observed between 2008 and 2011 may be an indication of improving marine survival.

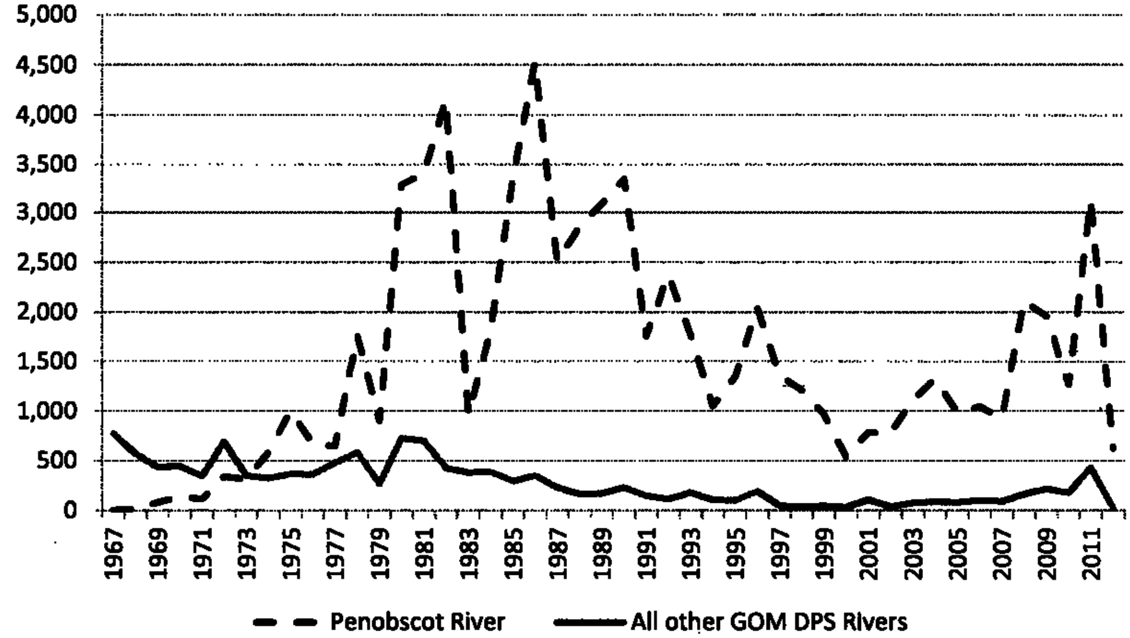

Figure 2. Adult returns to the GOM DPS Rivers between 1967 and 2012(Fay *et al.* 2006, USASAC 2001-2012).

Adult returns to the GOM DPS have been very low for many years and remain extremely low in terms of adult abundance in the wild. Further, the majority of all adults in the GOM DPS return to a single river, the Penobscot, which accounted for 91 percent of all adult returns to the GOM DPS between 2000 and 2011. Of the 3,125 adult returns to the Penobscot in 2011, the vast majority are the result of smolt stocking; and only a small portion were naturally-reared. The term naturally-reared includes fish originating from both natural spawning and from stocked hatchery fry (USASAC 2012). Hatchery fry are included as naturally-reared because hatchery fry are not marked and, therefore, cannot be distinguished from fish produced through natural spawning. Because of the extensive amount of fry stocking that takes place in an effort to recover the GOM DPS, it is possible that a substantial number of fish counted as naturally-reared were actually hatchery fry.

Low abundances of both hatchery-origin and naturally-reered adult salmon returns to Maine demonstrate continued poor marine survival. Declines in hatchery-origin adult returns are less sharp because of the ongoing effects of consistent hatchery supplementation of smolts. In the GOM DPS, nearly all of the hatchery-reared smolts are released into the Penobscot River -- 560,000 smolts in 2009 (USASAC 2010). In contrast, the number of returning naturally-reared adults continues at low levels due to poor marine survival.

In conclusion, the abundance of Atlantic salmon in the GOM DPS has been low and either stable or declining over the past several decades. The proportion of fish that are of natural origin is very small (approximately 6% over the last ten years) but appears stable. The conservation hatchery program has assisted in slowing the decline and helping to stabilize populations at low levels. However, stocking of hatchery products has not contributed to an increase in the overall abundance of salmon and as yet has not been able to increase the naturally reared component of the GOM DPS. Continued reliance on the conservation hatchery program could prevent extinction in the short term, but recovery of the GOM DPS must be accomplished through increases in naturally reared salmon.

3.1.3. Status of Atlantic Salmon in the Action Area

A summary of the status of the species rangewide 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 action area, identified as the Merrymeeting Bay SHRU, is comprised of the Kennebec and Androscoggin River watersheds.

Kennebec River

The Kennebec River, the largest watershed in the Merrymeeting Bay SHRU, flows 233 kilometers from Moosehead Lake to Merrymeeting Bay where it joins with the Androscoggin River (MDEP 1999) and flows another 32 km out to the Atlantic Ocean. In the Kennebec basin, historically important tributaries to Atlantic salmon included the Dead River, Carrabasset River and Sandy River (Atkins and Foster 1867), which are generally characterized as high elevation tributaries that are dominated by rapids, riffles and the occasional falls with a substrate composed of boulders, cobble, and gravel. The lower Kennebec tributaries, including Messalonskee stream which flows out of the Belgrade Lakes, and the Sebasticook River, which incorporates China Lake, Unity Pond, Moose Lake and Sebasticook Lake, were less important for Atlantic salmon spawning and rearing, yet the Sebasticook drainage was considered first rate by Atkins and Foster (1867) for production of alewives and shad.

The Kennebec River watershed currently supports a small run of Atlantic salmon. Restoration efforts in the watershed have utilized egg, fry, and parr stocking to promote returning adult salmon. As such, all lifestages of Atlantic salmon could be present in the action area of this consultation. On average, 43,000 fry were released annually into the Sandy River between 2001 and 2011, for a total of 399,000 fish (USASAC 2011). More than half of these fish (232,000) were released in 2010 and 2011 (USASAC 2011). While this effort has produced smolts and adult returns, it has not been enough to boost the population to any great extent.

More recently a large-scale restoration project was initiated utilizing eggs. Given shortages of Atlantic salmon hatchery resources, MDMR has been supplementing Atlantic salmon populations by producing fry from streamside incubators and by planting Atlantic salmon eggs directly into gravel (MDMR 2011a). This effort is more substantial in comparison to previous juvenile introductions. In 2010, 2011 and 2012, 568,000, 859,000 and 921,000 eggs respectively were release into the Sandy River (USASAC 2011, 2012, 2013). Based upon life-stage survival estimates from literature (average of 1.5% according to Legault (2004)), the smolt production estimates for each of these cohorts is 8,520, 12,885 and 13,815. Given that the Sandy River is relatively pristine, it is possible that production could exceed these estimates. In fact, some juvenile production data from the Sandy River suggests these smolt estimates are likely low. The first of these cohorts likely migrated in the spring of 2012. Given an annual supply of eggs for this project, smolt production should continue into the unforeseeable future.

In addition, some amount of natural reproduction is likely occurring in the Sandy River. Since the fishway at the Lockwood Project has been operational in 2006, adults have been captured and transported to the Sandy River. The eggs contributed to the Sandy River from these adults have ranged from 11,250 in 2006 to 247,500 in 2011. Estimated smolt production for this range would be between 169 and 3,713 annually.

Counts for Atlantic salmon in the Kennebec River are available since 2006 when a fishlift was installed at the Lockwood Dam (NMFS and USFWS 2009). Adult Atlantic salmon are trapped, and biological data (e.g., fork lengths) are collected before the salmon are trucked and released in the Sandy River, which is an upstream tributary of the Kennebec River containing plentiful spawning and rearing habitat (MDMR 2011a). Returning adult salmon at this first dam on the Kennebec River averaged eight fish per year from 1975 to 2000 and 23 fish per year from 2006 to 2012 (USASAC 2012; Table 7).

Table 7. Adult Atlantic salmon returns by origin to the Kennebec River recorded from 1975 to 2012.

Year	Hatchery Origin				Wild Origin				
	1SW	**2SW**	**3SW**	**Repeat**	**1SW**	**2SW**	**3SW**	**Repeat**	**Total**
1975-2001	12	189	5	1	0	9	0	0	216
2006	4	6	0	0	3	2	0	0	15
2007	2	5	1	0	2	6	0	0	16
2008	6	15	0	0	0	0	0	0	21
2009	0	16	0	6	1	10	0	0	33
2010	0	2	0	0	1	2	0	0	5
2011	0	21	0	0	2	41	0	0	64
2012	0	1	0	0	0	4	0	0	5
Total	24	255	6	7	9	74	0	0	375

Source: USASAC 2012.

Following spawning in the fall, Atlantic salmon kelts may immediately return to the sea, or overwinter in freshwater habitat and migrate in the spring, typically April or May (Baum 1997). Spring flows resulting in spillage at the dams facilitate out-migration of adult salmon (Shepard 1988). The number of kelts in the Kennebec River is proportional to the number of adults entering the river each year to spawn. As such, the number of kelts in the Kennebec River is likely to be a few dozen annually.

The Kennebec River in the vicinity of the Lockwood, Shawmut, and Weston Projects serves as migration habitat for adults returning to freshwater to spawn and for smolts and kelts returning to the ocean. The nearest mapped rearing habitat upstream of the Projects is within the Sandy River located approximately 11 miles upstream of the upper most of these dams (Weston).

However, a GIS-based Atlantic salmon habitat model (Wright *et al.* 2008) shows that habitat exists in the mainstem of the Kennebec River downstream of the Shawmut, Hydro-Kennebec, and Lockwood Projects that could provide some juvenile rearing habitat for salmon. The model, which predicts the presence of juvenile rearing habitat approximately 75 percent of the time, indicates that there are 117, 1,779, and 2,085 units (one unit = 100 m^2) of rearing habitat downstream of the Shawmut, Hydro-Kennebec, and Lockwood Projects, which could potentially produce 62, 961, and 1,126 juvenile salmon per year, respectively (Wright *et al.* 2008). Despite this production potential, it is unlikely that much of this habitat is used as prespawn salmon are currently trucked to spawning and rearing habitat in the Sandy River well upstream of Lockwood. However, the 1,126 habitat units downstream of Lockwood is currently accessible to prespawn adults and could be used for spawning and rearing of juvenile salmon. Although the model does not identify habitat that is suitable for spawning, MDMR has conducted field surveys of mainstem habitat and certain tributaries in order to identify areas of suitable habitat for salmon spawning and rearing. These field efforts have identified suitable spawning habitat as close as 300 meters of the Lockwood Project. However, based on redd and electrofishing surveys of the habitat, MDMR has concluded that the habitat is rarely used for spawning (P. Christman, MDMR, Pers. Comm., 2013). Therefore, although spawning and rearing habitat is present, it is unlikely that juvenile salmon would be abundant downstream of the Project.

Generally, salmon smolts begin moving out of Maine rivers in mid-April to June. Atlantic salmon smolts originating in the Sandy River will migrate through the Weston, Shawmut, and Lockwood Projects as they migrate to the ocean. Most data concerning the emigration of smolts in Maine have been collected in the Penobscot, Sheepscot, and Narraguagus Rivers. Based on unpublished data from smolt-trapping studies that we conducted in 2000 – 2005, smolts migrate from the Penobscot between late April and early June. The majority of the smolt migration appears to take place over a three to five week period after water temperatures rise to 10°C. In the spring of 2012, a smolt-trapping study was conducted on the Sandy River by NextEra Energy. NextEra Energy installed a rotary screw trap (RST) in the lower reaches to sample outmigrating Atlantic salmon smolts. The Sandy River RST was operational from April 18, 2012 to May 30, 2012. A total of 52 smolts were captured during 29 days of sampling. The first smolt was captured on April 18 and the last smolt was captured on May 21. Peak capture of smolts occurred in the first week of May. Ambient water temperatures in the Sandy River during sampling ranged from 8° C to 19° C. While the annual abundance of smolts in the Kennebec River is presently unknown, MDMR estimates the current egg stocking and natural reproduction in the Sandy River may be producing over 10,000 smolts annually. Smolt abundance in the river is likely to remain stable or grow as restoration efforts in the river continue.

Androscoggin River

The Androscoggin River originates at Umbagog Lake near Errol, New Hampshire and flows roughly 260 kilometers to Merrymeeting Bay (MDEP 1999). The upper portions of the Androscoggin, like the Kennebec, are high gradient. The Androscoggin River drops over 305 meters from its headwaters to where it meets the sea, with an average gradient of 3.9 meters per kilometer. In the Androscoggin watershed, Rumford Falls was the upper extent of Atlantic salmon migration, while Lewiston Falls was believed to be the upper extent of alewife and shad migrations (Foster and Atkins 1867). The Little Androscoggin River is the largest major subbasin of the Androscoggin with historically important salmon habitat that was accessible as far up as Snow's Falls located 3.2 kilometer outside of West Paris (Foster and Atkins 1867). Prior to its damming, the Androscoggin River provided access to a large and diverse aquatic habitat for great numbers of diadromous and resident fish species (Foster and Atkins 1867).

Historically, Atlantic salmon were reportedly abundant in the Androscoggin River, but adult returns have dwindled and native stocks of Atlantic salmon are considered extirpated south of the Androscoggin River watershed. Dams, pollution, and over-fishing have contributed to the decline of Atlantic salmon in the Androscoggin River. The returns of adult Atlantic salmon to the Androscoggin River in recent years have been small, and mostly comprised of stray, hatchery origin fish from active restoration programs on other rivers (Letter from MDMR to FERC dated March 25, 2010, Table 8).

Table 8. Adult Atlantic salmon returns by origin to the Androscoggin River recorded from 1983 to 2012 at the Brunswick Project (USASAC 2012).

	Hatchery Origin				**Wild Origin**				
	1SW	**2SW**	**3SW**	**Repeat**	**1SW**	**2SW**	**3SW**	**Repeat**	**Total**
1983-2000	26	507	6	2	6	83	0	1	**631**
2001	1	4	0	0	0	0	0	0	**5**
2002	0	2	0	0	0	0	0	0	**2**
2003	0	3	0	0	0	0	0	0	**3**
2004	3	7	0	0	0	1	0	0	**11**
2005	2	8	0	0	0	0	0	0	**10**
2006	5	1	0	0	0	0	0	0	**6**
2007	6	11	0	0	1	2	0	0	**20**
2008	8	5	0	0	2	1	0	0	**16**
2009	2	19	0	0	0	3	0	0	**24**
2010	2	5	0	0	0	2	0	0	**9**
2011	2	25	0	0	1	16	0	0	**44**
2012	0	0	0	0	0	0	0	0	**0**
Total	**57**	**597**	**6**	**2**	**10**	**108**	**0**	**1**	**737**

Prior to 2007, MDMR stated that there were no indications that the Androscoggin River had a reproducing population of Atlantic salmon (letter from MDMR to FERC dated March 25, 2010). Documented annual runs of returning adult salmon consisted primarily (98%) of fish originating as hatchery smolts released into Maine rivers. In 2007 and 2008 several returning adults captured at the Brunswick fishway were determined to be fry-stocked or naturally reared fish. As stocking efforts in other DPS rivers increase so does the amount of strays captured at the Brunswick Dam.

Adult Atlantic salmon are released above the Brunswick Dam to continue upstream migration after biological data (e.g., length) are collected. The mean fork length of returning adults was

603 mm in 2008 and 735 in 2009 (MDMR 2010). Several adult salmon have been captured at the Brunswick fishway with fin-clips or tags, indicating that these fish are strays or stocked landlocked salmon from other rivers (MDMR 2010). The Maine Atlantic Salmon Technical Advisory Committee (MASTAC) collects fin-clips for genetic samples in an attempt to identify the origin of returning salmon (MDMR 2010). The MASTAC plans to conduct future analyses to determine the origin of these and all other adult Atlantic salmon captured at the Brunswick fishway (MDMR 2010).

The next two dams encountered on the Androscoggin River upstream of the Brunswick Dam are the Pejepscot and Worumbo Dams. Both projects have anadromous upstream passage facilities. With passage at the first three dams on the river, Atlantic salmon have access up to Lewiston Falls (Fay *et al.* 2006, MDMR 2010). This available habitat represents approximately 27 miles of accessible water in the lower Androscoggin River from the Brunswick Project to Lewiston Falls. Atlantic salmon habitat is quantified in the GOM DPS by mapping Hydrologic Unit Codes 10 scale (HUC10) to define suitable Atlantic salmon habitat units (NMFS 2009a). Each habitat unit equals 100 square meters. The Androscoggin River consists of 97,598 historic HUC10 habitat units. An estimated 17% (16,978 units) of these historic habitat units within the Androscoggin River system are considered to be occupied and occur in the lower Androscoggin River drainage (NMFS 2009a). Atlantic salmon habitat quality is measured in HUC10s based on the suitability of several parameters using a scale from zero to three, which include temperature, biological communities, water quality, and substrate and cover. Low quality habitat scores have been assigned to the lower Androscoggin River, while high scores were determined in the upper inaccessible reaches of the river (NMFS 2009a).

Fay *et al.* (2006) report that "...practically all suitable rearing habitat in the Androscoggin River watershed is not currently accessible to Atlantic salmon." The availability of suitable spawning habitat is unknown; no documentation of successful spawning in the Androscoggin River exists although naturally reared fish have been documented to occur in the river (MDMR 2012). In 2011, HDR evaluated the spawning habitat in the Little River, 800 meters downriver of the Worumbo Project, and found numerous barriers and poor substrates. However, MDMR indicates that there is a significant amount of habitat in the Little River and that it could hold "tens of thousands of eggs" (MDMR 2012b). During the 2011 telemetry study, MDMR documented a radio tagged female Atlantic salmon moving throughout the Little River, and it is thought that it may have spawned in Gillespie Brook, one of its tributaries (MDMR 2012b). The mainstem Androscoggin River is expected to provide minimal spawning habitat due to the existing impoundments and/or unsuitable substrates. However, MDMR identified the Pejepscot (in the mainstem) and Lower Barker (in the Little Androscoggin) bypass reaches as containing suitable spawning habitat (MDMR 2012b). In addition, tributaries in the central reaches of the Androscoggin River contain abundant (-40,000 units) suitable Atlantic salmon spawning and rearing habitat that is presently inaccessible due to dams (NMFS 2009b). Above Worumbo Dam the only sizeable tributary other than the Little Androscoggin that might provide suitable spawning and rearing habitat would be the Sabattus River; however, Lower Dam (a.k.a. Farwell Mill Dam), which is located about three kilometers upstream in the mouth of the Sabattus River, blocks access to the majority of the habitat.

Atlantic salmon stocking practices are common in the region for the GOM DPS stock enhancement program, although the Androscoggin River has been stocked with fewer fish than any other river with a stocking program for anadromous Atlantic salmon. A total of 13,000 fry have been stocked in the Androscoggin River since stocking commenced in 2001 (USASAC 2012). Most recently, the total number of juvenile salmon stocked in the Androscoggin River (fry only) was 2,000 individuals in 2009 and 1,000 in 2010 and 1,000 in 2011 (USASAC 2010, 2011, 2012). These numbers are most likely estimates of the amount of fry stocked into the Little River by school groups participating in salmon outreach programs (MDMR 2010). In comparison, other major GOM rivers were stocked at the following levels in 2011 (number of juveniles indicated in parenthesis): the Penobscot (1.8 million), Machias (347,500), Dennys (539,000), and Kennebec (85,000) rivers (USASAC 2012).

There have been few studies of Atlantic salmon in the Androscoggin River. In 2011, MDMR radio tagged 21 adult salmon (12 wild and 9 hatchery raised) when they were trapped at the Brunswick Dam (MDMR 2012b). 29% (6 out of 21) of these fish dropped out of the Androscoggin soon after they were released, and at least four of these continued their migration in the Kennebec River. 43% (9 out of 21) of the tagged fish successfully migrated past the Pejepscot Project, whereas fewer than 10% (2 out of 21) successfully passed all three dams in the lower Androscoggin (MDMR 2012b). The remaining 29% (6 out of 21) passed the Brunswick Project but did not migrate any further in the River. The study showed minimal use of tributaries in the system, although many fish were detected in the mainstem, holding in the vicinity of cool water tributaries during the summer months (Little River and Meadow Brook downstream of the Worumbo project; Gerrish Brook upstream of the Worumbo Project; and Simpson Brook downstream of the Pejepscot Project). One female Atlantic salmon was detected several times in the Little River, and may have spawned with an untagged male in one of its tributaries. Likewise, one tagged male was detected in the bypass reach of Lower Barker Dam and may have spawned with an untagged female (MDMR 2012b).

The fact that only 10% (2 out of 21) of the tagged adult Atlantic salmon successfully migrated past all three of the lower dams in 2011 may indicate poor passage efficiencies at the Pejepscot and Worumbo Projects, but likely also suggests that the salmon are poorly motivated to seek out upstream habitat. This conclusion is further supported by the fact that nearly one third of the salmon dropped out of the river soon after release in the Brunswick headpond and did not return. Overall, this study appears to support the conclusion that the majority of Atlantic salmon that enter the Androscoggin are strays that were stocked in other GOM DPS rivers.

The Androscoggin River is considered within the same Ecological Drainage Unit (EDU) as the Penobscot and Kennebec Rivers (Fay *et al.* 2006), which was considered in the decision to expand the GOM DPS in 2009 (USFWS and NMFS 2009). While salmon migration and habitat use studies are limited in the Androscoggin River, a number of studies have been conducted in the Penobscot River that may be relevant to the Androscoggin River. Specifically, adult Atlantic salmon returns are most common in June on the Penobscot River (MDMR 2007, 2008), and have been tracked with telemetry and observed to stop migration and seek thermal refuge when temperatures exceed 22°C (Holbrook 2007). Adult salmon have also been observed falling back and out of the river during periods of very high water temperatures (Shepard 1995, Holbrook

2007). After spawning, kelts have been observed in the lower Penobscot River in November (USASAC 2007). Based on NMFS Penobscot River smolt trapping studies in 2000 - 2005, smolts migrate from the Penobscot between late April and early June with a peak in early May (Fay *et al.* 2006). These NMFS data also demonstrate that the majority of the smolt migration appears to take place over a two-week period after water temperatures rise to 10°C.

3.1.4. Factors Affecting Atlantic Salmon in the Action Area

3.1.4.1. Hydroelectric Facilities

Within the Merrymeeting Bay SHRU there are roughly 104 dams of which 15 are FERC licensed mainstem dams used for power generation or storage, resulting in over 59 kilometers of impounded river (MDEP 1999). Therefore, both the Kennebec and Androscoggin watersheds are heavily utilized for power production.

The Kennebec River Basin has been extensively developed for hydroelectric power production. There are currently 18 hydroelectric dams in the Kennebec watershed and 15 of these dams are impassable due to the lack of fishways. The Lockwood Project is the first impediment to upstream migration on the Kennebec River. There are nine facilities upstream of the Lockwood Project on the mainstem Kennebec River and an additional four on upstream tributaries. The vast majority of salmon habitat (nearly 90%) in the Kennebec River watershed is located above the Lockwood Project. Hydroelectric dams are known to impact Atlantic salmon through habitat alteration, fish passage delays, and entrainment and impingement.

On the Androscoggin below Rumford (the upper extent of the range of Atlantic salmon), major hydroelectric facilities include the upper and lower stations at the Rumford Falls project in Rumford; Riley/Jay/Livermore Projects in Jay, Riley and Livermore; Gulf Island/Deer Rips project in Lewiston-Auburn; Lewiston Falls project in Lewiston/Auburn; the Worumbo Project in Lisbon/Durham; Worumbo in Topsham/Brunswick; and the Brunswick project in Brunswick/Topsham. Today, the upper extent of fish passage in the Androscoggin River is Lewiston Falls, which is located 32 km (20 miles) upstream from Merrymeeting Bay.

Habitat Alteration

Dams have eliminated or degraded vast, but to date un-quantified, reaches of suitable rearing habitat in the Kennebec and Androscoggin River watersheds. The Kennebec River consists of 254,558 historic habitat units, with 44,402 units considered to be occupied. Similarly, the Androscoggin River consists of 97,598 historic habitat units, with 16,978 units considered to be occupied (NMFS 2009a). Impoundments created by these dams limit access to habitat, alter habitat, and degrade water quality through increased temperatures and 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 and Androscoggin River watersheds. Coincidently, these moderate to high gradient reaches, if free-flowing, would likely constitute the highest value as Atlantic salmon spawning, nursery, and adult resting habitat within the context of all potential salmon habitat within these reaches.

Compared to a natural hydrograph, the operation of dams in a store-and-release mode in the upper reaches of the two rivers results in reduced spring runoff flows, less severe flood events, and augmented summer and early fall flows. Such operations in turn reduce sediment flushing and transport and physical scouring of substrates, and increase surface area and volume of summer and early fall habitat in the main stem. The extent to which these streamflow modifications in the upper Kennebec and Androscoggin River watersheds impact salmon populations, habitat (including migratory corridors during applicable seasons), and restoration efforts is unknown. However, increased embeddedness of spawning and invertebrate colonization substrates, diminished flows during smolt and kelt outmigration, and enhanced habitat quantity and, potentially, "quality" for non-native predators such as smallmouth bass, are likely among the adverse impacts to salmon. Conversely, higher summer and early fall stream flows may provide some benefits to Atlantic salmon or their habitat within affected reaches, and may also help mitigate certain potential water quality impacts (e.g., dilution of harmful industrial and municipal discharges).

Habitat Connectivity

Smolts from the Kennebec and Androscoggin Rivers have to navigate through multiple dams on their migrations to the estuary every spring. While several studies have been conducted at hydroelectric dams in the lower Kennebec River to assess downstream passage effectiveness for smolts, survival of smolts migrating past dams is presently unknown. The route that a salmon smolt takes when passing a project is a major factor in its likelihood of survival. Fish that pass through a properly designed downstream bypass have a better chance of survival than a fish that goes over a spillway, which, in turn, has a better chance of survival than a fish swimming through the turbines. It can be assumed that close to 100% of smolts will survive when passing through a properly designed downstream bypass. Survival through turbines varies significantly based on numerous factors, but as described above can be significantly lower than the other two routes.

Although the survival of smolts migrating past dams in the Kennebec and Androscoggin Rivers is presently unknown, smolt studies conducted by Holbrook (2007) on the Penobscot River documented significant losses of smolts in the vicinity of mainstem dams. Of the tagged salmon smolts used in the study in 2005 and 2006, 43% and 60%, respectively, were lost in the vicinity of the West Enfield, Howland, and Milford Dams. Although these data do not definitively reveal sources of mortality, these losses are likely attributable to the direct and indirect effects of the dams (e.g., physical injury, predation). Alden Research Laboratory (Alden 2012) modeled the smolt survival rates of 15 hydroelectric dams in the Penobscot River. The average of the mean survival rates at the 15 projects (accounting for both direct and indirect mortality) was 89.5%, but survival at individual dams fell as low as 61.5%.

Atlantic salmon kelts move downstream after spawning in November or, alternatively, overwinter in freshwater and outmigrate early in the spring (mostly mid-April through late May). Lévesque *et al.* (1985) and Baum (1997) suggest that 80% of kelts overwinter in freshwater habitat prior to returning to the ocean. No kelt survival studies have been conducted on the Androscoggin River, however, downstream passage success at dams on the Penobscot has been studied. Kelt passage occurred during periods of spill at most dams, and a large portion of study fish used the spillage. Kelt attraction to, and use of, downstream passage facilities was highly variable depending on facility, year of study, and hydrological conditions (e.g., spill or not). Shepard (1989a) documented that kelts relied on spillage flows to migrate past the Milford and Veazie Dams on the Penobscot River during a study conducted in 1988. In fact, some kelts spent hours to days searching for spillway flows to complete their downstream migration during the 1988 study.

High quality spawning and rearing habitat is not presently accessible volitionally to Atlantic salmon in the Kennebec River. To access high quality spawning and rearing habitat, Atlantic salmon must be trapped at the Lockwood Project and transported by trucks to upstream areas. This is due to the lack of upstream fish passage facilities at mainstem dams including the Hydro Kennebec, Shawmut, and Weston Projects. While trap and truck fish passage can successfully move migrants to upstream areas, trap and truck operations to transport migratory fish species can result in adverse impacts including injury, disorientation, disease and mortality, delay in migration, and interruption of the homing instinct, which can lead to straying (OTA 1995). Other disadvantages to trap and truck passage include: holding and handling stress, reduced passage by other species that will not enter traps, and the need for long-term, guaranteed operational funding for dedicated biological staff, equipment, supplies, vehicles and tanks, etc.

Androscoggin River

In 1982, Central Maine Power Company (CMP) reconstructed the hydroelectric facility in Brunswick-Topsham (Brown *et al.* 2006) on the Androscoggin River. CMP installed a slot fishway with a trapping and sorting facility. At that time, the MDMR began the Anadromous Fish Restoration Program in the lower Androscoggin River main stem and tributaries below Lewiston Falls. In 1987, the Pejepscot Project, the second dam on the Androscoggin River, had upstream fish passage installed. In 1988, upstream passage facilities were installed at the Worumbo Project, the third upstream dam on the river. This provided an opportunity for anadromous species to migrate upstream as far as Lewiston Falls (Brown *et al.*2006).

No upstream passage studies for Atlantic salmon have been conducted at the dams on the Androscoggin River, although annual counts of pre-spawn migrating Atlantic salmon trapped at the Brunswick and Worumbo Dams have been made since 1983. Few Atlantic salmon are known to migrate upriver of all three passable dams in the lower Androscoggin River. Between zero and 44 Atlantic salmon per year (average of 15 fish) passed the Brunswick Dam between 2003 and 2012 (Table 9). Of these, an average of 13% (range between 0% and 56%) successfully passed the Worumbo Project. Similarly, in a radio telemetry study conducted in 2011, while the spillway rehabilitation was occurring, MDMR documented that fewer than 10% (2 out of 21) of tagged salmon passed at the Brunswick Project successfully migrated past the Worumbo Project. In the same study, MDMR documented that 43% (9 out of 21) of tagged salmon successfully passed the Pejepscot Project (MDMR 2012b). Individual Atlantic salmon may use existing habitat and tributaries between dams and may not attempt to pass the next upstream dam. Tributaries exist between the Brunswick Project and the Worumbo Project that may contain Atlantic salmon habitat (MDMR 2010). Individual Atlantic salmon may migrate to these tributaries to spawn or seek thermal refuge, instead of migrating further upstream past the Worumbo Project.

Table 9. The number of sea run Atlantic salmon passing the Brunswick and Worumbo Projects between 2003 and 2012, and the proportion that are known to pass all three of the lower-most dams in the Androscoggin River.

Year	Brunswick Project	Worumbo Project	Proportion that Pass the Worumbo Project
2003	3	1	33%
2004	12	1	8%
2005	10	0	0%
2006	6	2	33%
2007	21	7	33%
2008	18	2	11%
2009	24	1	4%
2010	9	5	56%
2011	44	3	7%
2012	0	0	
Average	**15**	**2**	**13%**

3.1.4.2. Delayed Effects of Downstream Passage

In addition to direct mortality sustained by Atlantic salmon at hydroelectric projects, Atlantic salmon in the Kennebec and Androscoggin Rivers will also sustain delayed mortality as a result of repeated passage events at multiple hydroelectric projects. Studies have investigated what is referred to as latent or delayed mortality, which occurs in the estuary or ocean environment and is associated with passage through one or more hydro projects (Budy *et al.* 2002, ISAB 2007, Schaller and Petrosky 2007, Haeseker *et al.* 2012). The concept describing this type of mortality is known as the hydrosystem-related, delayed-mortality hypothesis (Budy *et al.* 2002, Schaller and Petrosky 2007, Haeseker *et al.* 2012).

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 (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. In addition to linking hydrosystem experience to delayed mortality, Budy *et al.* (2002) cited evidence from mark-recapture studies that demonstrated differences in delayed mortality among passage routes (i.e., turbines, spillways, bypass and transport systems).

Some 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. Estimates of delayed mortality reported in this study ranged from 0.75 to 0.95 (mean = 0.81) for the study years of 1991-1998 and 0.06 to 0.98 (mean = 0.64) for the period of 1975-1990. Haeseker *et al.* (2012) assessed the effects of environmental conditions experienced in freshwater and the marine environment on delayed mortality of Snake River chinook salmon and steelhead trout. This study examined seasonal and life-stage-specific survival rates of both species and analyzed the influence of environmental factors (freshwater: river flow spilled and water transit time; marine: spring upwelling, Pacific Decadal Oscillation, sea surface temperatures). Haeseker *et al.* (2012) found that both the percentage of river flow spilled and water transit time influenced in-river and estuarine/marine survival rates, whereas the Pacific Decadal Oscillation index was the most important factor influencing variation in marine and cumulative smolt-to-adult survival of both species. Also, freshwater and marine survival rates were shown to be correlated, demonstrating a relation between hydrosystem experience on estuarine and marine survival. The studies described above clearly support the delayed-mortality hypothesis proposed by Budy *et al.* (2002). However, only one of the studies quantified delayed mortality, and the estimates varied considerably. Although Rechisky *et al.* (2012) found no evidence of hydrosystem related delayed mortality between juvenile Snake River and Yakima River Chinook salmon they acknowledged limitations within their study.

Although delayed mortality following passage through a hydrosystem has been demonstrated by the studies discussed above, effectively quantifying such losses remains difficult, mainly because of practical limitations in directly measuring mortality after fish have left a river system (i.e., during time spent in estuaries and the marine environment). Evaluations of delayed mortality have generally produced indirect evidence to support the link between hydrosystem experience and estuary and marine survival rates (and smolt-to-adult returns). In fact, in a review of delayed mortality experienced by Columbia River salmon, ISAB (2007) recommended that attempts should not be made to provide direct estimates of absolute delayed mortality, concluding that measuring such mortality relative to a damless reference was not possible. Alternatively, it was suggested that the focus should be on estimating total mortality of in-river fish, which was considered more critical to the recovery of listed salmonids. Consequently, it is difficult to draw absolute or quantifiable inferences from the Columbia River studies to other river systems beyond the simple conclusion that delayed mortality likely occurs for most anadromous salmonid populations. Additionally, although there is evidence of differential mortality between upper and lower river smolts in the Columbia River basin (Schaller and Petrosky 2007), data are not available for estimating a cumulative mortality rate based on the number of dams passed by downstream migrants.

Given the difficulty in estimating this type of mortality at the present time, we do not have sufficient data to specifically assess the effect of hydrosystem-related mortality in the Kennebec and Androscoggin Rivers. Thus, we have not attempted to quantify the delayed (or delayed) loss of smolts or kelts attributed to the licensee's projects in this Opinion. Nevertheless, considering the multiple FERC licensed hydroelectric projects in the Kennebec and Androscoggin River watersheds, it can be assumed that practically all smolts and kelts in the river must pass at least two hydroelectric dams during the downstream migrations and the resulting loss of endangered Atlantic salmon could be significant. According to a model developed by NMFS (2012), even a small cumulative mortality rate (1-10%) could have a significant effect on the number of returning 2 SW female Atlantic salmon in the Penobscot River watershed.

3.1.4.3.Predation

In addition to direct mortality during downstream passage, kelts and smolts are exposed to indirect mortality caused by sub-lethal injuries, increased stress, and/or disorientation. A large proportion of indirect mortality is a result of disorientation caused by downstream passage, which can lead to elevated levels of predation immediately downstream of the project (Mesa 1994).

Smallmouth bass and chain pickerel are each important predators of 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 very abundant in the Androscoggin and Kennebec Rivers, and they inhabit much of the main stem migratory corridor and areas containing juvenile Atlantic salmon. Smallmouth bass likely feed on fry and parr though little quantitative information exists regarding the extent of bass predation upon salmon fry and parr. Smallmouth bass are important predators of smolts in main stem 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 certainly feed upon fry and parr, as well as smolts, given their piscivorous feeding habits (Van den Ende 1993). Chain pickerel feed actively in temperatures below 10°C (Van den Ende 1993, MDIFW 2002). Smolts were, by far, the most common item in the diet of chain pickerel observed by 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.

Northern pike were illegally stocked in Maine, and their range now includes portions of the lower Androscoggin and Kennebec Rivers (MDIFW 2008). Northern pike are ambush predators that rely on vision and thus, predation upon smolts occurs primarily in daylight with the highest predation rates in low light conditions at dawn and dusk (Bakshtansky *et al.* 1982). Hatchery smolts experience higher rates of predation by fish than wild smolts, particularly from northern pike (Ruggles 1980, Bakshtansky *et al.* 1982).

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 items in cormorant sampled at main stem dam foraging sites. Common mergansers, belted kingfishers cormorants, and loons would likely prey upon Atlantic salmon in the Androscoggin and Kennebec River. The abundance of alternative prey resources such as upstream migrating alewife, likely minimizes the impacts of cormorant predation on the GOM DPS (Fay *et al.* 2006).

3.1.4.4.Contaminants and Water Quality

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 sct to maintain the existing water quality classification. Generally, the impacts of point source pollution are greater in the larger rivers of the GOM DPS.

Kennebec River

The DEP has a schedule for preparing a number of TMDLs for rivers and streams within the Kennebec River watershed. TMDLs allocate a waste load for a particular pollutant for impaired waterbodies. The main stem 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.

Androscoggin River

Poor water quality within segments of the Androscoggin River is of particular concern for fisheries restoration. The U.S. Environmental Protection Agency (USEPA) noted that two segments of the Androscoggin, including the lower four miles of the Gulf Island dam impoundment and the Livermore Falls impoundment do not attain water quality standards for class C waters (USEPA 2005). The non-attainment status is caused by point source discharges upriver from the three paper mills located in Berlin, New Hampshire (Fraser Paper), Rumford, Maine (Mead WestVaco), and Jay, Maine (International Paper); five municipal point sources from locations in Berlin and Gorham, New Hampshire and Bethel, Rumford-Mexico, and Livermore Falls, Maine; and non-point source pollutant loads from land use activities, particularly that related to residential development, silviculture, and agriculture (USEPA 2005).

The MDEP has four standards for classification of freshwater which are not classified as "great ponds". These are class AA, A, B, and C waters, in which class AA is the highest classification in which waters are considered to be "outstanding natural resources and which should be preserved because of their ecological, social, scenic or recreational importance"; and class C waters is the lowest classification in which class C waters "shall be of such quality that they are suitable for the designated uses of drinking water supply after treatment; fishing; recreation in and on the water; industrial process and cooling water supply; hydroelectric power generation, except as prohibited…, navigation, and as a habitat for fish and other aquatic life." (State of Maine, Title 38 *§ 465*).

The Gulf Island Dam impoundment does not meet the Class C standards for dissolved oxygen concentration in the summer at depths of 30 to 80 feet. In addition to the pollution sources upstream from the dam, the dam itself contributes to non-attainment of DO criteria and algae growth by creating an environment of low water movement and low vertical mixing with the deeper water column (USEPA 2005). The Livermore Falls impoundment does not attain the class C aquatic life criteria in which dissolved oxygen shall not fall below an instantaneous minimum of 5 ppm and 60 percent saturation, and a 30 day average long term minimum of 6.5 ppm (USEPA 2005).

3.1.5. Summary of Factors Affecting Recovery of Atlantic Salmon

There are a wide variety of factors that have and continue to affect the current status of the GOM DPS. The potential interactions among these factors are not well understood, nor are the reasons for the seemingly poor response of salmon populations to the many ongoing conservation efforts for this species.

Threats to the Species

The recovery plan for the previously designated GOM DPS (NMFS and USFWS 2005), the latest status review (Fay *et al.* 2006), and the 2009 listing rule all provide a comprehensive assessment of the many factors, including both threats and conservation actions, that are currently affecting the status and recovery of listed Atlantic salmon. The Services are writing a new recovery plan that will include the current, expanded GOM DPS and its designated critical habitat. The new recovery plan provides the most up to date list of significant threats affecting the GOM DPS. These are the following:

- Dams
- Inadequacy of existing regulatory mechanisms for dams
- Continued low marine survival rates for U.S. stocks of Atlantic salmon
- Lack of access to spawning and rearing habitat due to dams and road-stream crossings

In addition to these significant threats, there are a number of lesser stressors. These are the following:

- Degraded water quality
- Aquaculture practices, which pose ecological and genetic risks
- Climate change
- Depleted diadromous fish communities
- Incidental capture of adults and parr by recreational anglers
- Introduced fish species that compete or prey on Atlantic salmon
- Poaching of adults in DPS rivers
- Recovery hatchery program (potential for artificial selection/domestication)
- Sedimentation of spawning and rearing habitat

- Water extraction

Fay *et al.* (2006) examined each of the five statutory ESA listing factors and determined that each of the five listing factors is at least partly responsible for the present low abundance of the GOM DPS. The information presented in Fay *et al.* (2006) is reflected in and supplemented by the final listing rule for the new GOM DPS (74 FR 29344; June 19, 2009). The following gives a brief overview of the five listing factors as related to the GOM DPS.

1. **Present or threatened destruction, modification, or curtailment of its habitat or range** – Historically and, to a lesser extent currently, dams have adversely impacted Atlantic salmon by obstructing fish passage and degrading riverine habitat. Dams are considered to be one of the primary causes of both historic declines and the contemporary low abundance of the GOM DPS. Land use practices, including forestry and agriculture, have reduced habitat complexity (e.g., removal of large woody debris from rivers) and habitat connectivity (e.g., poorly designed road crossings) for Atlantic salmon. Water withdrawals, elevated sediment levels, and acid rain also degrade Atlantic salmon habitat.

2. **Overutilization for commercial, recreational, scientific, or educational purposes** – While most directed commercial fisheries for Atlantic salmon have ceased, the impacts from past fisheries are still important in explaining the present low abundance of the GOM DPS. Both poaching and by-catch in recreational and commercial fisheries for other species remain of concern, given critically low numbers of salmon.

3. **Predation and disease** – Natural predator-prey relationships in aquatic ecosystems in the GOM DPS have been substantially altered by introduction of non-native fishes (e.g., chain pickerel, smallmouth bass, and northern pike), declines of other native diadromous fishes, and alteration of habitat by impounding free-flowing rivers and removing instream structure (such as removal of boulders and woody debris during the log-driving era). The threat of predation on the GOM DPS is noteworthy because of the imbalance between the very low numbers of returning adults and the recent increase in populations of some native predators (e.g., double-crested cormorant), as well as non-native predators. Atlantic salmon are susceptible to a number of diseases and parasites, but mortality is primarily documented at conservation hatcheries and aquaculture facilities.

4. **Inadequacy of existing regulatory mechanisms** – The ineffectiveness of current federal and state regulations at requiring fish passage and minimizing or mitigating the aquatic habitat impacts of dams is a significant threat to the GOM DPS today. Furthermore, most dams in the GOM DPS do not require state or federal permits. Although the State of Maine has made substantial progress in regulating water withdrawals for agricultural use, threats still remain within the GOM DPS, including those from the effects of irrigation wells on salmon streams.

5. **Other natural or manmade factors** – Poor marine survival rates of Atlantic salmon are a significant threat, although the causes of these decreases are unknown. The role of ecosystem function among the freshwater, estuarine, and marine components of the Atlantic salmon's life history, including the relationship of other diadromous fish species in Maine (e.g., American shad, alewife, sea lamprey), is receiving increased scrutiny in

its contribution to the current status of the GOM DPS and its role in recovery of the Atlantic salmon. While current state and federal regulations pertaining to finfish aquaculture have reduced the risks to the GOM DPS (including eliminating the use of non-North American Atlantic salmon and improving containment protocols), risks from the spread of diseases or parasites and from farmed salmon escapees interbreeding with wild salmon still exist.

Efforts to Protect the GOM DPS of Atlantic salmon

Efforts aimed at protecting Atlantic salmon and their habitats in Maine have been underway for well over one hundred years. These efforts are supported by a number of federal, state, and local government agencies, as well as many private conservation organizations. The 2005 recovery plan for the originally-listed GOM DPS (NMFS and USFWS 2005) presented a strategy for recovering Atlantic salmon that focused on reducing the most severe threats to the species and immediately halting the decline of the species to prevent extinction. The 2005 recovery program included the following elements:

1. Protect and restore freshwater and estuarine habitats;
2. Minimize potential for take in freshwater, estuarine, and marine fisheries;
3. Reduce predation and competition for all life-stages of Atlantic salmon;
4. Reduce risks from commercial aquaculture operations;
5. Supplement wild populations with hatchery-reared DPS salmon;
6. Conserve the genetic integrity of the DPS;
7. Assess stock status of key life stages;
8. Promote salmon recovery through increased public and government awareness; and
9. Assess effectiveness of recovery actions and revise as appropriate.

A wide variety of activities have focused on protecting Atlantic salmon and restoring the GOM DPS, including (but not limited to) hatchery supplementation; removing dams or providing fish passage; improving road crossings that block passage or degrade stream habitat; 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. In light of the 2009 GOM DPS listing and designation of critical habitat, the Services are producing a new recovery plan for the expanded GOM DPS of Atlantic salmon.

3.2. Critical Habitat for Atlantic Salmon in the GOM DPS

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 3). 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).

Primary Constituent Elements of Atlantic Salmon Critical Habitat

Designation of critical habitat is focused on the known primary constituent elements (PCEs), within the occupied areas of a listed species that are deemed essential to the conservation of the species. Within the GOM DPS, the PCEs for Atlantic salmon are: 1) sites for spawning and rearing, and 2) sites for migration (excluding marine migration[1]). We chose not to separate spawning and rearing habitat into distinct PCEs, although each habitat does have distinct features, because of the GIS-based habitat prediction model approach that was used to designate critical habitat (74 FR 29300; June 19, 2009). This model cannot consistently distinguish between spawning and rearing habitat across the entire range of the GOM DPS.

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

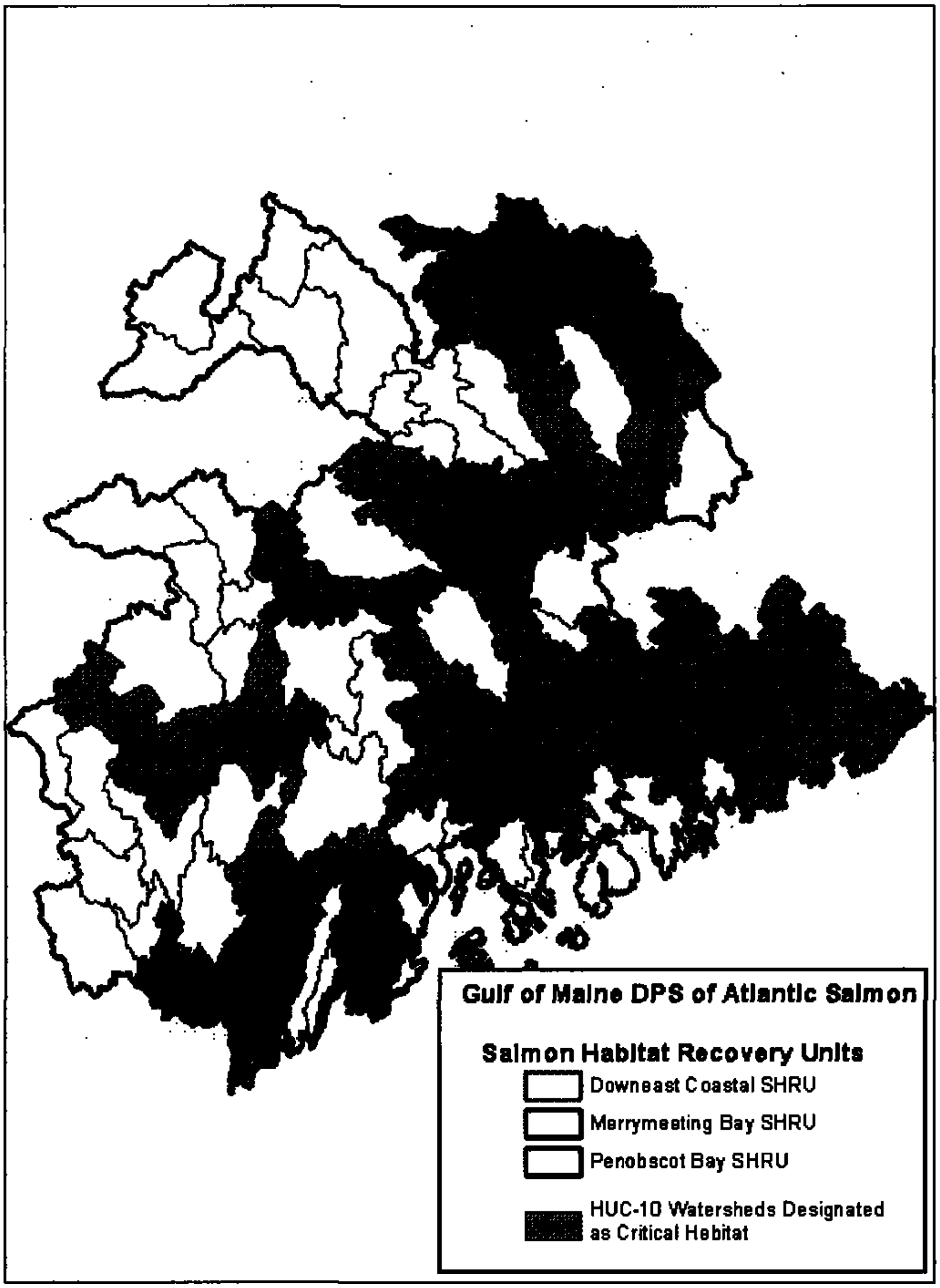

Figure 3. HUC-10 Watersheds Designated as Atlantic Salmon Critical Habitat within the GOM DPS.

The physical and biological features of the two PCEs for Atlantic salmon critical habitat are as follows:

Physical and Biological Features of the Spawning and Rearing PCE

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.
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.
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.
4. Freshwater rearing sites with space to accommodate growth and survival of Atlantic salmon parr.
5. 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.
6. Freshwater rearing sites with cool, oxygenated water to support growth and survival of Atlantic salmon parr.
7. Freshwater rearing sites with diverse food resources to support growth and survival of Atlantic salmon parr.

Physical and Biological Features of the Migration PCE

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.
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.
3. Freshwater and estuary migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation.
4. Freshwater and estuary migration sites free from physical and biological barriers that delay or prevent emigration of smolts to the marine environment.
5. Freshwater and estuary migration sites with sufficiently cool water temperatures and water flows that coincide with diurnal cues to stimulate smolt migration.
6. Freshwater migration sites with water chemistry needed to support sea water adaptation of smolts.

Habitat areas designated as critical habitat must contain one or more PCEs within the acceptable range of values required to support the biological processes for which the species uses that habitat. 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 has only been designated in areas (HUC-10 watersheds) considered currently occupied by the species. 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.

For an area containing PCEs to meet the definition of critical habitat, the ESA also requires that the physical and biological features essential to the conservation of Atlantic salmon in that area "may require special management considerations or protections." Activities within the GOM DPS that were identified as potentially affecting the physical and biological features of salmon habitat and, therefore, requiring special management considerations or protections include agriculture, forestry, changing land-use and development, hatcheries and stocking, roads and road-stream crossings, mining, dams, dredging, and aquaculture.

Salmon Habitat Recovery Units within Critical Habitat for the GOM DPS

In describing critical habitat for the GOM DPS, we divided the DPS into three Salmon Habitat Recovery Units or SHRUs. The three SHRUs include the Downeast Coastal, Penobscot Bay, and Merrymeeting Bay. The SHRU delineations were designed 1) to ensure that a recovered Atlantic salmon population has widespread geographic distribution to help maintain genetic variability and 2) to 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, as will be needed to achieve recovery of the GOM DPS.

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 within the GOM DPS was estimated through the use of a GIS-based salmon habitat model (Wright *et al.* 2008). For each SHRU, we determined that there were sufficient habitat units available 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. A brief historical description for each SHRU, as well as contemporary critical habitat designations and special management considerations, are provided below.

Downeast Coastal SHRU

The Downeast Coastal SHRU encompasses fourteen HUC-10 watersheds covering approximately 747,737 hectares (1,847,698 acres) within Washington and Hancock counties. In this SHRU there are approximately 59,066 units of spawning and rearing habitat for Atlantic salmon among approximately 6,039 kilometers of rivers, lakes and streams. Of the 59,066 units of spawning and rearing habitat, approximately 53,400 units of habitat in eleven HUC-10 watersheds are considered to be currently occupied. The Downeast SHRU has enough habitat units available within the occupied range that, in a restored state (*e.g.* improved fish passage or improved habitat quality), the Downeast SHRU could satisfy recovery objectives as described in the final rule for critical habitat (74 FR 29300; June 19, 2009). Certain tribal and military lands within the Downeast Coastal SHRU are excluded from critical habitat designation.

Penobscot Bay SHRU

The Penobscot Bay SHRU, which drains approximately 22,234,522 hectares (54,942,705 acres), contains approximately 315,574 units of spawning and rearing habitat for Atlantic salmon among approximately 17,440 kilometers of rivers, lakes and streams. Of the 315,574 units of spawning and rearing habitat (within 46 HUC-10 watersheds), approximately 211,000 units of habitat are considered to be currently occupied (within 28 HUC-10 watersheds). Three HUC-10 watersheds (Molunkus Stream, Passadumkeag River, and Belfast Bay) are excluded from critical habitat designation due to economic impact. Certain tribal lands within the Penobscot Bay SHRU are also excluded from critical habitat designation.

Merrymeeting Bay SHRU

The Merrymeeting Bay SHRU drains approximately 2,691,814 hectares of land (6,651,620 acres) and contains approximately 339,182 units of spawning and rearing habitat for Atlantic salmon located among approximately 5,950 kilometers of historically accessible rivers, lakes and streams. Of the 339,182 units of spawning and rearing habitat, approximately 136,000 units of habitat are considered to be currently occupied. There are forty-five HUC-10 watersheds in this SHRU, but only nine are considered currently occupied. Lands controlled by the Department of Defense within the Little Androscoggin HUC-10 and the Sandy River HUC-10 are excluded as critical habitat.

In conclusion, the June 19, 2009 final critical habitat designation for the GOM DPS (as revised on August 10, 2009) includes 45 specific areas occupied by Atlantic salmon that comprise approximately 19,571 km of perennial river, stream, and estuary habitat and 799 km^2 of lake habitat within the range of the GOM DPS and on which are found those physical and biological features essential to the conservation of the species. Within the occupied range of the GOM DPS, approximately 1,256 km of river, stream, and estuary habitat and 100 km^2 of lake habitat have been excluded from critical habitat pursuant to section 4(b)(2) of the ESA.

3.2.1. Status of Atlantic Salmon Critical Habitat in the Action Area

The environmental baseline of this Opinion describes the status of salmonid habitat, which is important for two reasons: a) because it affects the viability of the listed species within the action area at the time of the consultation; and b) because those habitat areas designated "critical" provide PCEs essential for the conservation (i.e., recovery) of the species. The environmental baseline also describes the status of critical habitat over the duration of the proposed action because it includes the persistent effects of past actions and the future effects of Federal actions that have not taken place but have already undergone section 7 consultation.

The complex life cycles exhibited by Atlantic salmon give rise to complex habitat needs, particularly during the freshwater phase (Fay *et al.* 2006). Spawning gravels must be a certain size and free of sediment to allow successful incubation of the eggs. Eggs also require cool, clean, and well-oxygenated waters for proper development. Juveniles need abundant food sources, including insects, crustaceans, and other small fish. They need places to hide from predators (mostly birds and bigger fish), such as under logs, root wads, and boulders in the stream, as well as beneath overhanging vegetation. They also need places to seek refuge from periodic high flows (side channels and off-channel areas) and from warm summer water temperatures (coldwater springs and deep pools). Returning adults generally do not feed in fresh water but instead rely on limited energy stores to migrate, mature, and spawn. Like juveniles, they also require cool water and places to rest and hide from predators. During all life stages, Atlantic salmon require cool water that is free of contaminants. They also need migratory corridors with adequate passage conditions (timing, water quality, and water quantity) to allow access to the various habitats required to complete their life cycle.

As discussed previously, critical habitat for Atlantic salmon has been designated in the Kennebec and Androscoggin Rivers. Both PCEs for Atlantic salmon (sites for spawning and rearing and sites for migration) are present in the action area as it was described in Section 2.6 of this Opinion (the entirety of the Kennebec and Androscoggin River watersheds). PCEs consist of the physical and biological elements identified as essential to the conservation of the species in the documents designating critical habitat. These PCEs include sites essential to support one or more life stages of Atlantic salmon (sites for spawning, rearing, and migration) and contain physical or biological features essential to the conservation of the species, for example, spawning gravels, water quality and quantity, unobstructed passage, and forage.

To facilitate and standardize determinations of effect for section 7 consultations involving Atlantic salmon critical habitat, we developed the "Matrix of PCEs and Essential Features for Designated Atlantic Salmon Critical Habitat in the GOM DPS" (Table 10). The matrix lists the PCEs, physical and biological features (essential features) of each PCE, and the potential conservation status of critical habitat within an action area. The two PCEs in the matrix (spawning and rearing, and migration) are described in regards to five distinct Atlantic salmon life stages: (1) adult spawning; (2) embryo and fry development; (3) parr development; (4) adult migration; and, (5) smolt migration. The conservation status of the essential features may exist in varying degrees of functional capacity within the action area. The three degrees of functional capacity used in the matrix are described in ascending order: (1) fully functioning; (2) limited function; and (3) not properly functioning. Using this matrix along with information presented in FERC's BA and site-specific knowledge of each project, we have determined that several essential features to Atlantic salmon in the action area have limited function or are not properly functioning currently (Table 11).

Table 10. Matrix of Primary Constituent Elements (PCEs) and essential features for assessing the environmental baseline of the action area.

		Conservation Status Baseline		
PCE	Essential Features	Fully Functioning	Limited Function	Not Properly Functioning
A) Adult Spawning: (October 1st - December 14th)				
	Substrate	highly permeable course gravel and cobble between 1.2 to 10 cm in diameter	40- 60% cobble (22.5-256 mm dia.) 40-50% gravel (2.2 – 22.2 mm dia.); 10-15% course sand (0.5 -2.2 mm dia.), and <3% fine sand (0.06-0.05mm dia.)	more than 20% sand (particle size 0.06 to 2.2 mm), no gravel or cobble
	Depth	17-30 cm	30 - 76 cm	< 17 cm or > 76 cm
	Velocity	31 to 46 cm/sec.	8 to 31cm/sec. or 46 to 83 cm/sec.	<5-8 cm/sec. or > 83cm/sec.
	Temperature	7° to 10°C	often between 7° to 10°C	always < 7° or > 10°C
	pH	> 5.5	between 5.0 and 5.5	< 5.0
	Cover	Abundance of pools 1.8-3.6 meters deep (McLaughlin and Knight 1987). Large boulders or rocks, over hanging trees, logs, woody debris, submerged vegetation or undercut banks	Limited availability of pools 1.8-3.6 meters deep (McLaughlin and Knight 1987). Large boulders or rocks, over hanging trees, logs, woody debris, submerged vegetation or undercut banks	Absence of pools 1.8-3.6 meters deep (McLaughlin and Knight 1987). Large boulders or rocks, over hanging trees, logs, woody debris, submerged vegetation or undercut banks
	Fisheries Interactions	Abundant diverse populations of indigenous fish species	Abundant diverse populations of indigenous fish species, low quantities of non-native species present	Limited abundance and diversity of indigenous fish species, abundant populations of non-native species
B) Embryo and Fry Development: (October 1st - April 14th)				
	Temperature	0.5°C and 7.2°C, averages nearly 6oC from fertilization to eye pigmentation	averages < 4oC, or 8 to 10°C from fertilization to eye pigmentation	>10°C from fertilization to eye pigmentation
	D.O.	at saturation	7-8 mg/L	< 7 mg/L
	pH	> 6.0	6 - 4.5	< 4.5
	Depth	5.3-15cm	NA	<5.3 or >15cm
	Velocity	4 – 15cm/sec.	NA	<4 or > 15cm/sec.
	Fisheries Interactions	Abundant diverse populations of indigenous fish species	Abundant diverse populations of indigenous fish species, low quantities of non-native species present	Limited abundance and diversity of indigenous fish species, abundant populations of non-native species

TABLE 10 continued...

		Conservation Status Baseline		
PCE	Essential Features	Fully Functioning	Limited Function	Not Properly Functioning
C) Parr Development: (All year)				
	Substrate	gravel between 1.6 and 6.4 cm in diameter and boulders between 30 and 51.2 cm in diameter. May contain rooted aquatic macrophytes	gravel < 1.2cm and/or boulders > 51.2. May contain rooted aquatic macrophytes	no gravel, boulders, or rooted aquatic macrophytes present
	Depth	10cm to 30cm	NA	<10cm or >30cm
	Velocity	7 to 20 cm/sec.	< 7cm/sec. or > 20 cm/sec.	velocity exceeds 120 cm/sec.
	Temperature	15° to 19°C	generally between 7-22.5oC, but does not exceed 29oC at any time	stream temperatures are continuously <7oC or known to exceed 29oC
	D.O.	> 6 mg/l	2.9 - 6 mg/l	< 2.9 mg/l
	Food	Abundance of larvae of mayflies, stoneflies, chironomids, caddisflies, blackflies, aquatic annelids, and mollusks as well as numerous terrestrial invertebrates and small fish such as alewives, dace or minnows	Presence of larvae of mayflies, stoneflies, chironomids, caddisflies, blackflies, aquatic annelids, and mollusks as well as numerous terrestrial invertebrates and small fish such as alewives, dace or minnows	Absence of larvae of mayflies, stoneflies, chironomids, caddisflies, blackflies, aquatic annelids, and mollusks as well as numerous terrestrial invertebrates and small fish such as alewives, dace or minnows
	Passage	No anthropogenic causes that inhibit or delay movement	Presence of anthropogenic causes that result in limited inhibition of movement	barriers to migration known to cause direct inhibition of movement
	Fisheries Interactions	Abundant diverse populations of indigenous fish species	Abundant diverse populations of indigenous fish species, low quantities of non-native species present	Limited abundance and diversity of indigenous fish species, abundant populations of non-native species

TABLE 10 continued…

		Conservation Status Baseline		
PCE	Essential Features	Fully Functioning	Limited Function	Not Properly Functioning
D) Adult migration: (April 15th- December 14th)				
	Velocity	30 cm/sec to 125 cm/sec	In areas where water velocity exceeds 125 cm/sec adult salmon require resting areas with a velocity of < 61 cm/s	sustained speeds > 61 cm/sec and maximum speed > 667 cm/sec
	D.O.	> 5mg/L	4.5-5.0 mg/l	< 4.5mg/L
	Temperature	14 – 20°C	temperatures sometimes exceed 20oC but remain below 23°C.	> 23°C
	Passage	No anthropogenic causes that delay migration	Presence of anthropogenic causes that result in limited delays in migration	barriers to migration known to cause direct or indirect mortality of smolts
	Fisheries Interactions	Abundant diverse populations of indigenous fish species	Abundant diverse populations of indigenous fish species, low quantities of non-native species present	Limited abundance and diversity of indigenous fish species, abundant populations of non-native species
E) Juvenile Migration: (April 15th - June 14th)				
	Temperature	8 - 11oC	5 - 11°C.	< 5oC or > 11oC
	pH	> 6	5.5 - 6.0	< 5.5
	Passage	No anthropogenic causes that delay migration	Presence of anthropogenic causes that result in limited delays in migration	barriers to migration known to cause direct or indirect mortality of smolts

Table 11. Current conditions of essential features of Atlantic salmon critical habitat having limited function or not properly functioning in the action area.

Pathway/Indicator	Life Stages Affected	PCEs Affected	Effect	Population Viability Attributes Affected
Passage/Access to Historical Habitat	Adult, juvenile, smolt	Freshwater migration	Upstream passage delays and inefficiencies limit access to spawning habitat. Poor downstream passage causes direct and delayed mortality of smolts and kelts.	Adult abundance and productivity,
Habitat Elements, Channel Dynamics, Watershed Condition	Adult, incubating eggs, juvenile, smolt	Freshwater migration, spawning, and rearing	Impoundments degrade spawning and rearing habitat, increase predation, limit productivity, and delay migrations.	Adult abundance and productivity Juvenile growth rate
Water Quality	Adult, juvenile, incubating eggs	Freshwater spawning and rearing	Impoundments degrade spawning and rearing habitat.	Adult abundance and productivity Juvenile growth rate

3.2.2. Factors affecting Atlantic Salmon Critical Habitat in the Action Area

In Section 3.1.4, we present the factors affecting the GOM DPS of Atlantic salmon within the Kennebec and Androscoggin River watersheds. To the extent that these same factors (hydroelectric operations, predation, and water quality) affect the essential features of rearing, spawning and migration habitat in the Kennebec and Androscoggin River watersheds, they are also affecting Atlantic salmon critical habitat.

The final rule designating critical habitat for the GOM DPS identifies a number of activities that have and will likely continue to impact 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, in each of the three SHRUs.

Today, dams are the greatest impediment, outside of marine survival, to the recovery of salmon in the Penobscot, Kennebec and Androscoggin river basins (Fay *et al.* 2006). Hydropower dams in the Kennebec and Androscoggin Rivers significantly impede the migration of Atlantic salmon and other diadromous fish and either reduce or eliminate access to roughly 330,000 units of historically accessible spawning and rearing habitat. In addition to hydropower dams, agriculture and urban development largely affect the lower third of the Merrymecting Bay SHRU by reducing substrate and cover, reducing water quality, and elevating water temperatures. Additionally, smallmouth bass and brown trout introductions, along with other non-indigenous species, significantly degrade habitat quality throughout the Merrymecting Bay SHRU by altering natural predator/prey relationships.

3.3. Shortnose sturgeon

3.3.1. Species Description

Shortnose sturgeon are benthic fish that mainly occupy the deep channel sections of large rivers. They feed on a variety of benthic and epibenthic invertebrates including mollusks, crustaceans (amphipods, chironomids, isopods), and oligochaete worms (Vladykov and Greeley 1963, Dadswell 1979 *in* NMFS 1998). Shortnose sturgeon have similar lengths at maturity (45-55 cm fork length) throughout their range, but, because sturgeon in southern rivers grow faster than those in northern rivers, southern sturgeon mature at younger ages (Dadswell *et al.* 1984). Shortnose sturgeon are long-lived (30-40 years) and, particularly in the northern extent of their range, mature at late ages. In the north, males reach maturity at five to ten years, while females mature between seven and thirteen years. Based on limited data, females spawn every three to five years while males spawn approximately every two years. The spawning period is estimated to last from a few days to several weeks. Spawning begins from late winter/early spring (southern rivers) to mid to late spring (northern rivers)[2] when the freshwater temperatures increase to 8-9°C. Several published reports have presented the problems facing long-lived species that delay sexual maturity (Crouse *et al.* 1987, Crowder *et al.* 1994, Crouse 1999). In general, these reports concluded that animals that delay sexual maturity and reproduction must have high annual survival as juveniles through adults to ensure that enough juveniles survive to reproductive maturity and then reproduce enough times to maintain stable population sizes.

Total instantaneous mortality rates (Z) are available for the Saint John River (0.12 - 0.15; ages 14-55; Dadswell 1979), Upper Connecticut River (0.12; Taubert 1980), and Pee Dee-Winyah River (0.08-0.12; Dadswell *et al.* 1984). Total instantaneous natural mortality (M) for shortnose sturgeon in the lower Connecticut River was estimated to be 0.13 (T. Savoy, Connecticut Department of Environmental Protection, personal communication). There is no recruitment information available for shortnose sturgeon because there are no commercial fisheries for the species. Estimates of annual egg production for this species are difficult to calculate because females do not spawn every year (Dadswell *et al.* 1984). Further, females may abort spawning attempts, possibly due to interrupted migrations or unsuitable environmental conditions (NMFS 1998). Thus, annual egg production is likely to vary greatly in this species. Fecundity estimates have been made and range from 27,000 to 208,000 eggs/female (Dadswell *et al.* 1984).

At hatching, shortnose sturgeon are blackish-colored, 7-11mm long and resemble tadpoles (Buckley and Kynard 1981). In 9-12 days, the yolk sac is absorbed and the sturgeon develops into larvae which are about 15mm total length (TL; Buckley and Kynard 1981). Sturgeon larvae are believed to begin downstream migrations at about 20mm TL. Laboratory studies suggest that young sturgeon move downstream in a 2-step migration; a 2- to 3-day migration by larvae followed by a residency period by young of the year (YOY), then a resumption of migration by yearlings in the second summer of life (Kynard 1997). Juvenile shortnose sturgeon (between 3-10 years of age) reside in the interface between saltwater and freshwater in most rivers (NMFS

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[2] For purposes of this consultation, Northern rivers are considered to include tributaries of the Chesapeake Bay northward to the St. John River in Canada. Southern rivers are those south of the Chesapeake Bay.

1998).

In populations that have free access to the total length of a river (e.g., no dams within the species' range in a river: Saint John, Kennebec, Altamaha, Savannah and Delaware Rivers), spawning areas are located at the farthest upstream reach of the river (NMFS 1998). In the northern extent of their range, shortnose sturgeon exhibit three distinct movement patterns. These migratory movements are associated with spawning, feeding, and overwintering activities. In spring, as water temperatures rise above 8°C, pre-spawning shortnose sturgeon move from overwintering grounds to spawning areas. Spawning occurs from mid/late March to mid/late May depending upon location and water temperature. Sturgeon spawn in upper, freshwater areas and feed and overwinter in both fresh and saline habitats. Shortnose sturgeon spawning migrations are characterized by rapid, directed and often extensive upstream movement (NMFS 1998).

Shortnose sturgeon are believed to spawn at discrete sites within their natal river (Kieffer and Kynard 1996). In the Merrimack River, males returned to only one reach during a four year telemetry study (Kieffer and Kynard 1996). Squires *et al.* (1982) found that during the three years of the study in the Androscoggin River, adults returned to a 1-km reach below the Brunswick Dam and Kieffer and Kynard (1996) found that adults spawned within a 2-km reach in the Connecticut River for three consecutive years. Spawning occurs over channel habitats containing gravel, rubble, or rock-cobble substrates (Dadswell *et al.* 1984, NMFS 1998). Additional environmental conditions associated with spawning activity include decreasing river discharge following the peak spring freshet, water temperatures ranging from 8 - 12°, and bottom water velocities of 0.4 to 0.7 m/sec (Dadswell *et al.* 1984, NMFS 1998). For northern shortnose sturgeon, the temperature range for spawning is 6.5-18.0°C (Kieffer and Kynard in press). Eggs are separate when spawned but become adhesive within approximately 20 minutes of fertilization (Dadswell *et al.* 1984). Between 8° and 12°C, eggs generally hatch after approximately 13 days. The larvae are photonegative, remaining on the bottom for several days. Buckley and Kynard (1981) found week old larvae to be photonegative and form aggregations with other larvae in concealment.

Adult shortnose sturgeon typically leave the spawning grounds soon after spawning. Non-spawning movements include rapid, directed post-spawning movements to downstream feeding areas in spring and localized, wandering movements in summer and winter (Dadswell *et al.* 1984, Buckley and Kynard 1985, O'Herron *et al.* 1993). Kieffer and Kynard (1993) reported that post-spawning migrations were correlated with increasing spring water temperature and river discharge. Young-of-the-year shortnose sturgeon are believed to move downstream after hatching (Dovel 1981) but remain within freshwater habitats. Older juveniles tend to move downstream in fall and winter as water temperatures decline and the salt wedge recedes. Juveniles move upstream in spring and feed mostly in freshwater reaches during summer.

Juvenile shortnose sturgeon generally move upstream in spring and summer and move back downstream in fall and winter; however, these movements usually occur in the region above the saltwater/freshwater interface (Dadswell *et al.* 1984, Hall *et al.* 1991). Adult sturgeon occurring in freshwater or freshwater/tidal reaches of rivers in summer and winter often occupy only a few short reaches of the total length (Buckley and Kynard 1985). Summer concentration areas in southern rivers are cool, deep, thermal refugia, where adult and juvenile shortnose sturgeon congregate (Flournoy *et al.* 1992, Rogers *et al.* 1994, Rogers and Weber 1995, Weber 1996).

The temperature preference for shortnose sturgeon is not known (Dadswell *et al.* 1984) but shortnose sturgeon have been found in waters with temperatures as low as 2-3°C (Dadswell *et al.* 1984) and as high as 34°C (Heidt and Gilbert 1978). However, temperatures above 28°C are thought to adversely affect shortnose sturgeon. In the Altamaha River, temperatures of 28-30°C during summer months create unsuitable conditions and shortnose sturgeon are found in deep cool water refuges.

Shortnose sturgeon are known to occur at a wide range of depths. A minimum depth of 0.6 meters is necessary for the unimpeded swimming by adults. Shortnose sturgeon are known to occur at depths of up to 30 meters but are generally found in waters less than 20 meters (Dadswell *et al.* 1984, Dadswell 1979). Shortnose sturgeon have also demonstrated tolerance to a wide range of salinities. Shortnose sturgeon have been documented in freshwater (Taubert 1980, Taubert and Dadswell 1980) and in waters with salinity of 30 parts-per-thousand (ppt) (Holland and Yeverton 1973). McCleave *et al.* (1977) reported adults moving freely through a wide range of salinities, crossing waters with differences of up to 10ppt within a two hour period. The tolerance of shortnose sturgeon to increasing salinity is thought to increase with age (Kynard 1996). Shortnose sturgeon typically occur in the deepest parts of rivers or estuaries where suitable oxygen and salinity values are present (Gilbert 1989). Shortnose sturgeon were listed as endangered on March 11, 1967 (32 FR 4001), and the species remained on the endangered species list with the enactment of the ESA in 1973.

Although the original listing notice did not cite reasons for listing the species, a 1973 Resource Publication, issued by the U.S. Department of the Interior, stated that shortnose sturgeon were "in peril…gone in most of the rivers of its former range [but] probably not as yet extinct" (USDOI 1973). Pollution and overfishing, including bycatch in the shad fishery, were listed as principal reasons for the species' decline. In the late nineteenth and early twentieth centuries, shortnose sturgeon commonly were taken in a commercial fishery for the closely related and commercially valuable Atlantic sturgeon (*Acipenser oxyrinchus*). More than a century of extensive fishing for sturgeon contributed to the decline of shortnose sturgeon along the east coast. Heavy industrial development during the twentieth century in rivers inhabited by sturgeon impaired water quality and impeded these species' recovery; possibly resulting in substantially reduced abundance of shortnose sturgeon populations within portions of the species' ranges (e.g., southernmost rivers of the species range: Santilla, St. Marys and St. Johns Rivers). A shortnose sturgeon recovery plan was published in December 1998 to promote the conservation and recovery of the species (see NMFS 1998). Shortnose sturgeon are listed as "vulnerable" on the IUCN Red List.

Although shortnose sturgeon are listed as endangered range-wide, in the final recovery plan we recognized 19 separate populations occurring throughout the range of the species. These populations are in New Brunswick Canada (1); Maine (2); Massachusetts (1); Connecticut (1); New York (1); New Jersey/Delaware (1); Maryland and Virginia (1); North Carolina (1); South Carolina (4); Georgia (4); and Florida (2). We have not formally recognized distinct population segments (DPS)[3] of shortnose sturgeon under the ESA. The 1998 Recovery Plan indicates that while genetic information may reveal that interbreeding does not occur between rivers that drain into a common estuary, at this time, such river systems are considered a single population compromised of breeding subpopulations (NMFS 1998).

Studies conducted since the issuance of the Recovery Plan have provided evidence that suggests that years of isolation between populations of shortnose sturgeon have led to morphological and genetic variation. Walsh *et al.* (2001) examined morphological and genetic variation of shortnose sturgeon in three rivers (Kennebec, Androscoggin, and Hudson). The study found that the Hudson River shortnose sturgeon population differed markedly from the other two rivers for most morphological features (total length, fork length, head and snout length, mouth width, interorbital width and dorsal scute count, left lateral scute count, right ventral scute count). Significant differences were found between fish from Androscoggin and Kennebec rivers for interorbital width and lateral scute counts which suggests that even though the Androscoggin and Kennebec rivers drain into a common estuary, these rivers support largely discrete populations of shortnose sturgeon. The study also found significant genetic differences among all three populations indicating substantial reproductive isolation among them and that the observed morphological differences may be partly or wholly genetic.

Grunwald *et al.* (2002) examined mitochondrial DNA (mtDNA) from shortnose sturgeon in eleven river populations. The analysis demonstrated that all shortnose sturgeon populations examined showed moderate to high levels of genetic diversity as measured by haplotypic diversity indices. The limited sharing of haplotypes and the high number of private haplotypes are indicative of high homing fidelity and low gene flow. The researchers determined that glaciation in the Pleistocene Era was likely the most significant factor in shaping the phylogeographic pattern of mtDNA diversity and population structure of shortnose sturgeon. The Northern glaciated region extended south to the Hudson River while the southern non-glaciated region begins with the Delaware River. There is a high prevalence of haplotypes restricted to either of these two regions and relatively few are shared; this represents a historical subdivision that is tied to an important geological phenomenon that reflects historical isolation. Analyses of haplotype frequencies at the level of individual rivers showed significant differences among all systems in which reproduction is known to occur. This implies that although higher level genetic stock relationships exist (i.e., southern vs. northern and other regional subdivisions), shortnose sturgeon appear to be discrete stocks, and low gene flow exists between the majority of populations.

Waldman *et al.* (2002) also conducted mtDNA analysis on shortnose sturgeon from 11 river systems and identified 29 haplotypes. Of these haplotypes, 11 were unique to northern, glaciated systems and 13 were unique to the southern non-glaciated systems. Only five were shared between them. This analysis suggests that shortnose sturgeon show high structuring and

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[3] The definition of species under the ESA includes any subspecies of fish, wildlife, or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature. To be considered a DPS, a population segment must meet two criteria under NMFS policy. First, it must be discrete, or separated, from other populations of its species or subspecies. Second, it must be significant, or essential, to the long-term conservation status of its species or subspecies. This formal legal procedure to designate DPSs for shortnose sturgeon has not been undertaken.

discreteness and that low gene flow rates indicated strong homing fidelity.

Wirgin *et al.* (2005) also conducted mtDNA analysis on shortnose sturgeon from 12 rivers (St. John, Kennebec, Androscoggin, Upper Connecticut, Lower Connecticut, Hudson, Delaware, Chesapeake Bay, Cooper, Peedee, Savannah, Ogeechee and Altamaha). This analysis suggested that most population segments are independent and that genetic variation among groups was high.

In 2007, we initiated a five-year status review to assess the status of shortnose sturgeon range-wide. The status review team was specifically charged with analyzing new genetic data to inform the current understanding of shortnose sturgeon genetics range-wide. Although these analyses are not yet available, life history studies indicate that shortnose sturgeon populations from different river systems are substantially reproductively isolated (Kynard 1997).

The best available information demonstrates differences in life history and habitat preferences between northern and southern river systems and given the species' anadromous breeding habits, the rare occurrence of migration between river systems, and the documented genetic differences between river populations, it is unlikely that populations in adjacent river systems interbreed with any regularity. This behavior likely accounts for the failure of shortnose sturgeon to repopulate river systems from which they have been extirpated, despite the geographic closeness of persisting populations. This particular characteristic of shortnose sturgeon also complicates recovery and persistence of this species in the future because, if a river population is extirpated in the future, it is unlikely that this river will be recolonized. Consequently, this Opinion will treat the nineteen separate populations of shortnose sturgeon as subpopulations (one of which occurs in the action area) for the purposes of this analysis.

3.3.2. Status and Trends of Shortnose Sturgeon Rangewide

Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. The range extended from the Saint John River in New Brunswick, Canada to the Indian River in Florida. Today, only 19 populations remain ranging from the St. Johns River, Florida (possibly extirpated from this system) to the Saint John River in New Brunswick, Canada. Shortnose sturgeon are large, long lived fish species. The present range of shortnose sturgeon is disjunct, with northern populations separated from southern populations by a distance of about 400 kilometers. The species is anadromous in the southern portion of its range (i.e., south of Chesapeake Bay), while northern populations are amphidromous (NMFS 1998). Population sizes vary across the species' range. From available estimates, the smallest populations occur in the Cape Fear (~8 adults; Moser and Ross 1995) and Merrimack Rivers (~100 adults; M. Kieffer, United States Geological Survey, personal communication), while the largest populations are found in the Saint John (~100,000; Dadswell 1979) and Hudson Rivers (~61,000; Bain *et al.* 1998). As indicated in Kynard (1996), adult abundance is less than the minimum estimated viable population abundance of 1000 adults for five of 11 surveyed northern populations and all natural southern populations. Kynard (1996) indicates that all aspects of the species' life history indicate that shortnose sturgeon should be abundant in most rivers. As such, the expected abundance of adults in northern and north-central populations should be thousands to tens of thousands of adults. Expected abundance in southern rivers is uncertain, but large rivers should likely have thousands of adults. The only river systems likely supporting populations of these sizes are the Saint John, Hudson and possibly the Delaware and the Kennebec, making the continued success of shortnose sturgeon in these rivers critical to the species as a whole. While no reliable estimate of the size of either the total species or the shortnose sturgeon population in the northeastern United States exists, it is clearly below the size that could be supported if the threats to shortnose sturgeon were removed; however, overall the species trend is considered to be stable.

3.3.3. Status and Distribution of Shortnose Sturgeon in the Action Area

Historic Distribution and Abundance

The Kennebec system includes the Kennebec, Androscoggin, and Sheepscot rivers. The Kennebec River, at its mouth, drains an area of 24,667 square kms encompassing the drainage area of the Androscoggin River and the smaller tributaries of Merrymecting Bay. The Kennebec River estuary below Chops Point (outlet of Merrymecting Bay) forms a complex with that of the Sheepscot River estuary. Atkins (1887) confirmed the presence of sturgeon in Maine rivers though he believed that they were common sturgeon (*Acipenser sturio*). Fried and McCleave (1973) first noted shortnose sturgeon within Montsweag Bay in the Sheepscot River in 1971, the first reported occurrence in all of Maine. Shortnose sturgeon were subsequently found in the Kennebec River by MDMR in 1977 (Squiers and Smith 1979).

Current Distribution and Abundance

MDMR has conducted studies in the past to determine the distribution and abundance of shortnose sturgeon in the estuarine complex of the Kennebec, Androscoggin and Sheepscot rivers (Squiers and Smith 1979, Squiers *et al.* 1982). Additional studies were conducted to determine the timing of the spawning run and the location of spawning areas in the tidal section of the Androscoggin River (Squiers 1982, Squiers *et al.* 1993). The estimated size of the adult population (>50 centimeters TL), based on a tagging and recapture study conducted between 1977 and1981, was 7,200 (95% CI = 5,000 - 10,800; Squiers *et al.* 1982). A Schnabel estimate using tagging and recapture data from 1998, 1999 and 2000 indicates a population estimate of 9,488 (95% CI, 6,942 to 13,358) for the estuarine complex (Squires 2003). The average density of adult shortnose sturgeon per 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).

3.3.3.1. Spawning

Suspected spawning areas on both the Androscoggin and Kennebec rivers were identified in gillnet studies conducted from 1977 through 1981 (Squiers *et al.* 1981, Squiers *et al.* 1982).

Androscoggin River

Large catches of shortnose sturgeon have been documented on the Androscoggin River about 500 meters downstream of the Brunswick Project between late April and mid-May. This site is approximately 44 kilometers upriver from the mouth of the Kennebec River and water temperatures ranged between 8.5°C and 14.5°C. Many of the males captured were freely expressing milt. During 1983, a few female sturgeon were so ripe that eggs were extruded as they were retrieved from the nets. The substrate at the sampling site graduated from ledge, boulders, cobbles, pebbles, and gravel on the Brunswick shore to sand in the middle to silt on the Topsham shore. The maximum depth at low tide was 6.7 meters, with an average depth of three meters. Water velocities measured along a transect from the Brunswick shore to the Topsham shore on October 14, 1983, during an outgoing tide ranged from 32cm/sec. to 60cm/sec.

Ages were determined for 58 shortnose sturgeon collected on the spawning run in the Androscoggin River in 1981; sex was not determined. Average age of the shortnose sturgeon collected on the spawning run was 12 with a median of 10 years. Length ranged between 52.5 centimeters FL to 90.0 centimeters FL with the average of 68.9 centimeters FL.

A follow-up study conducted in 1993 using radio telemetry, artificial substrate, and bottom-set plankton nets once again found ripe shortnose sturgeon concentrated about 500 meters below the Brunswick Project. Shortnose sturgeon eggs were collected in this area using artificial substrate and plankton nets. Spawning migration extended from the end of April to the last week in May with spawning occurring from May 7-19 based on eggs collected on artificial substrate. Temperatures ranged between 7°C and 17°C during this time. Gillnet catches and radio telemetry indicated that the peak spawning occurred from May 8 to May 10 at a water temperature of 14°C.

Kennebec River

Spawning site(s) on the Kennebec River are not as well delineated as the site(s) on the Androscoggin River. Squiers *et al.* (1982) suspected a spawning area occurred 11 kilometers below the former Edwards Dam (rkm 60) as males extruding milt were collected in 1980 and 1981. Additional samples were obtained on May 11, 1999 approximately 10 kilometers below the former Edwards Dam (rkm 60) when 135 adults were captured in an overnight set at 14°C. It is assumed that these sturgeon were on the spawning run.

MDMR conducted an ichthyoplankton survey from 1997 through 2001 to monitor the recolonization of the habitat above the Edwards Dam which was removed in 1999. Sampling sites located both above and below the dam location were surveyed via surface tows with one-meter plankton nets (800 microns) or stationary sets of one-half meter D-shaped plankton nets (1600 microns). A small number of shortnose sturgeon eggs and/or larvae were collected at sites located in the first nine kilometers below the former Edwards Dam (rkm 61-70) annually. No shortnose sturgeon eggs or larvae were collected above the former Edwards Dam site in 2000 or 2001(Wippelhauser 2003). It is likely that the primary spawning area for shortnose sturgeon in the Kennebec River is located in the first 11 kilometers below the former Edwards Dam site (rkms 59-70). While there have not been any directed studies to determine if shortnose sturgeon are utilizing the habitat above the former Edwards Dam, shortnose sturgeon have been captured upstream about 27 kilometers in Waterville, approximately a kilometer downstream of the Lockwood Project, and one was discovered stranded in the ledges downstream of the Project in 2003.

3.3.3.2. Foraging

Tracking data and gillnet studies indicate that the majority of shortnose sturgeon feed in the Bath region of the Kennebec River (rkm 16 to rkm 29) from mid-April through late November and early December. Sturgeon then migrate upriver to overwinter in Merrymeeting Bay. Although the major concentration of shortnose sturgeon is found in the Bath region which includes the Sasanoa River, shortnose sturgeon are also found in Montsweag Bay in the lower Sheepscot River and in Merrymecting Bay (rkm 29 to rkm 42) located upriver of Bath. Based on limited gillnetting data and telemetry data it appears that shortnose sturgeon occasionally make forays upriver to the Augusta/Gardiner (rkm 59-70) area during the summer months.

The salinities in the main foraging area in the Bath Region range from 0 to 21 ppt from May through November. There is very little stratification during most of this time period and the difference in salinities from the surface to the bottom are usually less than 1 ppt. Water temperature ranges from 4°C in April to over 24°C in July, to around 5°C in late November. DO levels are almost always near 100% saturation.

Some shortnose sturgeon also utilize Montsweag Bay, which is part of the Sheepscot River, as a foraging area. The Sheepseot River is interconnected with the Kennebec River through the Sasanoa River and Hockomock Bay. Salinities ranged from 12 to 28 ppt and temperatures ranged from 12 to 22°C in June and July in Montsweag Bay during an ultrasonic telemetry study (McCleave *et al.* 1977).

A few shortnose sturgeon stomachs, captured in Montsweag Bay, were examined by McClcave *et al.* (1977). The most common prey items found were crangon shrimp (*Crangon septemspinosous*); clams (*Mya arenaria*); and small winter fiounder (*Pseudopleuronectes americanus*). No food habit studies have been conducted for shortnose sturgeon in the Kennebec River. Tracking studies indicate that shortnose sturgeon make use of two large marshes in the Bath area: Hanson Bay (Pleasant Cove; rkm 21) in the Sasanoa River, and Winnegance Cove (rkm 17) in the Kennebec River. A Wetland Functional Assessment was conducted by Bath Iron Works (BIW) as part of the assessment of impacts of the proposed expansion of the shipyard into wetlands habitat (Normandeau Associates 1998) and included a quantitative assessment of the benthic community in Winnegance Creek. The benthic assemblage in Winnegance Creek (rkm 17) contained no mollusks, the preferred food of adult shortnose sturgeon in the Saint John River, New Brunswick (Dadswell 1979, Dadswell *et al.* 1984). One of the dominant species in Winnegance Creek was the sabellid polychaete (*Maranzariella viridis*) which was found in stomachs of shortnose sturgeon from the Saint John River but was not identified as a preferred food item.

No sampling for epibenthic invertebrates was done in the BIW Wetland Functional Assessment. On numerous occasions, gammarid amphipods were observed on the nets when sampling for sturgcon in the summer foraging area. In an earlier study on the food habits of smelt in the lower reaches of the Kennebec River, it was found that the dominant food item was gammarids, particularly *Gammarus oceanicus* (Flagg 1974). Shortnose sturgcon consumed gammarid amphipods and polychaete worms in the estuary of the Connecticut River (Savoy and Benway 2004). Shortnose sturgeon also fed heavily on gammarid amphipods in the Hudson River (Haley 1999).

3.3.3.3.Overwintering/Resting

No studies had been done to locate the overwintering sites of adult shortnose sturgeon in the Kennebec River prior to 1996. Based on catch per unit effort from gillnct sets in the lower Kennebec River, it was thought that the most likely overwintering sites were in the deep saline region of the lower river (below Bluff Head at rkm 15) and possibly in the adjacent estuary of the Sheepscot River (Squiers *et al.* 1982). Some shortnose sturgeon overwinter in the tidal freshwater sections of the Eastern and Cathance Rivers; which are tributaries to Merrymeeting Bay (Squiers *et al.* 1982).

MDMR attempted to identify shortnose sturgeon overwintering sites in the Kennebec River in 1996. A total of fifteen shortnose sturgeon were tagged in October and November, 1996 to track them to their overwintering habitat. Initial capture locations of the sturgcon varied within the Kennebec System: eight were captured, tagged and released in Pleasant Cove (rkm 21) on the Sasanoa River which joins the Kennebec River in Bath just a short distance downriver of the Sagadahoc bridge; five were captured, tagged and released in Winnegance Cove (rkm 17), which is located approximately 2700 meters below the Sagadahoc Bridge on the Kennebec River; and two were captured in Merrymecting Bay (rkm 38) and released at the Richmond town landing in channel west of Swan Island (rkm 40.5).

The eight shortnose sturgeon captured in Pleasant Cove and the five captured in Winnegance Cove were all later relocated: 11 of these 13 fish were relocated in Merrymeeting Bay. The first two sturgeon tagged in Pleasant Cove (code #338 and 356) were never found in Merrymeeting Bay. Sturgeon #338 did move from Pleasant Cove to Winnegance Cove and back and sturgeon #356 moved to Days Ferry (rkm 24) and back. Both sturgeon #338 and #356 were last found in Pleasant Cove (rkm 21) on November 13, 1996. After November 13, 1996, sturgeon with transmitters were only found in upper Merrymeeting Bay on the east side of Swan Island (rkm 38). Because 11 sturgeon were in the area it became impossible to separate signals as the sturgeon grouped together. Multiple signals were always found at the suspected overwintering site near Swan Island in Merrymeeting Bay. It was difficult to survey large areas of Merrymeeting Bay due to poor ice so it is possible other sturgeon were in the area and other overwintering areas exist.

In 1997, five additional shortnose sturgeon captured in the immediate vicinity of BIW were tagged: two were later captured by Normandeau Associates in an otter trawl, and three were captured by MDMR in gillnets. These tagged sturgeon remained in the lower Kennebec River in the Bath area until late November. One was later located in the area on December 2, 1997, but no others have been dctected sincc.

In 1998, 17 shortnose sturgeon were captured by Normandeau Associates under contract to BIW and tagged. Fourteen receiver/data loggers were deployed: nine around BIW and five upstream and downstream BIW. The majority of shortnose sturgeon moved out of the Bath area by the end of November although three remained in the Bath area in early December. Ten shortnose and one
Atlantic were at the overwintering site upriver in Merrymeeting Bay on December 15, 1998.

Additional manual tracking did not occur during this period due to weather conditions.
Five pre-spawning adult shortnose sturgeon originally captured and tagged in the Bangor/Brewer overwintering area of the Penobscot River in late September 2007 were later relocated in October and November of 2007 (Fernandes 2008, Fernandes *et al.* 2010). Four individuals were subsequently located at the Kennebec River overwintering area (Merrymeeting Bay) near rkm 38 in February 2008. These sturgeon were located between rkm 37.25 and 39.25 in a tidally influenced area in depths are approximately 4.5 to 6.0 meters in predominantly sandy substrate.

3.3.3.4.Migration

Recent data collected by University of Maine (UM) and MDMR indicate that migration between river systems is more extensive than was previously reported (Dadswell *et al.*1984, NMFS 1998). Sonic transmitters were implanted in a total of 39 shortnose sturgeon from June 14, 2006 through September 27, 2007 in the Penobscot River; however some tags were expelled and some individuals may have suffered mortality (Fernandes 2008, Fernandes *et al.* 2010). Eleven of these sturgeon have been subsequently detected in the Kennebec River by MDMR via the passive receiver array. The distance between the mouth of the Kennebec River and the mouth of the Penobscot River is about 70 kilometers. One tracked individual traveled 230 kilometers from its tagging site in Bangor on the Penobscot River to upper Kennebec River (Fernandes 2008, Fernandes *et al.* 2010). Movement from the Kennebec to the Penobscot was documented when two shortnose sturgeon PIT tagged by MDMR in the Kennebec River in 1998 and 1999 were recaptured in the Penobscot River in 2006 by UM researchers.

Ultrasonic transmitters were implanted in five pre-spawning adult shortnose sturgeon in late September 2007 in the Bangor/Brewer overwintering area on the Penobscot River (Fernandes 2008, Fernandes *et al.* 2010). The intent was to track these individuals the following spring to locate the spawning area(s) in the Penobscot River. MDMR subsequently detected four of these prespawning adults with its passive receiver array in the Kennebec River during October and November 2007. Four of the five sturgeon were subsequently located in the Kennebec River overwintering area near rkm 38 in February 2008. These sturgeon were located between rkm 37.25 and 39.25. The fifth shortnose sturgeon implanted with a transmitter during the same time period and area was located in the Kennebec River overwintering area.

MDMR deployed its passive receiver array in early April 2008. Four of the five Penobscot shortnose sturgeon located in the Kennebec River overwintering grounds in February 2008 were detected. These four were females with late stage eggs. One migrated upriver to the Farmingdale/Hallowell (rkm 61) reach in the Kennebec River that had been previously identified by MDMR as a spawning area. Another migrated to the Lockwood Project in Waterville (rkm 97), which is the upstream limit of sturgeon habitat and was made accessible with the removal of the Edwards Dam in 1999. A third fish migrated to the known spawning area on the Androscoggin River near Brunswick, ME (rkm 44). Collectively these three fish moved rapidly downriver after a few days and are presumed to have left the Kennebec River system. The fourth sturgeon with late stage eggs migrated to the mouth of the Androscoggin and was last located in Merrymeeting Bay on May 12, 2008. Its signal was not picked up on any of the downriver receivers.

In addition to the Penobscot females with late stage eggs, an additional three Penobscot River shortnose sturgcon outfitted with acoustic transmitters in 2006 were located in the Kennebec River in the spring of 2008. One fish arrived at Townsend Gut on May 10, 2008 and migrated through the Sasanoa River to the Kennebec River and on May 20 arrived in the Farmingdale/Hallowell reach. Another fish was located in the Merrymecting Bay overwintering area in the Kennebec River on April 16, 2008 and migrated to the Eastern River arriving on April 19, 2008 arriving in the Sasanoa River on April 25, 2008 and moving to the Phippsburg area from April 25 to May 19, 2008. Subsequently the individual migrated upriver to the Farmingdale/Hallowell reach of the Kennebec River on May 21, 2008, remained for two days and was subsequently picked up in Phippsburg on May 24, 2008 and was last recorded on May 28, 2008. The third tagged fish was recorded at Townsend Gut on May 12, 2008 and was never subsequently picked up on any of the Kennebec River receivers.

3.3.4. Factors Affecting Shortnose Sturgeon in the Action Area

Dams and Hydroelectric Facilities

Historically, the upstream migration of sturgeon on the Kennebec River was limited to Waterville at Ticonic Falls (rkm 98) (NMFS and USFWS 1998), approximately the location of the Lockwood Project. Ticonic Falls is located 65 rkm downstream of the fall line (based on reference points provided by Oakley 2005). The construction of Edwards Dam at rkm 71 in 1837 denied sturgeon access to historical habitat in the Kennebec River until 1999 when it was removed. Since its removal, almost 100% of historic habitat is now accessible. Since the removal of the Edwards Dam, shortnose sturgeon have been documented at the Lockwood Dam (rkm 98) indicating that this habitat is being utilized to some extent. One shortnose sturgeon was stranded below the Lockwood Dam spillway in 2003 as result of flow manipulation to allow the installation of flashboards. During the re-licensing of the Lockwood Hydroelectric Project, FERC requested ESA section 7 formal consultation; a Biological Opinion was issued by us on January 12, 2005, where we concluded the proposed re-licensing was likely to adversely affect but not likely to jeopardize the continued existence of shortnose sturgcon. The Opinion included an Incidental Take Statement (ITS), Reasonable and Prudent Measures, and Terms and Conditions designed to minimize and monitor future effects of the project, including strandings. No additional strandings of shortnose sturgeon have been reported. There is a fish lift at the Lockwood project, but to date, no shortnose sturgeon have been documented in the lift. The FERC license for this project includes a requirement that any shortnose sturgeon observed in the lift be removed and returned downstream of the project. This is consistent with the terms of the Opinion's ITS. Additionally, the Project's shortnose sturgeon handling plan is updated annually by the licensee.

In the Androscoggin River, the Brunswick Hydroelectric Project (rkm 44) is located at the head-of-tide at the site of a natural falls. This facility was licensed by FERC in 1979 and the license is set to expire in 2029. The limited storage capacity of the Brunswick Dam restricts its ability to influence river flows; therefore, during the FERC licensing process, a minimum flow requirement was deemed not necessary. The location of historical spawning grounds on the Androscoggin River is unknown, but it is unlikely that sturgeon could navigate the natural falls located at Brunswick Dam (NMFS and USFWS 1998).

Dredging and Blasting

There is an authorized Federal Navigation Channel in the Kennebec River extending from the mouth of the river to Augusta. This channel is maintained by the ACOE. Historically, the Kennebec River has been dredged along Swan Island in Merrymecting Bay (~ rkm 36), at Gardiner (~ rkms 59) and from Hallowell to Augusta (~ rkm 65-69). The upriver dredging projects are all located in tidal freshwater habitat. No channel maintenance dredging above Bath, where spawning habitat used to be located prior to the removal of Edwards Dam, has been conducted since 1963. On average, shoaled areas at Doubling Point and Popham Beach are dredged every three years. Maintenance dredging was last conducted in October 2003. The primary user of the deepwater channel in the lower Kennebec River is the U.S. Navy that routinely moves ship to and from the BIW facility in Bath, ME. ESA section 7 consultation between the ACOE and NMFS has been completed on the effects of the maintenance dredging of this channel. Interactions with shortnose sturgeon have been recorded during hopper dredging activities in this river including the entrainment of five shortnose sturgeon at Doubling Point over three days in October 2003 when three shortnose sturgeon were killed and the other two suffered serious injuries. In April 2003, a shortnose sturgeon was killed in a bucket dredge (NMFS, Biological Opinion 2004) operating in the BIW sinking basin. More recently, a live shortnose sturgeon was recorded in dredging operations in the BIW sinking basin on June 1, 2009 and later released alive (M. Bowen, Normandeau Associates, pers. comm. 2009).

There are no Federal navigation projects in the Androscoggin River or Sheepscot Rivers, however, private dredging activities occur throughout the estuarine complex.

Water quality and Contaminants

During the late 1960s and early 1970s, dissolved oxygen (DO) levels reached zero parts per million in the Kennebec and Androscoggin Rivers from the head-of-tide to the mid-estuary during the summer months. The drop in oxygen levels commonly caused fish kills. DO levels improved significantly in the late 1970s and 1980s, coincident with improved point source treatment of municipal and industrial waste. Although DO was at severely low levels until the late 1970s, a population of shortnose sturgeon managed to persist in the system during this time period. The substrate in the upper freshwater section of both the Kennebec and Androscoggin rivers was severely degraded by wood chips, sawdust, and organic debris until the late 1970s. This accumulation was quickly flushed from the river systems after the cessation of log drives and the construction of water treatment plants.

Dioxin, likely generated from wastewater discharges from pulp and paper mills and municipal wastewater treatment plants, has been found in fish tissue samples collected in the Kennebec and Androscoggin Rivers (MDEP 2005). The concentrations of dioxins in fishes collected from Maine rivers have decreased significantly over time. Concentrations of dioxins in fishes collected from Maine rivers were in the 2 to 30 parts-per-thousand (ppt) range in the mid 1980s while today levels are much more commonly seen in the less than 1 to 2 ppt range. The Androscoggin River has had the highest dioxin levels for fishes in the state of Maine. Levels of tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) were as high as 20 - 30 pg/g (parts-per-trillion) in fishes sampled from the Androscoggin and Kennebec Rivers during 1984-1986, before dropping to 0.1 pg/g in 2004 (ME DEP 2005). MDEP has conducted limited testing for heavy metals, PCBs, and organochlorine pesticides in the tidal waters of the Kennebec River.

The Maine Center for Disease Control issues fish consumption advisories for segments of the Kennebec and Androscoggin Rivers. As of July, 2013 they advise no consumption of fish between Augusta and Chops Point (~ rkm 69) and 6 to 12 meals a year in the tidal section of the Androscoggin River. The consumption advisory for the Kennebec River from Augusta to the Shawmut Project in Fairfield is 5 meals of trout a year and 1 to 2 bass meals a month. Contaminant analysis of muscle, liver, and ovarian tissue has been performed for a shortnose sturgeon killed in May 2003 during dredging operations at BIW on the Kennebec River (see above). Fourteen metals, one semivolatile compound, one PCB Aroclor, PCDDs, and PCDFs were detected in one or more of the tissue samples. Of these chemicals, cadmium and zinc were detected at concentrations above an adverse effect concentration reported for fishes in the literature (Brundage 2003).

Despite water quality degradation in the past, the Kennebec estuarial complex has continued to support sturgeon. Improvements in habitat quality from the 1980s to the present should facilitate recovery of the shortnose sturgeon in this estuary.

3.3.5. Summary of Factors affecting Recovery of Shortnose Sturgeon

The Shortnose Sturgeon Recovery Plan (NMFS 1998) identifies habitat degradation or loss (resulting, for example, from dams, bridge construction, channel dredging, and pollutant discharges) and mortality (resulting, for example, from impingement on cooling water intake screens, dredging and incidental capture in other fisheries) as principal threats to the species' survival.

Several natural and anthropogenic factors continue to threaten the recovery of shortnose sturgeon range-wide. Shortnose sturgeon continue to be taken incidentally in fisheries along the east coast and are probably targeted by poachers throughout their range (Dadswell 1979, Dovel *et al.* 1992, Collins *et al.* 1996). Bridge construction and demolition projects may interfere with normal shortnose sturgeon migratory movements and disturb sturgeon concentration areas. Unless appropriate precautions are taken, internal damage and/or death may result from blasting projects with powerful explosives. Hydroelectric dams may affect shortnose sturgeon by restricting habitat, altering river flows or temperatures necessary for successful spawning and/or migration and causing mortalities to fish that become entrained in turbines. Maintenance dredging of Federal navigation channels and other areas can adversely affect or jeopardize shortnose sturgeon populations. Hydraulic dredges can lethally take sturgeon by entraining sturgeon in dredge dragarms and impeller pumps. Mechanical dredges have also been documented to lethally take shortnose sturgeon. In addition to direct effects, dredging operations may also impact shortnose sturgeon by destroying benthic feeding areas, disrupting spawning migrations, and filling spawning habitat with re-suspended fine sediments. Shortnose sturgeon are susceptible to impingement on cooling water intake screens at power plants. Electric power and nuclear power generating plants can affect sturgeon by impinging larger fish on cooling water intake screens and entraining larval fish. The operation of power plants can have unforeseen and extremely detrimental impacts to water quality which can affect shortnose sturgeon. For example, the St. Stephen Power Plant near Lake Moultrie, South Carolina was shut down for several days in June 1991 when large mats of aquatic plants entered the plant's intake canal and clogged the cooling water intake gates. Decomposing plant material in the tailrace canal coupled with the turbine shut down (allowing no flow of water) triggered a low dissolved oxygen water condition downstream and a subsequent fish kill. The South Carolina Wildlife and Marine Resources Department reported that twenty shortnose sturgeon were killed during this low dissolved oxygen event.

Contaminants, including toxic metals, polychlorinated aromatic hydrocarbons (PAHs), pesticides, and polychlorinated biphenyls (PCBs) can have substantial deleterious effects on aquatic life including production of acute lesions, growth retardation, and reproductive impairment (Cooper 1989, Sinderman 1994). Ultimately, toxins introduced to the water column become associated with the benthos and can be particularly harmful to benthic organisms (Varanasi 1992) like sturgeon. Heavy metals and organochlorine compounds are known to accumulate in fat tissues of sturgeon, but their long term effects are not yet known (Ruelle and Henry 1992, Ruelle and Keunlyne 1993). Available data suggests that early life stages of fish are more susceptible to environmental and pollutant stress than older life stages (Rosenthal and Alderdice 1976).

Although there is little information available comparing the levels of contaminants in shortnose sturgeon tissues rangewide, some research on other related species indicates that concern about the effects of contaminants on the health of sturgeon populations is warranted. Detectible levels of chlordane, DDE (1,1-dichloro-2, 2-bis(p-chlorophenyl)ethylene), DDT (dichlorodiphenyl-trichloroethane), and dieldrin, and elevated levels of PCBs, cadmium, mercury, and selenium were found in pallid sturgeon tissue from the Missouri River (Ruelle and Henry 1994). These compounds were found in high enough levels to suggest they may be causing reproductive failure and/or increased physiological stress (Ruelle and Henry 1994). In addition to compiling data on contaminant levels, Ruelle and Henry also determined that heavy metals and organochlorine compounds (i.e., PCBs) accumulate in fat tissues. Although the long term effects of the accumulation of contaminants in fat tissues is not yet known, some speculate that lipophilic toxins could be transferred to eggs and potentially inhibit egg viability. In other fish species, reproductive impairment, reduced egg viability, and reduced survival of larval fish are associated with elevated levels of environmental contaminants including chlorinated hydrocarbons. A strong correlation that has been made between fish weight, fish fork length, and DDE concentration in pallid sturgeon livers indicates that DDE increases proportionally with fish size (NMFS 1998).

Contaminant analysis was conducted on two shortnose sturgeon from the Delaware River in the fall of 2002. Muscle, liver, and gonad tissue were analyzed for contaminants (ERC 2003). Sixteen metals, two semivolatile compounds, three organochlorine pesticides, one PCB Aroclor, as well as polychlorinated dibenzo-p-dioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs) were detected in one or more of the tissue samples. Levels of aluminum, cadmium, PCDDs, PCDFs, PCBs, DDE (an organochlorine pesticide) were detected in the "adverse affect" range. It is of particular concern that of the above chemicals, PCDDs, DDE, PCBs and cadmium, were detected as these have been identified as endocrine disrupting chemicals.

Contaminant analysis conducted in 2003 on tissues from a shortnose sturgeon from the Kennebec River revealed the presence of fourteen metals, one semivolatile compound, one PCB Aroclor, PCDDs and PCDFs in one or more of the tissue samples. Of these chemicals, cadmium and zinc were detected at concentrations above an adverse effect concentration reported for fish in the literature (ERC 2003). While no directed studies of chemical contamination in shortnose sturgeon have been undertaken, it is evident that the heavy industrialization of the rivers where shortnose sturgeon are found is likely adversely affecting this species.

During summer months, especially in southern areas, shortnose sturgeon must cope with the physiological stress of water temperatures that may exceed 28°C. Flournoy *et al.* (1992) suspected that, during these periods, shortnose sturgeon congrogate in river regions which support conditions that relieve physiological stress (i.e., in cool deep thermal refuges). In southern rivers where sturgeon movements have been tracked, sturgeon refrain from moving during warm water conditions and are often captured at release locations during these periods (Flournoy *et al.*, 1992, Rogers and Weber 1995, Weber 1996). The loss and/or manipulation of these discrete refuge habitats may limit or be limiting population survival, especially in southern river systems.

Pulp mill, silvicultural, agricultural, and sewer discharges, as well as a combination of non-point source discharges, which contain elevated temperatures or high biological demand, can reduce dissolved oxygen levels. Shortnose sturgeon are known to be adversely affected by dissolved oxygen levels below five milligrams per liter. Shortnose sturgeon may be less tolerant of low dissolved oxygen levels in high ambient water temperatures and show signs of stress in water temperatures higher than 28°C (Flournoy *et al.* 1992). At these temperatures, concomitant low levels of dissolved oxygen may be lethal.

3.4. Atlantic Sturgeon

3.4.1. Species Description

The section below describes the Atlantic sturgeon listing, provides life history information that is relevant to all DPSs of Atlantic sturgeon, and provides information specific to the status of each DPS of Atlantic sturgeon. Below, we also previde a description of the Atlantic sturgeon DPSs likely to occur in the action area and their use of the action area.

The Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) is a subspecies of sturgeon distributed along the eastern coast of North America from Hamilton Inlet, Labrador, Canada to Cape Canaveral, FL (Scott and Scott 1988; ASSRT 2007;). We have divided U.S. populations of Atlantic sturgeon into five DPSs[4] (77 FR 5880 and 77 FR 5914). These are: the Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs (Figure 4).

The results of genetic studies suggest that natal origin influences the distribution of Atlantic

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[4] To be considered for listing under the ESA, a group of organisms must constitute a "species." A "species" is defined in section 3 of the ESA to include "any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature."

sturgeon in the marine environment (Wirgin and King 2011). However, genetic data, as well as tracking and tagging data, demonstrate that sturgeon from each DPS and Canada occur throughout the full range of the subspecies. Therefore, sturgeon originating from any of the five DPSs can be affected by threats in the marine, estuarine, and riverine environment that occur far from natal spawning rivers.

On February 6, 2012, we published notice in the *Federal Register* that we were listing the New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs as "endangered," and the Gulf of Maine DPS as "threatened" (77 FR 5880 and 77 FR 5914). The effective date of the listings is April 6, 2012. The DPSs do not include Atlantic sturgeon spawned in Canadian rivers. Therefore, fish that originated in Canada are not included in the listings. As described below, individuals originating from all five listed DPSs may occur in the action area. Information general to all Atlantic sturgeon, as well as information specific to each of the DPSs, is provided below.

Atlantic Sturgeon Life History

Atlantic sturgeon are long-lived (approximately 60 years), late maturing, estuarine dependent, anadromous[5] fish (Bigelow and Schroeder 1953, Vladykov and Greeley 1963, Mangin 1964, Pikitch *et al.* 2005, Dadswell 2006, ASSRT 2007). They are a relatively large fish, even among sturgeon species (Pikitch *et al.* 2005) and can grow to over 14 feet weighing 800 pounds. Atlantic sturgeon are bottom feeders that suck food into a ventral protruding mouth (Bigelow and Schroeder 1953). Four barbels in front of the mouth assist the sturgeon in locating prey (Bigelow and Schroeder 1953). Diets of adult and migrant subadult Atlantic sturgeon include mollusks, gastropods, amphipods, annelids, decapods, isopods, and fish such as sand lance (Bigelow and Schroeder 1953, ASSRT 2007, Guilbard *et al.* 2007, Savoy 2007). Juvenile Atlantic sturgeon feed on aquatic insects, insect larvae, and other invertebrates (Bigelow and Schroeder 1953, ASSRT 2007, Guilbard *et al.* 2007).

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[5] Anadromous refers to a fish that is born in freshwater, spends most of its life in the sea, and returns to freshwater to spawn (NEFSC FAQs, available at http://www.nefsc.noaa.gov/faq/fishfaq1a.html, modified June 16, 2011)

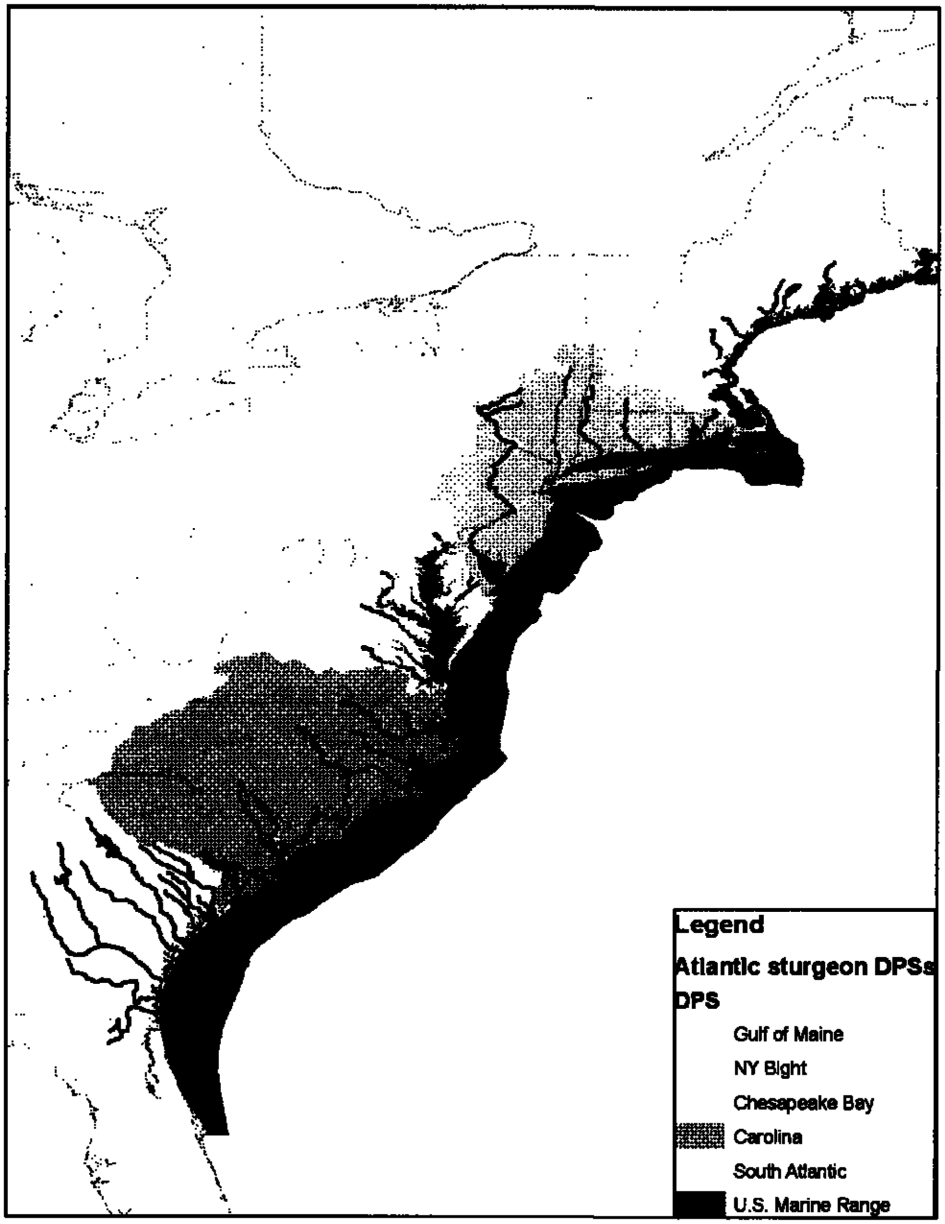

Figure 4 Geographic Locations for the Five ESA-listed DPSs of Atlantic Sturgeon

Rate of maturation is affected by water temperature and gender. In general: (1) Atlantic sturgeon that originate from southern systems grow faster and mature sooner than Atlantic sturgeon that originate from more northern systems; (2) males grow faster than females; (3) fully mature females attain a larger size (i.e. length) than fully mature males. The largest recorded Atlantic sturgeon was a female captured in 1924 that measured approximately 4.26 meters (Vladykov and Greeley 1963). Dadswell (2006) reported seeing seven fish of comparable size in the St. John River estuary from 1973 to 1995. Observations of large-sized sturgeon are particularly important given that egg production is correlated with age and body size (Smith *et al.* 1982, Van Eenennaam *et al.* 1996, Van Eenennaam and Doroshov 1998, Dadswell 2006). The lengths of Atlantic sturgeon caught since the mid-late 20th century have typically been less than three meters (Smith *et al.* 1982, Smith and Dingley 1984, Smith 1985, Scott and Scott 1988, Young *et al.* 1998, Collins *et al.* 2000, Caron *et al.* 2002, Dadswell 2006, ASSRT 2007, Kahnle *et al.* 2007, DFO 2011). While females are prolific, with egg production ranging from 400,000 to 4 million eggs per spawning year, females spawn at intervals of two to five years (Vladykov and Greeley 1963, Smith *et al.* 1982, Van Eenennaam *et al.* 1996, Van Eenennaam and Doroshov 1998, Stevenson and Secor 1999, Dadswell 2006). Given spawning periodicity and a female's relatively late age to maturity, the age at which 50% of the maximum lifetime egg production is achieved is estimated to be 29 years (Boreman 1997). Males exhibit spawning periodicity of one to five years (Smith 1985, Collins *et al.* 2000, Caron *et al.* 2002). While long-lived, Atlantic sturgeon are exposed to a multitude of threats prior to achieving maturation and have a limited number of spawning opportunities once mature.

Water temperature plays a primary role in triggering the timing of spawning migrations (ASMFC 2009). Spawning migrations generally occur during February-March in southern systems, April-May in Mid-Atlantic systems, and May-July in Canadian systems (Murawski and Pacheco 1977; Smith 1985; Bain 1997; Smith and Clugston 1997; Caron *et al.* 2002). Male sturgeon begin upstream spawning migrations when waters reach approximately 6°C (43° F) (Smith *et al.* 1982; Dovel and Berggren 1983; Smith 1985; ASMFC 2009), and remain on the spawning grounds throughout the spawning season (Bain 1997). Females begin spawning migrations when temperatures are closer to 12°to 13°C (54° to 55°F) (Dovel and Berggren 1983; Smith 1985; Collins *et al.* 2000), make rapid spawning migrations upstream, and quickly depart following spawning (Bain 1997).

The spawning areas in most U.S. rivers have not been well defined. However, the habitat characteristics of spawning areas have been identified based on historical accounts of where fisheries occurred, tracking and tagging studies of spawning sturgeon, and physiological needs of early life stages. Spawning is believed to occur in flowing water between the salt front of estuaries and the fall line of large rivers, when and where optimal flows are 46-76 centimeters per second and depths are 3-27 meters (Borodin 1925, Dees 1961, Leland 1968, Scott and Crossman 1973, Crance 1987, Shirey *et al.* 1999, Bain *et al.* 2000, Collins *et al.* 2000, Caron *et al.* 2002, Hatin *et al.* 2002, ASMFC 2009). Sturgeon eggs are deposited on hard bottom substrate such as cobble, coarse sand, and bedrock (Dees 1961, Scott and Crossman 1973, Gilbert 1989, Smith and Clugston 1997, Bain *et al.* 2000, Collins *et al.* 2000, Caron *et al.* 2002, Hatin *et al.* 2002, Mohler 2003, ASMFC 2009), and become adhesive shortly after fertilization (Murawski and Pacheco 1977, Van den Avyle 1984, Mohler 2003). Incubation time for the eggs increases as water temperature decreases (Mohler 2003). At temperatures of 20° and 18° C, hatching occurs approximately 94 and 140 hours, respectively, after egg deposition (ASSRT 2007).

Larval Atlantic sturgeon (i.e. less than four weeks old, with total lengths (TL) less than 30 millimeters; Van Eenennaam *et al.* 1996) are assumed to mostly live on or near the bottom and inhabit the same riverine or estuarine areas where they were spawned (Smith *et al.* 1980, Bain *et al.* 2000, Kynard and Horgan 2002, ASMFC 2009). 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 (Haley 1999, Hatin *et al.* 2007, McCord *et al.* 2007, Munro *et al.* 2007) while older fish are more salt-tolerant and occur in both high salinity and low salinity waters (Collins *et al.* 2000). Atlantic sturgeon remain in the natal estuary for months to years before emigrating to open ocean as subadults (Holland and Yelverton 1973, Dovel and Berggen 1983, Waldman *et al.* 1996, Dadswell 2006, ASSRT 2007).

After emigration from the natal estuary, subadults and adults travel within the marine environment, typically in waters less than 50 mcters in depth, using coastal bays, sounds, and ocean waters (Vladykov and Greeley 1963, Murawski and Pacheco 1977, Dovel and Berggren 1983, Smith 1985, Collins and Smith 1997, Welsh *et al.* 2002, Savoy and Pacileo 2003, Stein *et al.* 2004, Laney *et al.* 2007, Dunton *et al.* 2010, Erickson *et al.* 2011, Wirgin and King 2011). Tracking and tagging studies reveal seasonal movements of Atlantic sturgeon along the coast. Satellite-tagged adult sturgeon from the Hudson River concentrated in the southern part of the Mid-Atlantic Bight at depths greater than 20 meters during winter and spring, and in the northern portion of the Mid-Atlantic Bight at depths less than 20 meters in summer and fall (Erickson *et al.* 2011). Shirey (Delaware Department of Fish and Wildlife, unpublished data reviewed in ASMFC 2009) found a similar movement pattern for juvenile Atlantic sturgeon based on recaptures of fish originally tagged in the Delaware River. After leaving the Delaware River estuary during the fall, juvenile Atlantic sturgeon were recaptured by commercial fishermen in nearshore waters along the Atlantic coast as far south as Cape Hatteras, NC from November through early March. In the spring, a portion of the tagged fish re-entered the Delaware River estuary. However, many fish continued a northerly coastal migration through the Mid-Atlantic as well as into southern New England waters, where they were recovered throughout the summer months. Movements as far north as Maine were documented. A southerly coastal migration was apparent from tag returns reported in the fall, with the majority of these tag returns from relatively shallow nearshore fisheries, with few fish reported from waters in excess of 25 meters (C. Shirey, Delaware Department of Fish and Wildlife, unpublished data reviewed in ASMFC 2009). Areas where migratory Atlantic sturgeon commonly aggregate include the Bay of Fundy (e.g., Minas and Cumberland Basins), Massachusetts Bay, Connecticut River estuary, Long Island Sound, New York Bight, Delaware Bay, Chesapeake Bay, and waters off of North Carolina from the Virginia/North Carolina border to Cape Hatteras at depths up to 24 meters (Dovel and Berggren 1983, Dadswell *et al.* 1984, Johnson *et al.* 1997, Rochard *et al.* 1997, Kynard *et al.* 2000, Eyler *et al.* 2004, Stein *et al.* 2004, Wehrell 2005, Dadswell 2006, ASSRT 2007, Laney *et al.* 2007). These sites may be used as foraging sites and/or thermal refuge.

3.4.2. Dctermination 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. We have considered the best available information to determine from which DPSs individuals in the action area are likely to have originated. We have determined that Atlantic sturgeon in the action area are likely to originate from two of the five ESA listed DPSs (NYB and GOM) as well as from the St. John River in Canada. Fish originating from the St. John River are not listed under the ESA. Currently, if the fish does not have an identifying tag, the only way to tell the river (or DPS) of origin for a particular individual is by gcnctic sampling. The distribution of Atlantic sturgcon is influenced by geography, with Atlantic sturgeon from a particular DPS becoming less common the further you are from the river of origin. Areas that are geographically close are expected to have a similar composition of individuals.

Based on the analysis of genetic data, it was determined that 92% of the fish in the spawning region of the Hudson River originated from the NYB DPS while 8% originated from the GOM DPS. Given the lack of data specific to the Kennebec river spawning region, we determined that using these ratios for the Kennebec River represented the best available information for this spawning river. Based on the above percentages, some percentage of fish on the spawning grounds in the Kennebec River could be from the St. John while a more limited percentage could be from the NYB DPS. However, the most significant percentage would be expected to be from the GOM DPS. Thus, we used the breakdown of 92% of the fish being from the GOM DPS while the remaining 8% are from either the NYB DPS or the St. John. Since more fish in this area are attributed to the St. John River, a higher proportion of the 8% are attributed to this population. Therefore, in the action area, we expect Atlantic sturgeon to occur at the following frequencies: GOM DPS 92%, St. John River (Canada) 7%, and NYB DPS 1%. The genetic assignments have a plus/minus 5% confidence interval; however, for purposes of section 7 consultation, we have selected the reported values above, which approximate the mid-point of the range, as a reasonable indication of the likely genetic makeup of Atlantic sturgeon in the action area. These assignments and the data from which they are derived are described in detail in Damon-Randall *et al.* (2013).

3.4.3. Status and Trends of Atlantic Sturgeon Range-wide

Distribution and Abundance

Atlantic sturgeon underwent significant range-wide declines from historical abundance levels due to overfishing in the mid to late 19th century when a caviar market was established (Scott and Crossman 1973, Taub 1990, Kennebec River Resource Management Plan 1993, Smith and Clugston 1997, Dadswell 2006, ASSRT 2007). Abundance of spawning-aged females prior to this period of exploitation was predicted to be greater than 100,000 for the Delaware River, and at least 10,000 females for other spawning stocks (Secor and Waldman 1999, Secor 2002). Historical records suggest that Atlantic sturgeon spawned in at least 35 rivers prior to this period. Currently, only 17 U.S. rivers are known to support spawning (i.e., presence of young-of-year or gravid Atlantic sturgeon documented within the past 15 years) (ASSRT 2007). While there may be other rivers supporting spawning for which definitive evidence has not been obtained (e.g., in the Penobscot and York Rivers), the number of rivers supporting spawning of Atlantic sturgeon are approximately half of what they were historically. In addition, only five rivers (Kennebec, Androscoggin, Hudson, Delaware, James) are known to currently support spawning from Maine through Virginia, where historical records show that there used to be 15 spawning rivers (ASSRT 2007). Thus, there are substantial gaps between Atlantic sturgeon spawning rivers among northern and Mid-Atlantic states which could make recolonization of extirpated populations more difficult.

At the time of the listing, there were no current, published population abundance estimates for any of the currently known spawning stocks or for any of the five DPSs of Atlantic sturgeon. An estimate of 863 mature adults per year (596 males and 267 females) was calculated for the

Hudson River based on fishery-dependent data collected from 1985 to 1995 (Kahnle *et al.* 2007). An estimate of 343 spawning adults per year is available for the Altamaha River, GA, based on fishery-independent data collected in 2004 and 2005 (Schueller and Peterson 2006). Using the data collected from the Hudson and Altamaha Rivers to estimate the total number of Atlantic sturgeon in either subpopulation is not possible, since mature Atlantic sturgeon may not spawn every year (Vladykov and Greeley 1963, Smith 1985, Van Eenennaam *et al.* 1996, Stevenson and Secor 1999, Collins *et al.* 2000, Caron *et al.* 2002), the age structure of these populations is not well understood, and stage-to-stage survival is unknown. In other words, the information that would allow us to take an estimate of annual spawning adults and expand that estimate to an estimate of the total number of individuals (*e.g.*, yearlings, subadults, and adults) in a population is lacking. The ASSRT presumed that the Hudson and Altamaha rivers had the most robust of the remaining U.S. Atlantic sturgeon spawning populations (ASSRT 2007).

Lacking complete estimates of population abundance across the distribution of Atlantic sturgeon, the NEFSC developed a virtual population analysis model with the goal of estimating bounds of Atlantic sturgeon ocean abundance (Kocik *et al.* 2013). The Atlantic Sturgeon Production Index (ASPI) provides a general abundance metric to assess risk for actions that may affect Atlantic sturgeon in the ocean; however, it is not a comprehensive population estimate (Table 12).

In additional to the ASPI, a population estimate was derived from the Northeast Area Monitoring and Assessment Program (NEAMAP) (Table 12). NEAMAP trawl surveys are conducted from Cape Cod, Massachusetts to Cape Hatteras, North Carolina in nearshore waters at depths up to 18.3 meters (60 feet) during the fall since 2007 and spring since 2008. Each survey employs a spatially stratified random design with a total of 35 strata and 150 stations. The ASMFC has initiated a new stock assessment with the goal of completing it by the end of 2014. NOAA Fisheries will be partnering with them to conduct the stock assessment, and the ocean population abundance estimates produced by the NEFSC will be shared with the stock assessment committee for consideration in the stock assessment.

Table 12 Description of the ASPI model and NEAMAP survey based area estimate method.

Model Name	Model Description
A. ASPI	Uses tag-based estimates of recapture probabilities from 1999 to 2009. Natural mortality based on Kahnle *et al.* (2007) rather than estimates derived from tagging model. Tag recaptures from commercial fisheries are adjusted for non reporting based on recaptures from observers and researchers. Tag loss assumed to be zero.
B. NEAMAP Swept Area	Uses NEAMAP survey-based swept area estimates of abundance and assumed estimates of gear efficiency. Estimates based on average of ten surveys from fall 2007 to spring 2012.

Table 13 Modeled Results

Model Run	Model Years	95% low	Mean	95% high
A. ASPI	1999-2009	165,381	417,934	744,597

B.1 NEAMAP Survey, swept area assuming 100% efficiency	2007-2012	8,921	33,888	58,856
B.2 NEAMAP Survey, swept area assuming 50% efficiency	2007-2012	13,962	67,776	105,984
B.3 NEAMAP Survey, swept area assuming 10% efficiency	2007-2012	89,206	338,882	588,558

As illustrated by Table 13 above, the ASPI model currently projects a mean population size of 417,934 Atlantic sturgeon, and the NEAMAP Survey projects mean population sizes ranging from 33,888 to 338,882 depending on the assumption made regarding efficiency of that survey. The NEAMAP estimate, in contrast to the ASPI, is more empirically derived and does not depend on as many assumptions. For the purposes of this Opinion, while the ASPI model will be considered as part of the ASMFC stock assessment, we consider the NEAMAP estimate as the best available information on population size of Atlantic sturgeon in the ocean. Assuming a 50% catchability (defined as 1) the product of the probability of capture given encounter (i.e. net efficiency), and 2) the fraction of the population within the sampling domain), the ocean estimate for Atlantic sturgeon is 67,776. Currently, there are no comprehensive population estimates for any of spawning populations that will be affected by this action. Thus, we have presented the only available information on population sizes.

Table 15 Summary of calculated population estimates based upon the NEAMAP Survey swept area assuming 50% efficiency

DPS	Estimated Ocean Population Abundance
GOM (11%)	7,455
NYB (51%)	34,566
CB (13%)	8,811
Carolina (2%)	1,356
SA (22%)	14,911
Canada (1%)	678

3.4.4. Threats Faced by Atlantic sturgeon throughout their range

Atlantic sturgeon are susceptible to over-exploitation given their life history characteristics (e.g., late maturity and dependence on a wide variety of habitats). Similar to other sturgeon species (Vladykov and Greeley 1963, Pikitch *et al.* 2005), Atlantic sturgeon experienced range-wide declines from historical abundance levels due to overfishing (for caviar and meat) and impacts to habitat in the 19th and 20th centuries (Taub 1990, Smith and Clugston 1997, Secor and Waldman 1999).

Because a DPS is a group of populations, the stability, viability, and persistence of individual populations affects the persistence and viability of the larger DPS. The loss of any population within a DPS could result in: (1) a long-term gap in the range of the DPS that is unlikely to be recolonized; (2) loss of reproducing individuals; (3) loss of genetic biodiversity; (4) loss of unique haplotypes; (5) loss of adaptive traits; and (6) reduction in total number. The loss of a population will negatively impact the persistence and viability of the DPS as a whole, as fewer than two individuals per generation spawn outside their natal rivers (Secor and Waldman 1999). The persistence of individual populations, and in turn the DPS, depends on successful spawning and rearing within the freshwater habitat, emigration to marine habitats to grow, and return of adults to natal rivers to spawn.

Based on the best available information, NMFS has concluded that unintended catch in fisheries, vessel strikes, poor water quality, fresh water availability, dams, lack of regulatory mechanisms for protecting the fish, and dredging are the most significant threats to Atlantic sturgeon (77 FR 5880 and 77 FR 5914; February 6, 2012). While all the threats are not necessarily present in the same area at the same time, given that Atlantic sturgeon subadults and adults use ocean waters from Labrador, Canada to Cape Canaveral, FL, as well as estuaries of large rivers along the U.S. East Coast, activities affecting these water bodies are likely to impact more than one Atlantic sturgeon DPS. In addition, because Atlantic sturgeon depend on a variety of habitats, every life stage is likely affected by one or more of the identified threats.

Atlantic sturgeon are particularly sensitive to bycatch mortality because they are a long-lived species, have an older age at maturity, have lower maximum fecundity values, and a large percentage of egg production occurs later in life. Based on these life history traits, Boreman (1997) calculated that Atlantic sturgeon can only withstand the annual loss of up to 5% of their population to bycatch mortality without suffering population declines. Mortality rates of Atlantic sturgeon taken as bycatch in various types of fishing gear range between 0 and 51%, with the greatest mortality occurring in sturgeon caught by sink gillnets. Atlantic sturgeon are particularly vulnerable to being caught in sink gillnets; therefore, fisheries using this type of gear account for a high percentage of Atlantic sturgeon bycatch. Fisheries known to incidentally catch Atlantic sturgeon occur throughout the marine range of the species and in some riverine waters as well. Because Atlantic sturgeon mix extensively in marine waters and may access multiple river systems, they are subject to being caught in multiple fisheries throughout their range. In addition, stress or injury to Atlantic sturgeon taken as bycatch but released alive may result in increased susceptibility to other threats, such as poor water quality (e.g., exposure to toxins and low DO). This may result in reduced ability to perform major life functions, such as foraging and spawning, or even post-capture mortality.

As a wide-ranging anadromous species, Atlantic sturgeon are subject to numerous federal (U.S. and Canadian), state and provincial, and inter-jurisdictional laws, regulations, and agency activities. While these mechanisms, including the prohibition on possession, have addressed impacts to Atlantic sturgeon through directed fisheries, the listing determination concluded that the mechanisms in place to address the risk posed to Atlantic sturgeon from commercial bycatch were insufficient.

An ASMFC interstate fishery management plan for sturgeon (Sturgeon FMP) was developed and implemented in 1990 (Taub 1990). In 1998, the remaining Atlantic sturgeon fisheries in U.S. state waters were closed per Amendment 1 to the Sturgeon FMP. Complementary regulations were implemented by NMFS in 1999 that prohibit fishing for, harvesting, possessing, or retaining Atlantic sturgeon or their parts in or from the EEZ in the course of a commercial fishing activity.

Commercial fisheries for Atlantic sturgeon still exist in Canadian waters (DFO 2011). Sturgeon belonging to one or more of the DPSs may be harvested in the Canadian fisheries. In particular, the Bay of Fundy fishery in the Saint John estuary may capture sturgeon of U.S. origin given that sturgeon from the Gulf of Maine and the New York Bight DPSs have been incidentally captured in other Bay of Fundy fisheries (DFO 2010, Wirgin and King 2011). Because Atlantic sturgeon are listed under Appendix II of the Convention on International Trade in Endangered Species (CITES), the U.S. and Canada are currently working on a conservation strategy to address the potential for captures of U.S. fish in Canadian-directed Atlantic sturgeon fisheries and of Canadian fish incidentally captured in U.S. commercial fisheries. At this time, there are no estimates of the number of individuals from any of the DPSs that are captured or killed in Canadian fisheries each year.

Based on geographic distribution, most U.S. Atlantic sturgeon that are intercepted in Canadian fisheries are likely to originate from the Gulf of Maine DPS, with a smaller percentage from the New York Bight DPS.

Bycatch in U.S. waters is one of the primary threats faced by all five DPSs. At this time, we have an estimate of the number of Atlantic sturgeon captured and killed in sink gillnet and otter trawl fisheries authorized by federal FMFs (NMFS NEFSC 2011) in the Northeast Region but do not have a similar estimate for southeast fisheries. We also do not have an estimate of the number of Atlantic sturgeon captured or killed in state fisheries. At this time, we are not able to quantify the effects of other significant threats (e.g., vessel strikes, poor water quality, water availability, dams, and dredging) in terms of habitat impacts or loss of individuals. While we have some information on the number of mortalities that have occurred in the past in association with certain activities (e.g., mortalities in the Delaware and James Rivers that are thought to be due to vessel strikes), we are not able to use those numbers to extrapolate effects throughout one or more DPSs. This is because of (1) the small number of data points and, (2) the lack of information on the percent of incidents that the observed mortalities represent.

As noted above, the NEFSC prepared an estimate of the number of encounters of Atlantic sturgeon in fisheries authorized by Northeast FMPs (NMFS NEFSC 2011). The analysis estimates that from 2006 through 2010, there were averages of 1,548 and 1,569 encounters per year in observed gillnet and trawl fisheries, respectively, with an average of 3,118 encounters combined annually. Mortality rates in gillnet gear were approximately 20%. Mortality rates in otter trawl gear are generally lower, at approximately 5%.

Global climate change may affect all DPSs of Atlantic sturgeon in the future; however, effects of increased water temperature and decreased water availability are most likely to affect the South Atlantic and Carolina DPSs. Implications of climate change to the Atlantic sturgeon DPSs have been speculated, yet no scientific data are available on past trends related to climate effects on this species, and current scientific methods are not able to reliably predict the future magnitude of climate change and associated impacts or the adaptive capacity of these species. Impacts of climate change on Atlantic sturgeon are uncertain at this time, and cannot be quantified. Any prediction of effects is made more difficult by a lack of information on the rate of expected change in conditions and a lack of information on the adaptive capacity of the species (i.e., its ability to evolve to cope with a changing environment). For analysis on the potential effects of climate change on Atlantic sturgeon, see Section 5 below.

3.4.5. Gulf of Maine DPS of Atlantic sturgeon

The GOM DPS includes the following: all anadromous Atlantic sturgeon that spawn or are spawned in the watersheds from the Maine/Canadian border and, extending southward, all watersheds draining into the GOM as far south as Chatham, MA. The marine range of Atlantic sturgeon from the GOM DPS extends from Hamilton Inlet, Labrador, Canada, to Cape Canaveral, FL. The riverine range of the GOM DPS and the adjacent portion of the marine range are shown in Figure1. Within this range, Atlantic sturgeon historically spawned in the Androscoggin, Kennebec, Merrimack, Penobscot, and Sheepscot Rivers (ASSRT 2007). Spawning still occurs in the Kennebec and Androscoggin Rivers, and it is possible that it still occurs in the Penobscot River as well. Spawning in the Androscoggin River was just recently confirmed by the Maine Department of Marine Resources when they captured a larval Atlantic sturgeon during the 2011 spawning season below the Brunswick Dam. There is no evidence of recent spawning in the remaining rivers. In the 1800s, construction of the Essex Dam on the Merrimack River at river kilometer (rkm) 49 blocked access to 58% of Atlantic sturgeon habitat in the river (Oakley 2003, ASSRT 2007). However, the accessible portions of the Merrimack seem to be suitable habitat for Atlantic sturgeon spawning and rearing (i.e., nursery habitat) (Keiffer and Kynard 1993). Therefore, the availability of spawning habitat does not appear to be the reason for the lack of observed spawning in the Merrimack River. Studies are ongoing to determine whether Atlantic sturgeon are spawning in the Penobscot and Saco Rivers. Atlantic sturgeon that are spawned elsewhere continue to use habitats within these rivers as part of their overall marine range (ASSRT 2007).

At its mouth, the Kennebec River drains an area of 24,667 square kilometers, and is part of a large estuarine system that includes the Androscoggin and Sheepscot Rivers (ASMFC 1998a, NMFS and USFWS 1998d, Squiers 1998). The Kennebec and Androscoggin Rivers flow into Merrymeeting Bay, a tidal freshwater bay, and exit as a combined river system through a narrow channel, flowing approximately 32 kilometers (20 miles) to the Atlantic Ocean as the tidal segment of the Kennebec River (Squiers 1998). This lower tidal segment of the Kennebec River forms a complex with the Sheepscot River estuary (ASMFC 1998a, Squiers 1998).

Substrate type in the Kennebec estuary is largely sand and bedrock (Fenster and Fitzgerald 1996, Moore and Reblin 2010). Main channel depths at low tide typically range from 17 meters (58 feet) near the mouth to less than 10 meters (33 feet) in the Kennebec River above Merrymeeting Bay (Moore and Reblin 2010). Salinities range from 31 parts per thousand at Parker Head (5 kilometers from the mouth) to 18 parts per thousand at Doubling Point during summer low flows (ASMFC 1998a). The 14-kilometer river segment above Doubling Point to Chops Point (the outlet of Merrymeeting Bay) is an area of transition (mid estuary) (ASMFC 1998a). The salinities in this section vary both seasonally and over a tidal cycle. During spring freshets this section is entirely fresh water but during summer low flows, salinities can range from 2 to 3 parts per thousand at Chops Point to 18 parts per thousand at Doubling Point (ASMFC 1998a). The river is essentially tidal freshwater from the outlet of Merrymeeting Bay upriver to the site of the former Edwards Dam (ASMFC 1998a). Mean tidal amplitude ranges from 2.56 meters at the mouth of the Kennebec River estuary to 1.25 meters in Augusta near the head of tide on the Kennebec River (in the vicinity of the former Edwards Dam) and 1.16 meters at Brunswick on the Androscoggin River (ASMFC 1998a).

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 (Squiers *et al.* 1981, SMFC 1998a, NMFS and USFWS 1998d). 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 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; and, (3) capture of nine adults during a gillnet survey conducted from 1977 to 1981, the majority of which were captured in July in the area from Merrymeeting Bay and upriver as far as Gardiner, ME (NMFS and USFWS 1998d, ASMFC 2007). The low salinity of waters above Merrymeeting Bay are consistent with values found in other rivers where successful Atlantic sturgeon spawning is known to occur.

Age to maturity for GOM DPS Atlantic sturgeon is unknown. However, Atlantic sturgeon riverine populations exhibit clinal variation with faster growth and earlier age to maturity for those that originate from southern waters, and slower growth and later age to maturity for those that originate from northern waters (75 FR 61872; October 6, 2010). Age at maturity is 11 to 21 years for Atlantic sturgeon originating from the Hudson River (Young *et al.* 1998), and 22 to 34 years for Atlantic sturgeon that originate from the Saint Lawrence River (Scott and Crossman1973). Therefore, age at maturity for Atlantic sturgeon of the GOM DPS likely falls within these values. Of the 18 sturgeon examined from the commercial fishery that occurred in the Kennebec River in 1980, all of which were considered mature, age estimates for the 15 males ranged from 17-40 years, and from 25-40 years old for the three females (Squiers *et al.* 1981).

Several threats play a role in shaping the current status of GOM 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 *et al.* 1979). In 1849, 160 tons of sturgeon were caught in the Kennebec River by local fishermen (Squiers *et al.* 1979). After the collapse of sturgeon stock in the 1880s, the sturgeon fishery was almost non-existent. 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 in state and federal waters still occur. In the marine range, GOM DPS Atlantic sturgeon are incidentally captured in federal and state-managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (Stein *et al.* 2004, ASMFC 2007). As explained above, we have estimates of the number of subadults and adults that are killed as a result of bycatch in fisheries authorized under Northeast FMPs. At this time, we are not able to quantify the impacts from other threats or estimate the number of individuals killed as a result of other anthropogenic threats. Habitat disturbance and direct mortality from anthropogenic sources are the primary concerns.

Riverine habitat may be affected by dredging and other in-water activities, disturbing spawning habitat and also altering the benthic forage base. Many rivers in the GOM DPS have navigation channels that are maintained by dredging. Dredging outside of federal channels and in-water construction occurs throughout the GOM 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. 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, and are also not able to quantify any effects to habitat. Connectivity is disrupted by the presence of dams on several 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 historical natural falls and likely represent the maximum upstream extent of sturgeon occurrence even if the dams were not present. Because no Atlantic sturgeon 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. The extent that Atlantic sturgeon are affected by operations of dams in the Gulf of Maine region is currently unknown; however, the documentation of an Atlantic sturgeon larvae downstream of the Brunswick Dam in the Androscoggin River suggests that Atlantic sturgeon spawning may be occurring in the vicinity of that project and therefore, may be affected by project operations. The range of Atlantic sturgeon in the Penobscot River is limited by the presence of the Veazie Dam, which prevents Atlantic sturgeon from accessing approximately 29 kilometers of habitat, including the presumed historical spawning habitat located downstream of Milford Falls, the site of the Milford Dam. The removal of the Veazie Dam this year will restore access to the entirety of the species' historical range in the Penobscot River. Atlantic sturgeon are known to occur in the Penobscot River, but it is unknown whether spawning is currently occurring or whether the presence of the Veazie Dam affects the likelihood of spawning occurring in this river. The Essex Dam on the Merrimack River blocks access to approximately 58% of historically accessible habitat in this river. Atlantic sturgeon occur in the Merrimack River but spawning has not been documented. As with the Penobscot, it is unknown how the Essex Dam affects the likelihood of spawning in this river.

GOM 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 (Lichter *et al.* 2006, EPA 2008). Many rivers in Maine, including the Androscoggin River, were heavily polluted in the past from pulp and paper mills' industrial discharges. 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.

There are no direct in-river abundance estimates for the GOM DPS. The Atlantic Sturgeon Status Review Team (ASSRT) (2007) presumed that the GOM DPS was comprised of less than 300 spawning adults per year, based on extrapolated abundance estimates from the Hudson and Altamaha riverine populations of Atlantic sturgeon. Surveys of the Kennebec River over two time periods, 1977-1981 and 1998-2000, resulted in the capture of nine adult Atlantic sturgeon (Squiers 2004). However, since the surveys were primarily directed at capture of shortnose sturgeon, the capture gear used may not have been selective for the larger-sized adult Atlantic sturgeon; several hundred subadult Atlantic sturgeon were caught in the Kennebec River during these studies. As described earlier, we have estimated that there are a minimum of 7,455 GOM DPS adult and subadult Atlantic sturgeon of size vulnerable to capture in federal marine fisheries. We note further that this estimate is predicated on the assumption that fish in the GOM DPS would be available for capture in the NEAMAP survey which extends from Block Island Sound (RI) southward.

Summary of the Gulf of Maine DPS

Spawning for the GOM DPS is known to occur in two rivers (Kennebec and Androscoggin). Spawning may be occurring in other rivers, such as the Sheepscot, Merrimack, and Penobscot, but has not been confirmed. There are indications of potential increasing abundance of Atlantic sturgeon belonging to the GOM DPS. 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). These observations suggest that abundance of the GOM DPS of Atlantic sturgeon is sufficient such that recolonization to rivers historically suitable for spawning may be occurring. However, despite some positive signs, there is not enough information to establish a trend for this DPS.

Some of the impacts from the threats that contributed to the decline of the GOM 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). In Maine state waters, there are strict regulations on the use of fishing gear that incidentally catches sturgeon. In addition, in the last several years 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 GOM DPS are not commonly taken as bycatch in areas south of Chatham, MA, with only 8% (e.g., 7 of 84 fish) of interactions observed south of Chatham being assigned to the GOM DPS (Wirgin and King 2011). Tagging results also indicate that GOM DPS fish tend to remain within the waters of the Gulf of Maine and only occasionally venture to points south.

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 % originated from the GOM 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. 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, ASMFC 2007, Kahnle *et al.* 2007, Brown and Murphy 2010). We have determined that the GOM 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.

3.4.6. New York Bight DPS of Atlantic sturgeon

The NYB DPS includes the following: all anadromous Atlantic sturgeon spawned in the watersheds that drain into coastal waters from Chatham, MA to the Delaware-Maryland border on Fenwick Island. Within this range, Atlantic sturgeon historically spawned in the Connecticut, Delaware, Hudson, and Taunton Rivers (Murawski and Pacheco 1977, Secor 2002, ASSRT 2007). Spawning still occurs in the Delaware and Hudson Rivers, but there is no recent evidence (within the last 15 years) of spawning in the Connecticut and Taunton Rivers (ASSRT 2007). Atlantic sturgeon that are spawned elsewhere continue to use habitats within the Connecticut and Taunton Rivers as part of their overall marine range (ASSRT 2007, Savoy 2007, Wirgin and King 2011).

The Hudson River and Estuary extend 504 kilometers from the Atlantic Ocean to Lake Tear of-the-Clouds in the Adirondack Mountains (Dovel and Berggren 1983). The estuary is 246 km long, beginning at the southern tip of Manhattan Island (rkm 0) and running north to the Troy Dam (rkm 246) near Albany (Sweka *et al.* 2007). All Atlantic sturgeon habitats are believed to occur below the dam. Therefore, presence of the dam on the river does not restrict access of Atlantic sturgeon to necessary habitats (e.g., for spawning, rearing, foraging, over wintering) (NMFS and USFWS 1998, ASSRT 2007).

Use of the river by Atlantic sturgeon has been described by several authors. Briefly, spawning likely occurs in multiple sites within the river from approximately rkm 56 to rkm 182 (Dovel and Berggren 1983, Van Eenennaam *et al.* 1996, Kahnle *et al.* 1998, Bain *et al.* 2000). Selection of sites in a given year may be influenced by the position of the salt wedge (Dovel and Berggren 1983, Van Eenennaam *et al.* 1996, Kahnle *et al.* 1998). The area around Hyde Park (approximately rkm134) has consistently been identified as a spawning area through scientific studies and historical records of the Hudson River sturgeon fishery (Dovel and Berggren 1983, Van Eenennaam *et al.* 1996, Kahnle *et al.* 1998, Bain *et al.* 2000). Habitat conditions at the Hyde Park site are described as freshwater year round with bedrock, silt and clay substrates and waters depths of 12-24 m (Bain *et al.* 2000). Bain *et al.* (2000) also identified a spawning site at rkm 112 based on tracking data. The rkm 112 site, located to one side of the river, has clay, silt and sand substrates, and is approximately 21-27 m deep (Bain *et al.* 2000).

Young-of-year (YOY) have been recorded in the Hudson River between rkm 60 and rkm 148, which includes some brackish waters; however, larvae must remain upstream of the salt wedge because of their low salinity tolerance (Dovel and Berggren 1983, Kahnle *et al.* 1998, Bain *et al.* 2000). Catches of immature sturgeon (age 1 and older) suggest that juveniles utilize the estuary from the Tappan Zee Bridge through Kingston (rkm 43- rkm 148) (Dovel and Berggren 1983, Bain *et al.* 2000). Seasonal movements are apparent with juveniles occupying waters from rkm 60 to rkm 107 during summer months and then moving downstream as water temperatures decline in the fall, primarily occupying waters from rkm 19 to rkm 74 (Dovel and Berggren 1983, Bain *et al.* 2000). Based on river-bottom sediment maps (Coch 1986) most juvenile sturgeon habitats in the Hudson River have clay, sand, and silt substrates (Bain *et al.* 2000). Newburgh and Haverstraw Bays in the Hudson River are areas of known juvenile sturgeon concentrations (Sweka *et al.* 2007). Sampling in spring and fall revealed that highest catches of juvenile Atlantic sturgeon occurred during spring in soft-deep areas of Haverstraw Bay even though this habitat type comprised only 25% of the available habitat in the Bay (Sweka *et al.* 2007). Overall, 90% of the total 562 individual juvenile Atlantic sturgeon captured during the course of this study (14 were captured more than once) came from Haverstraw Bay (Sweka *et al.* 2007). At around three years of age, Hudson River juveniles exceeding 70 cm total length begin to migrate to marine waters (Bain *et al.* 2000).

In general, Hudson River Atlantic sturgeon mature at approximately 11 to 21 years of age (Dovel and Berggren 1983, ASMFC 1998, Young *et al.* 1998). A sample of 94 pre-spawning adult Atlantic sturgeon from the Hudson River was comprised of males 12 to 19 years old, and females that were 14 to 36 years old (Van Eenennaam *et al.* 1996). The majority of males were 13 to 16 years old while the majority of females were 16 to 20 years old (Van Eenennaam *et al.* 1996). These data are consistent with the findings of Stevenson and Secor (1999) who noted that, amongst a sample of Atlantic sturgeon collected from the Hudson River fishery from 1992-1995, growth patterns indicated males grew faster and, thus, matured earlier than females. The spawning season for Hudson River Atlantic sturgeon extends from late spring to early summer (Dovel and Berggren 1983, Van Eenennaam *et al.* 1996).

The abundance of the Hudson River Atlantic sturgeon riverine population prior to the onset of expanded exploitation in the 1800's is unknown but, has been conservatively estimated at 10,000 adult females (Secor 2002). Current abundance is likely at least one order of magnitude smaller than historical levels (Secor 2002, ASSRT 2007, Kahnle *et al.* 2007). As described above, an estimate of the mean annual number of mature adults (863 total; 596 males and 267 females) was calculated for the Hudson River riverine population based on fishery-dependent data collected from 1985-1995 (Kahnle *et al.* 2007). Kahnle *et al.* (1998, 2007) also showed that the level of fishing mortality from the Hudson River Atlantic sturgeon fishery during the period of 1985-1995 exceeded the estimated sustainable level of fishing mortality for the riverine population and may have led to reduced recruitment. All available data on abundance of juvenile Atlantic sturgeon in the Hudson River Estuary indicate a substantial drop in production of young since the mid 1970's (Kahnle *et al.* 1998). A decline appeared to occur in the mid to late 1970's followed by a secondary drop in the late 1980's (Kahnle *et al.* 1998, Sweka *et al.* 2007, ASMFC 2010). Catch-per-unit-effort data suggest that recruitment has remained depressed relative to catches of juvenile Atlantic sturgeon in the estuary during the mid-late 1980's (Sweka *et al.* 2007, ASMFC 2010). In examining the CPUE data from 1985-2007, there are significant fluctuations during this time. There appears to be a decline in the number of juveniles between the late 1980s and early 1990s and while the CPUE is generally higher in the 2000s as compared to the 1990s, given the significant annual fluctuation it is difficult to discern any trend. Despite the CPUEs from 2000-2007 being generally higher than those from 1990-1999, they are low compared to the late 1980s.

In the Delaware River and Estuary, Atlantic sturgeon occur from the mouth of the Delaware Bay to the fall line near Trenton, NJ, a distance of 220 km (NMFS and USFWS 1998, Simpson 2008). As is the case in the Hudson River, all historical Atlantic sturgeon habitats appear to be accessible in the Delaware (NMFS and USFWS 1998, ASSRT 2007). Recent multi-year studies have provided new information on the use of habitats by Atlantic sturgeon within the Delaware River and Estuary (Simpson 2008, Brundage and O'Herron 2009, Calvo *et al.* 2010, Fox and Breece 2010).

Historical records from the 1830's indicate Atlantic sturgeon may have spawned as far north as Bordentown, just below Trenton, NJ (Pennsylvania Commission of Fisheries 1897). Cobb (1899) and Borodin (1925) reported spawning occurring between rkm 77 and 130 (Delaware City, DE to Chester City, PA). Based on recent tagging and tracking studies carried out from 2009-2011, Breece (2011) reports likely spawning locations at rkm 120-150 and rkm 170-190. Mature adults have been tracked in these areas at the time of year when spawning is expected to occur and movements have been consistent with what would be expected from spawning adults. Based on tagging and tracking studies, Simpson (2008) suggested that spawning habitat also exists from Tinicum Island (rkm 136) to the fall line in Trenton, NJ (rkm 211). To date, eggs and larvae have not been documented to confirm that actual spawning is occurring in these areas. However, as noted below, the presence of young of the year in the Delaware River provides confirmation that spawning is still occurring in this river.

Sampling in 2009 that targeted YOY resulted in the capture of more than 60 YOY in the Marcus Hook anchorage (rkm 127) area during late October-late November 2009 (Fisher 2009, Calvo *et al.* 2010). Twenty of the YOY from one study and six from the second study received acoustic tags that provided information on habitat use by this early life stage (Calvo *et al.* 2010, Fisher 2011). YOY used several areas from Deepwater (rkm 105) to Roebling (rkm 199) during late fall to early spring. Some remained in the Marcus Hook area while others moved upstream, exhibiting migrations in and out of the area during winter months (Calvo *et al.* 2010, Fisher 2011). At least one YOY spent some time downstream of Marcus Hook (Calvo *et al.* 2010, Fisher 2011). Downstream detections from May to August between Philadelphia (rkm 150) and New Castle (rkm 100) suggest non-use of the upriver locations during the summer months (Fisher 2011). By September 2010, only three of 20 individuals tagged by DE DNREC persisted with active tags (Fisher 2011). One of these migrated upstream to the Newbold Island and Roebling area (rkm 195), but was back down in the lower tidal area within three weeks and was last detected at Tinicum Island (rkm 141) when the transmitter expired in October (Fisher 2011). The other two remained in the Cherry Island Flats (rkm 113) and Marcus Hook Anchorage area (rkm130) until their tags transmissions also ended in October (Fisher 2011).

The Delaware Estuary is known to be a congregation area for sturgeon from multiple DPSs. Generally, non-natal late stage juveniles (sometimes also referred to as subadults) immigrate into the estuary in spring, establish home range in the summer months in the river, and emigrate from the estuary in the fall (Fisher 2011). Subadults tagged and tracked by Simpson (2008) entered the lower Delaware Estuary as early as mid-March but, more typically, from mid-April through May. Tracked sturgeon remained in the Delaware Estuary through the late fall departing in November (Simpson 2008). Previous studies have found a similar movement pattern of upstream movement in the spring-summer and downstream movement to overwintering areas in the lower estuary or nearshore ocean in the fall-winter (Brundage and Meadows 1982, Shirey *et al.* 1997, 1999, Brundage and O'Herron 2009, Brundage and O'Herron in Calvo *et al.* 2010).

Brundage and O'Herron (in Calvo *et al.* 2010) tagged 26 juvenile Atlantic sturgeon, including six young of the year. For non YOY fish, most detections occurred in the lower tidal Delaware River from the middle Liston Range (rkm 70) to Tinicum Island (rkm 141). For non YOY fish, these researchers also detected a relationship between the size of individuals and the movement pattern of the fish in the fall. The fork length of fish that made defined movements to the lower bay and ocean averaged 815 mm (range 651-970 mm) while those that moved towards the bay but were not detected below Liston Range averaged 716 mm (range 505-947 mm), and those that appear to have remained in the tidal river into the winter averaged 524 mm (range 485-566 mm) (Calvo *et al.* 2010). During the summer months, concentrations of Atlantic sturgeon have been located in the Marcus Hook (rkm 123-129) and Cherry Island Flats (rkm 112-118) regions of the river (Simpson 2008, Calvo *et al.* 2010) as well as near Artificial Island (Simpson 2008). Sturgeon have also been detected using the Chesapeake and Delaware Canal (Brundage 2007, Simpson 2008).

Adult Atlantic sturgeon captured in marine waters off of Delaware Bay in the spring were tracked in an attempt to locate spawning areas in the Delaware River, (Fox and Breece 2010). Over the period of two sampling seasons (2009-2010) four of the tagged sturgeon were detected in the Delaware River. The earliest detection was in mid-April while the latest departure occurred in mid-June (Fox and Breece 2010). The sturgeon spent relatively little time in the river each year, generally about four weeks, and used the area from New Castle, DE (rkm 100) to Marcus Hook (rkm 130) (Fox and Breece 2010). A fifth sturgeon tagged in a separate study was also tracked and followed a similar timing pattern but traveled farther upstream (to rkm 165) before exiting the river in early June (Fox and Breece 2010).

There is no abundance estimate for the Delaware River population of Atlantic sturgeon. Harvest records from the 1800's indicate that this was historically a large population with an estimated 180,000 adult females prior to 1890 (Secor and Waldman 1999, Secor 2002). Sampling in 2009 to target young-of- the year (YOY) Atlantic sturgeon in the Delaware River (i.e., natal sturgeon) resulted in the capture of 34 YOY, ranging in size from 178 to 349 mm TL (Fisher 2009) and the collection of 32 YOY Atlantic sturgeon in a separate study (Brundage and O'Herron in Calvo *et al.* 2010). Genetics information collected from 33 of the 2009 year class YOY indicates that at least three females successfully contributed to the 2009 year class (Fisher 2011). Therefore, while the capture of YOY in 2009 provides evidence that successful spawning is still occurring in the Delaware River, the relatively low numbers suggest the existing riverine population is limited in size.

Several threats play a role in shaping the current status and trends observed in the Delaware River and Estuary. In-river threats include habitat disturbance from dredging, and impacts from historical pollution and impaired water quality. A dredged navigation channel extends from Trenton seaward through the tidal river (Brundage and O'Herron 2009), and the river receives significant shipping traffic. Vessel strikes have been identified as a threat in the Delaware River; however, at this time we do not have information to quantify this threat or its impact to the population or the NYB DPS. Similar to the Hudson River, there is currently not enough information to determine a trend for the Delaware River population.

Summary of the New York Bight DPS

Atlantic sturgeon originating from the NYB DPS spawn in the Hudson and Delaware rivers. While genetic testing can differentiate between individuals originating from the Hudson or Delaware river the available information suggests that the straying rate is high between these rivers. There are no indications of increasing abundance for the NYB DPS (ASSRT 2009 & 2010). Some of the impact from the threats that contributed to the decline of the NYB DPS have been removed (e.g., directed fishing) or reduced as a result of improvements in water quality since passage of the Clean Water Act (CWA). In addition, there have been reductions in fishing effort in state and federal waters, which may result in a reduction in bycatch mortality of Atlantic sturgeon. Nevertheless, areas with persistent, degraded water quality, habitat impacts from dredging, continued bycatch in state and federally-managed fisheries, and vessel strikes remain significant threats to the NYB DPS.

In the marine range, NYB DPS Atlantic sturgeon are incidentally captured in federal and state managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (Stein *et al.* 2004, ASMFC 2007). Based on mixed stock analysis results presented by Wirgin and King (2011), over 40 percent of the Atlantic sturgeon bycatch interactions in the Mid Atlantic Bight region were sturgeon from the NYB DPS. Individual-based assignment and mixed stock analysis of samples collected from sturgeon captured in Canadian fisheries in the Bay of Fundy indicated that approximately 1-2% were from the NYB DPS. At this time, we are not able to quantify the impacts from other threats or estimate the number of individuals killed as a result of other anthropogenic threats.

Riverine habitat may be impacted by dredging and other in-water activities, disturbing spawning habitat and also altering the benthic forage base. Both the Hudson and Delaware rivers have navigation channels that are maintained by dredging. Dredging is also used to maintain channels in the nearshore marine environment. Dredging outside of Federal channels and in-water construction occurs throughout the New York Bight region. While some dredging projects operate with observers present to document fish mortalities, many do not. We have reports of one Atlantic sturgeon entrained during hopper dredging operations in Ambrose Channel, New Jersey. 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 and, additionally, are unable to quantify any effects to habitat.

In the Hudson and Delaware Rivers, dams do not block access to historical habitat. The Holyoke Dam on the Connecticut River blocks further upstream passage; however, the extent that Atlantic sturgeon would historically have used habitat upstream of Holyoke is unknown. Connectivity may be disrupted by the presence of dams on several smaller rivers in the New York Bight region. Because no Atlantic sturgeon occur upstream of any hydroelectric projects in the New York Bight region, passage over hydroelectric dams or through hydroelectric turbines is not a source of injury or mortality in this area. The extent that Atlantic sturgeon are affected by operations of dams in the New York Bight region is currently unknown.

NYB DPS Atlantic sturgeon may also be affected by degraded water quality. In general, water quality has improved in the Hudson and Delaware over the past decades (Lichter *et al.* 2006, USEPA 2008). Both the Hudson and Delaware rivers, as well as other rivers in the New York

Bight region, were heavily polluted in the past from industrial and sanitary sewer discharges. 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.

Vessel strikes occur in the Delaware River. Twenty-nine mortalities believed to be the result of vessel strikes were documented in the Delaware River from 2004 to 2008, and at least 13 of these fish were large adults. Given the time of year in which the fish were observed (predominantly May through July, with two in August), it is likely that many of the adults were migrating through the river to the spawning grounds. Because we do not know the percent of total vessel strikes that the observed mortalities represent, we are not able to quantify the number of individuals likely killed as a result of vessel strikes in the NYB DPS.

Studies have shown that to rebuild, Atlantic sturgeon can only sustain low levels of anthropogenic mortality (Boreman 1997, ASMFC 2007, Kahnle *et al.* 2007, Brown and Murphy 2010). There are no empirical abundance estimates of the number of Atlantic sturgeon in the NYB DPS. We have determined that the NYB DPS is currently at risk of extinction due to: (1) precipitous declines in population sizes and the protracted period in 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 population recovery.

3.4.7. Factors Affecting Atlantic Sturgeon in Action Area

3.4.7.1.Dams and Hydroelectric Facilities

Historically, the upstream migration of Atlantic sturgeon on the Kennebec River was limited to Waterville at Tieonic Falls (rkm 98) (NMFS and USFWS 1998), approximately the location of the Lockwood Project. Ticonic Falls is located 65 rkm downstream of the fall line (based on reference points provided by Oakley 2005). The construction of Edwards Dam at rkm 71 in 1837 denied sturgeon access to historical habitat in the Kennebec River until 1999 when it was removed. Since its removal, almost 100% of historic habitat is now accessible.

In the Androscoggin River, the Brunswick Hydroelectric Project (rkm 44) is located at the head-of-tide at the site of a natural falls. This facility was licensed by FERC in 1979 and the license is set to expire in 2029. The limited storage capacity of the Brunswick Dam restricts its ability to influence river flows; therefore, during the FERC licensing process, a minimum flow requirement was deemed not necessary. The location of historical spawning grounds on the Androscoggin River is unknown, but it is unlikely that sturgeon could navigate the natural falls located at Brunswick Dam (NMFS and USFWS 1998).

As Atlantic sturgeon do not occur upstream of any hydroelectric projects in the Kennebec or Androscoggin Rivers, passage over hydroelectric dams or through hydroelectric turbines is not a source of injury or mortality in the action area. The extent that Atlantic sturgeon are affected by operations of hydroelectric facilities in these Rivers is currently unknown.

3.4.7.2. Contaminants and Water Quality

Atlantic sturgeon are vulnerable to effects from contaminants and water quality over their entire life history. In addition, their long life span increases the potential for environmental contaminants to build up in the tissue which may affect the development of the individual or its gametes. Point source discharges (i.e., municipal wastewater, paper mill effluent, industrial or power plant cooling water or waste water) and compounds associated with discharges (i.e., metals, dioxins, dissolved solids, phenols, and hydrocarbons) contribute to poor water quality that may also impact the health of individual sturgeon. The compounds associated with discharges can alter the chemistry and temperature of receiving waters, which may lead to mortality, changes in fish behavior, deformations, and reduced egg production and survival. Contaminants including heavy metals, polychlorinated aromatic hydrocarbons (PAHs), pesticides, and polychlorinated biphenyls (PCBs), can have serious, deleterious effects on aquatic life and are associated with the production of acute lesions, growth retardation, and reproductive impairment (Ruelle and Keenlyne 1993). Contaminants introduced into the water column or through the food chain eventually become associated with the benthos where bottom dwelling species like Atlantic sturgeon are particularly vulnerable.

4. ENVIRONMENTAL BASELINE OF THE ACTION AREA

Environmental baselines for biological opinions include the past and present impacts of all state, federal or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this Opinion includes the effects of several activities that may affect the survival and recovery of the listed species and may affect critical habitat in the action area.

4.1. Formal or Early Section 7 Consultations

In the Environmental Baseline section of an Opinion, we discuss the anticipated impacts of all proposed Federal actions in the action area that have already undergone formal or early section 7 consultation. Effects of Federal actions that have been completed are encompassed in the Status of the Species section of the Opinion.

On September 17, 2012, September 19, 2012, and October 18, 2012 we issued Opinions to the FERC on the impacts to listed species from ISPPs being proposed by Brookfield Renewable Power for the Hydro-Kennebec Project, Topsham Hydro Partners for the Pejepseot Project, and Miller Hydro Group for the Worumbo Project. The purpose of these ISPPs is to collect information on passage efficiency and survival of Atlantic salmon adults and smolts attempting to migrate past the Projects. The incidental take statements authorize take for proposed studies, fishway improvements, and ongoing operation of these projects for five year interim periods (2012-2016). At the end of this period, Brookfield, Topsham Hydro, and Miller Hydro will develop final SPPs that contain additional protection measures for listed fish, if necessary, and FERC will reinitiate formal consultation in order to obtain take authorization for the remainder of each projects' license term. We concluded that the proposed actions were not likely to jeopardize the continued existence of listed Atlantic salmon.

The ITSs accompanying the Opinions exempted the incidental take of Atlantic salmon smolts, adults, and kelts due to injury and harassment associated with the upstream and downstream passage studies (Table 16). We also authorized take for the operation of the projects over the term of the ISPPs. These authorizations expire at the end of the proposed ISPP (2016).

Table 16. Take of Atlantic salmon authorized for ISPPs for project operation and fish passage studies at the Pejepscot, Worumbo, and Hydro-Kennebec Projects

			Operations		**Monitoring**	
Project	**Duration**	**Lifestage**	**Harass**	**Kill**	**Harm and Harass**	**Kill***
Pejepscot	2012-2016	Adults	24.75%	0.25%	40/year	11 total
		Smolts		8.40%	172/year	
		Kelts		28%	20/year	
Worumbo	2012-2016	Adults		1 fish		12 total
		Smolts		8.40%	172/year	
		Kelts		10 fish	20/year	
Hydro Kennebec	2012-2016	Smolts		7.9%	200/year	
		Kelts		28%	20/year	

*Number anticipated to be killed due to handling and tagging only.

We also completed two formal consultations for activities in Bond Brook, a tributary to the Kennebec River in Augusta, Maine. The first project involved coal tar remediation in the brook. The second project involved upgrades to a combined sewer overflow in Bond Brook. We exempted the non-lethal take of two adult Atlantic salmon for each project.

4.2. Kennebec Hydro Developers Group Agreement

In 1987, the owners of several hydropower projects on the Kennebec and Sebastieook Rivers, including the owners of the Projects addressed under this ISPP, reached an agreement with state and federal fishery agencies on anadromous fish passage initiatives that dam owners would undertake. The agreement, known as the Kennebec Hydro Developer Group Agreement (KHDG Agreement), was designed to facilitate the restoration of American shad, river herring, and Atlantic salmon in the Kennebec River basin. The 1998 KHDG Agreement, modified the original Agreement to include provisions for supporting the removal of Edwards dam and for providing fish passage for Atlantic salmon, American shad, river herring and American eel at the Lockwood, Shawmut and Weston projects, as well as other hydroelectric projects located on the mainstem Kennebec and Sebasticook rivers. Under KHDG, the hydro owners directly funded restoration efforts, including dam removals at Edwards and Fort Halifax.

The 1998 KHDG Agreement established triggers that, if reached, would initiate a sequential process of upstream and downstream fishway construction at the Lockwood, Hydro-Kennebec, Shawmut, and Weston Projects on the Kennebec River, and the Burnham and Benton Falls Projects in the Sebasticook River. The KHDG Agreement indicates that permanent downstream passage facilities will be operational at the time that the upstream fishways become operational.

The Agreement lays out two potential triggers for the construction of fishways: 1) a threshold number of shad trapped at the existing fish trap at the Lockwood Project, or 2) "a biological trigger initiated for Atlantic salmon, alewife or blueback herring." The number of shad trapped at the Lockwood Project has been consistently low since the implementation of the Agreement. Between 2006 and 2012, an average of 11 shad have been trapped at the Project per year (Brookfield Renewable Energy Group 2013), significantly below the 8,000 required to trigger the construction of permanent upstream fishways. In regards to the "biological trigger," the KHDG agreement states that "Should the growth of salmon or river herring runs make it necessary to adopt an alternative approach for triggering fishway installation…the resource agencies will meet with the licensees(s) to attempt to reach consensus on the need, timing and design of permanent upstream fish passage facilities…" The Agreement further states that if neither of the triggers have been met prior to December 2014, "the parties will meet to assess the progress in restoring" diadromous fish species in the Kennebec River. As neither of the triggers has been met, it is anticipated that discussions will be occurring in the near future to determine what modifications to the KHDG Agreement may be necessary to restore diadromous fish to the Kennebec River.

The licensee's proposed ISPP does not supersede their obligations under the KHDG Agreement. The provisions of the Agreement have been incorporated into the Projects' licenses and FERC has not proposed to remove those provisions. In their ISPP, the licensee proposes date-certain upstream fishway installation for Atlantic salmon at the Lockwood, Shawmut and Weston Projects, although the triggers as defined in the Agreement have yet to be met. It is expected that the licensee will meet the other provisions of the Agreement such as the requirements that 1) downstream passage studies be conducted prior to the date that permanent downstream passage facilities are to be operational, 2) that permanent downstream passage facilities are operational at the same time as permanent upstream passage facilities, and 3) that efficiency and survival studies will be conducted after the construction of any interim or permanent upstream or downstream fish passage facilities.

4.3. Scientific Studies

Atlantic salmon

MDMR is authorized under the USFWS' endangered species blanket permit (No. 697823) to conduct monitoring, assessment, and habitat restoration activities for listed Atlantic salmon populations in Maine. The extent of take from MDMR activities during any given year is not expected to exceed 2% of any life stage being impacted, except that for adults, it would be less than 1%. MDMR will continue to conduct Atlantic salmon research and management activities in the Kennebec River watershed while the proposed action is carried out. The information gained from these activities will be used to further salmon conservation actions in the GOM DPS.

We are also a sub-permittee under USFWS' ESA section 10 endangered species blanket permit. Research authorized under this permit is currently ongoing regarding Atlantic salmon populations in the Merrymeeting Bay SHRU. Although these activities will result in some take of Atlantic salmon, adverse impacts are expected to be minor and such take is authorized by an existing ESA permit. The information gained from these activities will be used to further salmon conservation actions in the GOM DPS.

USFWS is also authorized under an ESA section 10 endangered species blanket permit to conduct the conservation hatchery program at the Craig Brook and Green Lake National Fish Hatcheries. The mission of the hatcheries is to raise Atlantic salmon parr and smolts for stocking into selected Atlantic salmon rivers in Maine. Over 90% of adult returns to the GOM DPS are currently provided through production at the hatcheries. The hatcheries provide a significant buffer from extinction for the species.

Shortnose sturgeon

Research activities for shortnose sturgeon conducted by University of Maine investigators are authorized through scientific research permits issued by NMFS. Permit number 16306 was recently issued (May 2012), and will extend until 2017. The research team consists of scientists from MDMR, USGS, UM, and the University of Southern Maine. Their research objectives are to: 1) use mark-recapture techniques to generate population estimates and to define stock structure and distribution, 2) determine the degree of demographic correspondence and connectivity of local in-river sturgeon populations, and 3) identify habitat use, movement patterns, and life history characteristics of shortnose sturgeon in Maine waters. The treatments would include weighing, measuring, photographing, anesthetize, inserting PIT tag, Floy/T-bar tag insertion, tissue sample, blood sample, boroscope, gastric lavage, fin ray section, apical spine sample, and external satellite tagging. Not all specimens sampled would receive all treatments. The research sites include the Penobscot, Kennebec, Saco, and Merrimack Rivers. Additionally, several smaller coastal rivers in Maine and New Hampshire will also be surveyed. The Section 10 permit allows the directed non-lethal take of 7,205 shortnose sturgeon of various life stages over the duration of the permit, with 200 deliberate mortalities of early life stage (ELS) occurring annually. The Biological Opinion issued as a result of section 7 consultation on the effects of the directed take authorized under Permit 16306, concluded that this take is not likely to jeopardize the continued existence of any ESA-listed species under NMFS jurisdiction

Atlantic sturgeon

The MDMR, in collaboration with scientists at UM and others, are conducting studies on the Atlantic sturgeon population in the GOM DPS. The research proposed to be conducted through a scientific research permit (NMFS No. 16526) would include determining movement patterns and rate of exchange between coastal river systems, characterizing the population structure (i.e., sex ratios and aging), and generating estimates of population abundance. The proposed action would involve several major river systems in Maine, including the Penobscot, Kennebec, Androscoggin and Sheepscot rivers. Smaller coastal rivers throughout Maine would also be targeted. The applicant would use gill nets to capture up to 975 juvenile and adult Atlantic sturgeon, and D-nets to sample 200 early life stage (ELS) annually. Atlantic sturgeon captured by gill nets, trammel nets, trawls, and beach seines would be measured, weighed, photographed, PIT tagged, Floy/T-bar tagged, tissue sampled, boroscoped, apical spine sampled, blood sampled, anesthetized, fin ray sectioned, and implanted with an acoustic telemetry tag. The applicant would use MS-222 as an anesthetic or on occasion, electronarcosis; see the application for further details. Not all Atlantic sturgeon would undergo all procedures. In total, up to 200 ELS, plus two annual incidental mortalities of juvenile Atlantic sturgeon and up to one adult Atlantic sturgeon over the life of the permit would be anticipated as the result of research. Research conducted prior to issuance of this permit has demonstrated a low mortality rate using similar gear types; approximately 120 Atlantic sturgeon were captured over a five year study with four incidental mortalities occurring to juvenile fish.

4.3. Other Federally Authorized Activities in the Action Area

We have completed several informal consultations on effects of in-water construction activities in the Kennebec and Androscoggin Rivers permitted by the ACOE. This includes several dock, pier, and bank stabilization and dredging projects. No interactions with Atlantic salmon, shortnose or Atlantic sturgeon have been reported in association with any of these projects.

4.4. State or Private Activities in the Action Area

Information on the number of sturgeon captured or killed in state fisheries is extremely limited and as such, efforts are currently underway to obtain more information on the numbers of sturgeon captured and killed in state water fisheries. We are currently working with the Atlantic States Marine Fisheries Commission (ASMFC) and the coastal states to assess the impacts of state authorized fisheries on sturgeon. We anticipate that some states are likely to apply for ESA section 10(a)(1)(B) Incidental Take Permits to cover their fisheries; however, to date, no applications have been submitted.

In 2007, the MDMR authorized a limited catch-and-release fall fishery (September 15 to October 15) for Atlantic salmon in the Penobscot River upstream of the former Bangor Dam. The fishery was closed prior to the 2009 season. There is no indication that the fishery will be reinstated in the future.

4.5. Impacts of Other Human Activities in the Action Area

Other human activities that may affect listed species and critical habitat include direct and indirect modification of habitat due to hydroelectric facilities and the introduction of pollutants from paper mills, sewers, and other industrial sources. Pollution has been a major problem for these river systems, which continues to receive discharges from sewer treatment facilities and paper production facilities (metals, dioxin, dissolved solids, phenols, and hydrocarbons).

Hydroelectric facilities can alter the river's natural flow pattern and temperatures. In addition, the release of silt and other fine river sediments during dam maintenance can be deposited in sensitive spawning habitat nearby. These facilities also act as barriers to normal upstream and downstream movements, and block access to important habitats. Passage through these facilities may result in the mortality of downstream migrants.

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 the listed species considered here. 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. Consideration of effects of the proposed action in light of predicted changes in environmental conditions due to anticipated climate change are included in the Effects of the Action section below (Section 6.0).

5.1. Background Information on Global climate change

The global mean temperature has risen 0.76°C (1.36°F) over the last 150 years, and the linear trend over the last 50 years is nearly twice that for the last 100 years (IPCC 2007) and precipitation has increased nationally by 5%-10%, mostly due to an increase in heavy downpours (NAST 2000). 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 other 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 are most apparent over the past few decades. Information on future impacts of climate change in the action area is discussed below.

Climate model projections exhibit a wide range of plausible scenarios for both temperature and precipitation over the next century. Both of the principal climate models used by the National Assessment Synthesis Team (NAST) project warming in the southeast by the 2090s, but at different rates (NAST 2000): the Canadian model scenario shows the southeast U.S. experiencing a high degree of warming, which translates into lower soil moisture as higher temperatures increase evaporation; the Hadley model scenario projects less warming and a significant increase in precipitation (about 20%). The scenarios examined, which assume no major interventions to reduce continued growth of world greenhouse gases (GHG), indicate that temperatures in the U.S. will rise by about 3°-5°C (5°-9°F) on average in the next 100 years which is more than the projected global increase (NAST 2000). A warming of about 0.2°C (0.4°F) per decade is projected for the next two decades over a range of emission scenarios (IPCC 2007). This temperature increase will very likely be associated with more extreme precipitation and faster evaporation of water, leading to greater frequency of both very wet and very dry conditions. Climate warming has resulted in increased procipitation, river discharge, and glacial and sea-ice melting (Greene *et al.* 2008).

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 2006). 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 2006). The NAO impacts climate variability throughout the northern hemisphere (IPCC 2006). Data from the 1960s through the present show that the NAO index has increased from minimum values in the 1960s to strongly positive index values in the 1990s and somewhat declined since (IPCC 2006). This warming extends over 1000m (0.62 miles) deep and is deeper than anywhere in the world oceans and is particularly evident under the Gulf Stream/ North Atlantic Current system (IPCC 2006). 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 (Greene *et al.* 2008, IPCC 2006). There is evidence that the NADW has already freshened significantly (IPCC 2006). 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 whole earth system (Greene *et al.* 2008).

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 next few decades on coastal and marine resources on smaller geographic scales, such as the Penobscot River, 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. Warming is very likely to continue in the U.S. over the next 25 to 50 years regardless of reduction in GHGs, due to emissions that have already occurred (NAST 2000). It is very likely that the magnitude and frequency of ecosystem changes will continue to increase in the next 25 to 50 years, and it is possible that the rate of change will accelerate. 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).

A warmer and drier climate is expected to result in reductions in stream flows and increases in water temperatures. Expected consequences could be 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). Because many rivers are already under a great deal of stress due to excessive water withdrawal or land development, and this stress may be exacerbated by changes in climate, anticipating and planning adaptive strategies may be critical (Hulme 2005). A warmer-wetter climate could ameliorate poor water quality conditions in places where human-caused concentrations of nutrients and pollutants other than heat 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 and affect recreational uses of lakes, streams, and wetlands. Surface water resources in the southeast 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 water stress, 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 may experience greater changes in discharge and water stress than unimpacted, free-flowing rivers (Palmer *et al.* 2008).

While debated, researchers anticipate: 1) the frequency and intensity of droughts and floods will change across the nation; 2) a warming of about 0.2°C (0.4°F) per decade; and 3) a rise in sea level (NAST 2000). A warmer and drier climate will reduce stream flows and increase water temperature resulting in a decrease of DO and an increase in the concentration of nutrients and toxic chemicals due to reduced flushing. Sea level is expected to continue rising: during the 20th century global sea level has increased 15 to 20 cm (6-8 inches).

5.2. Species Specific Information on Climate Change Effects

5.2.1. Effects to Atlantic Salmon and Critical Habitat

Atlantic salmon may be especially vulnerable to the effects of climate change in New England, since the areas surrounding many river catchments where salmon are found are heavily populated and have already been affected by a range of stresses associated with agriculture, industrialization, and urbanization (Elliot *et al.* 1998). Climate effects related to temperature regimes and flow conditions determine juvenile salmon growth and habitat (Friedland1998). 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 and Reid 2003).

One recent 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 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 (Elliot *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, Elliot *et al.* 1998). 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). Unfortunately, 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).

It is anticipated that these climate change effects could significantly affect the functioning of the 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 degrees 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.

5.2.2. Shortnose sturgeon

Global climate change may affect shortnose sturgeon in the future. Rising sea level may result in the salt wedge moving upstream in affected rivers. Shortnose sturgeon spawning occurs in fresh water reaches of rivers because early life stages have little to no tolerance for salinity. Similarly, juvenile shortnose sturgeon have limited tolerance to salinity and remain in waters with little to no salinity. If the salt wedge moves further upstream, shortnose sturgeon spawning and rearing habitat could be restricted. In river systems with dams or natural falls that are impassable by sturgeon, the extent that spawning or rearing may be shifted upstream to compensate for the shift in the movement of the saltwedge would be limited. While there is an indication that an increase in sea level rise would result in a shift in the location of the salt wedge, for most spawning rivers there are no predictions on the timing or extent of any shifts that may occur; thus, it is not possible to predict any future loss in spawning or rearing habitat. However, in all river systems, spawning occurs miles upstream of the saltwedge. It is unlikely that shifts in the location of the saltwedge would eliminate freshwater spawning or rearing habitat. If habitat was severely restricted, productivity or survivability may decrease.

The increased rainfall predicted by some models in some areas may increase runoff and scour spawning areas and flooding events could cause temporary water quality issues. Rising temperatures predicted for all of the U.S. could exacerbate existing water quality problems with DO and temperature. While this occurs primarily in rivers in the southeast U.S. and the Chesapeake Bay, it may start to occur more commonly in the northern rivers. Shortnose sturgeon are tolerant to water temperatures up to approximately 28°C (82.4°F); these temperatures are experienced naturally in some areas of rivers during the summer months. If river temperatures rise and temperatures above 28°C are experienced in larger areas, sturgeon may be excluded from some habitats.

Increased droughts (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 spring may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, all shortnose sturgeon life stages, including adults, may become susceptible to strandings. Low flow and drought conditions are also expected to cause additional water quality issues. Any of the conditions associated with climate change are likely to disrupt river ecology causing shifts in community structure and the type and abundance of prey. Additionally, cues for spawning migration and spawning could occur earlier in the season causing a mismatch in prey that are currently available to developing shortnose sturgeon in rearing habitat; however, this would be mitigated if prey species also had a shift in distribution or if developing sturgeon were able to shift their diets to other species.

5.2.3. Atlantic sturgeon

Global climate change may affect all DPSs of Atlantic sturgeon in the future; however, effects of increased water temperature and decreased water availability are most likely to effect the South Atlantic and Carolina DPSs. Rising sea level may result in the salt wedge moving upstream in affected rivers. Atlantic sturgeon spawning occurs in fresh water reaches of rivers because early life stages have little to no tolerance for salinity. Similarly, juvenile Atlantic sturgeon have limited tolerance to salinity and remain in waters with little to no salinity. If the salt wedge moves further upstream, Atlantic sturgeon spawning and rearing habitat could be restricted. In river systems with dams or natural falls that are impassable by sturgeon, the extent that spawning or rearing may be shifted upstream to compensate for the shift in the movement of the saltwedge would be limited. While there is an indication that an increase in sea level rise would result in a shift in the location of the salt wedge, at this time there are no predictions on the timing or extent of any shifts that may occur; thus, it is not possible to predict any future loss in spawning or rearing habitat. However, in all river systems, spawning occurs miles upstream of the saltwedge. It is unlikely that shifts in the location of the saltwedge would eliminate freshwater spawning or rearing habitat. If habitat was severely restricted, productivity or survivability may decrease.

The increased rainfall predicted by some models in some areas may increase runoff and scour spawning areas and flooding events could cause temporary water quality issues. Rising temperatures predicted for all of the U.S. could exacerbate existing water quality problems with DO and temperature. While this occurs primarily in rivers in the southeast U.S. and the Chesapeake Bay, it may start to occur more commonly in the northern rivers. Atlantic sturgeon prefer water temperatures up to approximately 28°C (82.4°F); these temperatures are experienced naturally in some areas of rivers during the summer months. If river temperatures rise and temperatures above 28°C are experienced in larger areas, sturgeon may be excluded from some habitats.

Increased droughts (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 spring may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, all Atlantic sturgeon life stages, including adults, may become susceptible to strandings or habitat restriction. Low flow and drought conditions are also expected to cause additional water quality issues. Any of the conditions associated with climate change are likely to disrupt river ecology causing shifts in community structure and the type and abundance of prey. Additionally, cues for spawning migration and spawning could occur earlier in the season causing a mismatch in prey that are currently available to developing sturgeon in rearing habitat.

6. EFFECTS OF THE ACTION

This section of an Opinion assesses the direct and indirect effects of the proposed action on threatened and endangered species or critical habitat, together with the effects of other activities that are interrelated or interdependent (50 CFR 402.02). Indirect effects are those that are caused later in time, but are still reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend upon the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02). The trapping of Atlantic salmon by MDMR will occur at the Lockwood fish trap and Brunswick fishway after the proposed action has occurred. This activity would not occur but for the existence of the fish traps. However, as this activity has already been authorized under a research and recovery blanket permit with USFWS (permit number 697823); its effects will not be addressed in this Opinion. We have not identified any other interrelated or interdependent actions.

These activities will affect the GOM DPS of Atlantic salmon, shortnose sturgeon, the GOM DPS of Atlantic sturgeon and the New York Bight DPS of Atlantic sturgeon as well as critical habitat designated from the GOM DPS of Atlantic salmon. The sections that follow present our analysis of the following: (1) construction of fish passage facilities; (2) hydroelectric operations under the terms of the ISPP; and (3) implementation of upstream and downstream fish passage efficiency and survival studies required by the proposed ISPP.

6.1. Effects of Fishway Construction

Effects of the construction of fishways at the Lockwood, Shawmut, and Weston Projects are likely to be restricted to the habitat immediately downriver each of these Projects. Shortnose and Atlantic sturgeon use habitat downstream of the Lockwood Project; but as they are not passed at the facility it is not anticipated that they would be present in the habitat downstream of the Shawmut and Weston Projects. Construction at the Lockwood Project itself is not anticipated to require in-water work (R. Richter, Brookfield Renewable Power, 2013). Therefore, shortnose and Atlantic sturgeon are not anticipated to be exposed to the effects of construction.

The mainstem Kennebec River serves as an important migratory corridor for adult Atlantic salmon migrating upriver to spawning habitat between May and October, as well as to outmigrating smolts between April and June and outmigrating kelts in early winter and spring. Potential effects associated with in-water construction generally include inhibiting fish passage, increasing noise and suspended sediment levels, causing direct injury and mortality during construction, and potentially spilling toxic substances (e.g., equipment leaks). Interim upstream fish passage at the Lockwood Project involves trapping and trucking pre-spawn Atlantic salmon upriver to spawning and rearing habitat in the Sandy River. Therefore, no pre-spawn Atlantic salmon will be in the vicinity of the Shawmut and Weston Projects at the time of construction. To minimize the effects to outmigrating smolts and kelts all in-river construction will occur outside of the outmigration period. Therefore, as construction at Lockwood will not involve any in-water work, it is expected that construction associated with the proposed ISPP will not affect listed sturgeon and salmon in the action area.

Atlantic Salmon Critical Habitat

Proposed construction activities will temporarily reduce the status of several habitat indicators relative to Atlantic salmon critical habitat. We expect these activities to cause temporary adverse effects to the migratory PCE of critical habitat by reducing water quality due to increased turbidity and the filling of habitat. The habitat in the Kennebec River does not currently function for upstream migration of pre-spawn adult Atlantic salmon due to the lack of fish passage facilities at all of the Projects upstream of Lockwood. However, the habitat does function as a migration corridor for outmigrating smolts and kelts in the spring as they make their way to the estuary. Construction will be timed so that in-water effects to the habitat (turbidity, noise and the presence of temporary fill) will not coincide with the smolt outmigration period.

The construction of the fishways will place temporary and permanent fill below the ordinary high water (OHW) line in the Kennebec River. It is anticipated that the amount of temporary and permanent fill will not exceed 500 square feet at either the Shawmut or Weston Projects. As all fill will be placed and removed in the Kennebec River outside of the spring outmigration period and as adults cannot access the Projects, it is anticipated that construction activities will have an insignificant effect on the migration PCE. However, the placement of permanent fill will negatively affect the functioning of the habitat at these Projects by precluding the use of the habitat for migration. However, as the permanent fill associated with the new structures will occupy less than half of one habitat unit at the Shawmut and Weston Projects, it is not anticipated that it will alter the functioning of the habitat for Atlantic salmon.

6.2. Effects of Hydroelectric Operations

Hydroelectric dams can impact Atlantic salmon, shortnose sturgeon and Atlantic sturgeon through habitat alteration, fish passage delays, entrainment in turbines and impingement on screens and/or racks. Currently, the Lockwood, Shawmut, Weston, and Brunswick, and Lewiston Falls Projects are operated pursuant to the terms and conditions of existing FERC licenses. Existing FERC license articles require that all of the Projects except Lewiston Falls be operated in a run-of-river mode with minimal impoundment fluctuations. The Lewiston Falls Project is licensed to operate with up to four feet of impoundment fluctuation to allow for peaking under normal conditions.

6.2.1. Atlantic salmon

The modified licenses proposed by FERC implement protection measures described in the ISPP to minimize the effect of operations of the licensee's hydroelectric facilities on migrating Atlantic salmon. The ISPP involves 1) the sequential construction of upstream fishways at the Lockwood, Shawmut, and Weston Projects; 2) downstream survival studies at the Lockwood, Shawmut, Weston, and Brunswick Projects; and 3) upstream passage studies at the Lockwood and Brunswick Projects. The studies conducted at the Projects are a component of an adaptive management strategy that will be implemented by the licensee in consultation with us to maximize the survival of outmigrating smolts and kelts and the passage success of upstream migrating pre-spawn salmon. Although no performance standards have been proposed as part of the ISPP, it is expected that high survival and passage rates will be required under the terms of the final SPP. Since we cannot accurately predict the survival of Atlantic salmon achieved through each of the individual protection measures, it will be assumed that survival and passage efficiency at these Projects will at a minimum be maintained at existing levels throughout the interim period, but most likely will improve as a result of adaptive management.

6.2.1.1. Upstream Passage Effects

To complete their upstream migration, all pre-spawn Atlantic salmon in the Androscoggin and Kennebec Rivers must navigate past hydroelectric projects via fishways. Fishways collect motivated fish into human-made structures that allow them to proceed in their migration. These fish are necessarily crowded together into a narrow channel or trap, which exposes them to increased levels of injury and delay, as well as to stress from elevated water temperatures, energetic exhaustion and disease. Forcing fish to alter their migratory behavior and potentially exposing them to the corresponding stress and injury negatively affects 100% of the Atlantic salmon motivated to migrate past a hydroelectric project.

Except for the Lockwood Project, all of the Projects on the Kennebec River currently lack upstream passage facilities for diadromous fish. The construction of fishways at the Lockwood, Hydro-Kennebec, Shawmut, and Weston Projects will improve access to approximately 70,000 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 improve 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 Bombazee Ripps, Wesserunsett Stream and Carrabassett Stream. The upstream fishways at the Lockwood, Shawmut, and Weston Projects will become operational in 2016, 2018, and 2020, respectively. In addition, a volitional upstream fish lift will become operational at the Hydro-Kennebec Project in 2016. Salmon will need volitional passage at all four of these dams in order to access the spawning and rearing habitat in the Sandy River. Therefore, until the fishway at the Weston Project is operational, it is anticipated that pre-spawn Atlantic salmon will not have access to mainstem habitat in the Kennebec River upriver of the Lockwood Project. The existing trap and truck operation provides interim upstream passage for Atlantic salmon by transporting them above the currently impassable dams to the habitat in the Sandy River.

Between 2013 and 2020, Atlantic salmon will continue to be trucked from the Lockwood Project to the Sandy River by the MDMR. As such, upstream migrating Atlantic salmon would continue to be denied volitional access to upstream spawning habitat by the licensee's Projects on the Kennebec until 2020. While trap and truck fish passage can successfully move migrants to upstream areas, trap and truck operations to transport migratory fish species can result in adverse impacts including injury, disorientation, disease and mortality, delay in migration, and interruption of the homing instinct, which can lead to straying (OTA 1995). Other disadvantages to trap and truck passage include: holding and handling stress, reduced passage by other species that will not enter traps, and the need for long-term, guaranteed operational funding for dedicated biological staff, equipment, supplies, vehicles and tanks, etc. Therefore, we assume that all upstream migrating adult Atlantic salmon will be affected by trap and truck operations on the Kennebec River over the interim period. Since 2006, adult Atlantic salmon returns to the Kennebec River have ranged from 5 to 64 fish (average = 26). We expect these relatively low numbers of returning adults to continue throughout the duration of the ISPP.

The handling and trucking of the Atlantic salmon that enter the fish trap at Lockwood will be conducted by MDMR, which holds a section 10(a)(1)(A) research permit under the USFWS's regional endangered species blanket permit (No. 697823) that authorizes the handling of listed Atlantic salmon. Therefore, the effects of handling and transporting are not considered as part of the proposed action. However, all migrating adult Atlantic salmon in the mainstem will be affected by the Project as they will be trapped and potentially delayed by the dam and its fish passage facilities.

No upstream passage studies have been conducted at the Lockwood Project so it is unknown what proportion of salmon are able to locate and utilize the existing fish trap. A review of the literature and passage efficiencies at dams in Maine suggests that passage rates at lifts tend to be low. A meta-analysis conducted by Noonan *et al.* (2012) indicates that the average passage efficiency of salmonids at five fish lifts was approximately 35%. A study at the Golfech-Malause hydroelectric complex on the River Garonne in France determined that only 47% of motivated Atlantic salmon successfully used the fish lift (Croze *et al.* 2008). Hydropower dams in Maine have also shown similarly low success rates at passing salmon. Fish lifts exist at the Cataract and Skelton Projects on the Saco River in Maine. Based on trap counts between 2002 and 2012, an average of 54% (range: 20%-100%) of Atlantic salmon that were passed at the Cataract Project were passed at the Skelton Project, the next upstream dam on the river (FPL Energy 2007-2013). Likewise, a telemetry study conducted on the Androscoggin River indicated that only 43% of the salmon motivated to migrate upriver of the Brunswick Project successfully use the fish lift at the Pejepscot Project, the next upstream dam on the River (MDMR 2012). As many of the Atlantic salmon that migrate in the Androscoggin and Saco Rivers have strayed from other rivers, it is likely that the observed passage rates are affected by a lack of motivation to migrate. However, we consider the passage rates at these fishways as the best available information on fish lift passage effectiveness for Atlantic salmon. The average passage rate at these eight Projects is approximately 40%. We assume, therefore, that at least 40% of Atlantic salmon motivated to migrate upstream of the Lockwood Project during the proposed interim period are trapped successfully.

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 comprised 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 2010). 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, 40% will pass successfully, 0.6% (1% x 60% failing to pass) will be killed, and 59.4% (99% x 60% failing to pass) will either spawn in downstream habitat or return to the ocean without spawning.

Androscoggin River

The vertical slot fishway at the Brunswick Project was designed to pass anadromous fish including Atlantic salmon, and consequently it provides access for adult Atlantic salmon to habitat upstream of the Project. With passage facilities also at the Pejepscot and Worumbo Projects, Atlantic salmon can migrate up to impassable barriers 1) in the main stem to the next upstream dam at Lewiston Falls in Lewiston, 2) to Lower Barker Mills Dam in the Little Androscoggin River in Auburn, and 3) to Lower Dam (a.k.a. Farwell) in the Sabattus River in Lisbon (MDMR 2010).

Atlantic salmon are known to successfully utilize the upstream fishway at the Brunswick Project. However, no studies have been conducted to determine the passage efficiency of the fishway for Atlantic salmon. A similar fishway at the West Enfield Project on the Penobscot River has been found to be 88-89% effective at passing upstream migrating Atlantic salmon (Shepard 1995). However, Noonan *et al.* (2012) found that not all vertical slot fishways are as successful at passing salmonids. In a meta-analysis of fishway efficiency at dams, they determined that the average passage efficiency of three pool and slot type fishways was 52% for salmonids. Averaging the efficiencies of these four projects would suggest that the Brunswick fishway is at least 61% efficient at passing motivated pre-spawn Atlantic salmon.

The conclusions from the upstream passage expert panel that we convened in 2010 can be used to estimate mortality of pre-spawn adults at the Brunswick Project. Assuming a similar effect occurs at Brunswick as occurs in the Penobscot, 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 Brunswick Project, 61% will pass successfully, 0.4% (1% x 39% failing to pass) will be killed, and 38.6% (99% x 39% failing to pass) will either spawn in downstream habitat, migrate to the Kennebec River, or return to the ocean without spawning.

Upstream Impediments to Passage

The Androscoggin River upriver of the Lewiston Falls Dam is currently inaccessible to anadromous fish because there is no fish passage at the Project. This unoccupied habitat is not designated as critical habitat for Atlantic salmon as it was not deemed essential for the recovery of the species (50 CFR Part 226). However, impassable dams exclude Atlantic salmon from approximately 80,000 units of spawning and rearing habitat within the Androscoggin River (NMFS 2009b), or 83% of the potential rearing habitat within the Androscoggin drainage. No upstream passage facilities exist at the Lewiston Falls Project, and the licensee is not proposing to construct any during the seven year ISPP.

The Deer Rips Dam is 4.40 kilometers upriver of the Lewiston Falls Project and is the next upstream barrier to migrating fish. The approximately one square kilometer of habitat between the two projects has been made inaccessible to Atlantic salmon by the lack of passage at the Lewiston Falls Project. The habitat is impounded and is, therefore, not currently suitable as rearing or spawning habitat. This reach of river is not currently stocked with Atlantic salmon so there should be no homing of salmon to it.

The presence of the dam may force upstream migrating Atlantic salmon approaching the dam to stray into downstream habitat. It may also lead to some fish being significantly delayed downstream of the Project as they seek a path past the dam. Between 2003 and 2012, an average of two salmon a year succeeded in passing the Worumbo Project. Therefore, it is expected that very few salmon would be in the habitat immediately downstream of the Lewiston Falls Project.

Stranding

It is possible that operation of the Lewiston Falls or Lockwood Projects could affect migrating Atlantic salmon, particularly during flashboard replacement and/or during and after spill events, by inadvertently trapping or stranding them in the various pools downstream of the Projects. To reduce the potential effects of stranding on Atlantic salmon and other fish species, the licensee will monitor downstream pools after significant spill events and during flashboard replacement and collect any stranded Atlantic salmon and release them back into the river. The licensee will record its monitoring actions following each significant spill event.

The addition of rubber dams along the spillways at the Lewiston Falls Projects are expected to help reduce the potential impacts to Atlantic salmon in two ways: 1) by allowing better control of the location of spill, and 2) by reducing the time it currently takes to replace failed flashboard sections. Combined, these modifications are anticipated to reduce the potential for stranding of Atlantic salmon in the various pools in and around Great Falls.

The licensee has developed a draft Atlantic Salmon Rescue and Handling Plan for the Lewiston Falls Project, and has proposed to monitor ledge areas in the Lockwood bypass reach during flashboard replacement. The licensee has proposed to implement the rescue plan at Lewiston Falls between May 1 and July 31 annually. In a telemetry study conducted in 2011, one of the three Atlantic salmon that passed the Worumbo Project was documented to move back and forth between the area downstream of Lower Barker Dam on the Little Androscoggin and just downstream of Lewiston Falls in the mainstem between October 14 and December 12. Given this information, the Atlantic salmon Rescue and Handling Plan should be implemented between May 1 and December 31 if salmon are known to be in the area.

The licensee has been surveying the ledges downstream of the Lewiston Falls Dam for the last four years (2009-2012) and has not detected any stranded salmon (R. Richter, Brookfield Renewable Power, pers. comm., 2013). Regardless, as an average of two adult salmon pass the Worumbo Project every year, Atlantic salmon could be present in the habitat downstream of Lewiston Falls and, given the flow and ledge conditions could become stranded in the pools downstream of the Project. Given that no salmon have been stranded over the last four years, it is assumed that no more than one Atlantic salmon will become stranded over the seven year interim period. The licensee monitors for salmon in the Lockwood bypass reach annually during flashboard replacement, and occasionally have had to rescue up to two fish a year due to dewatering of the reach (R. Richter, Brookfield Renewable Power, pers. comm., 2013). Therefore, it is assumed that two Atlantic salmon a year could become stranded at the Lockwood Project. Any stranded fish could potentially be injured due to abrasions caused with contact with ledge, and could be severely stressed due to the effects of stranding, handling, and transport. Given the implementation of the handling plan, this injury and stress is not likely to be long lasting and should have no effect on the survival of the fish.

6.2.1.2.Downstream Passage Effects

Under the proposed action, the Lockwood, Shawmut, Weston, and Brunswick Projects could potentially affect any outmigrating juvenile salmon and kelts by: 1) injury and mortality associated with entrainment through project facilities, 2) delayed outmigration influencing outmigrating timing, 3) potential to increase predation on outmigrating juveniles in project reservoirs, and 4) increasing stress levels, which leads to a subsequent decrease in saltwater tolerance. The Projects' impoundments would continue to alter water quality, stream channel migratory routes, and the timing and behavior of outmigrating fish.

The Lockwood, Shawmut, Weston, and Brunswick Projects all operate with some form of downstream fish passage and protection for outmigrating smolts and kelts, including reduced spacing of trashracks and guidance booms for protection against turbine entrainment and sluice gates or other openings for downstream passage. Since none of the fishways are 100% effective, turbine entrainment, impingement and migratory delays of Atlantic salmon are expected at each dam. Therefore, continuing to operate the Lockwood, Shawmut, Weston, and Brunswick Projects will affect downstream movements of Atlantic salmon in the Kennebec and Androscoggin River watersheds.

Atlantic salmon smolts

Site-specific mortality (initial; 1-hr and delayed; 48-hr) rates for Atlantic salmon smolts passed via turbine units were not available for the Weston, Shawmut, Lockwood or Brunswick projects. As such, the licensee has conducted an assessment of Atlantic salmon smolt and kelt survival in the BA submitted to FERC. Estimates for passage survival of Atlantic salmon smolts through Francis, Kaplan and propeller units were developed based on existing empirical studies conducted at other hydroelectric projects with similar characteristics. Average turbine injury and survival rates varied among projects due to differences in turbine types as well as their differing site characteristics. Survival estimates for turbine passage were also generated using the Advanced Hydro Turbine model developed by Franke *et al.* (1997). The Franke blade strike model predicts the probabilities of leading edge strikes, considered the primary mechanism of mortality when fish pass through turbines (Eicher Associates Inc. 1987, Cada 2001). Turbine passage survival was calculated using site-specific turbine parameters and for a range of body lengths (5-9 inches) considered to be representative of outmigrating salmon smolts in Maine rivers (NRC 2004, Fay *et al.* 2006).

Whole station smolt survival estimates for each of the projects were calculated by integrating river flows, Project operating flows, spill effectiveness, downstream bypass effectiveness rates, turbine entrainment rates, and spillway and turbine survival rates. Three models intended to estimate whole station survival of smolts passing each Project were constructed using the available empirical and modeled survival estimates for both spill and turbine passage (Table 17):

1. Initial Survival Rate Model (Model A): Spill survival based on 1-hr empirical survival

data and turbine survival based on 1-hr empirical survival data.
2. Delayed Survival Rate Model (Model B): Spill survival based on 48-hr empirical survival data and turbine survival based on 48-hr empirical survival data.
3. Delayed/Calculated Survival Rate Model (Model C): Spill survival based on 48-hr empirical survival data and turbine survival based on Franke estimates.
4. Delayed/Calculated Survival Rate Model (Model C*): Same analysis as Model C, but the rates have been updated to incorporate the results of a downstream passage efficiency study conducted in 2012.

Table 17. Whole Station Survival Estimates for Atlantic Salmon Smolts Passing the Weston, Shawmut, Lockwood and Brunswick Projects under Median Flow Conditions (50% Flow Exceedence)

Project	Model A	Model B	Model C	Model C*
Weston	93%	92%	90%	94%
Shawmut	91%	90%	90%	95%
Lockwood	94%	93%	92%	94%
Brunswick	95%	93%	93%	93%

As Model C* includes the most recent data on the passage efficiency of the interim downstream fishways, and incorporates a level of delayed mortality (48-hours), it is assumed that it is the best available estimate of downstream survival at these Projects. Therefore, for the interim period downstream survival at median flows is anticipated to be at least 94%, 95%, 94%, and 93% at the Weston, Shawmut, Lockwood, and Brunswick Projects, respectively. These survival rates will vary based on the amount of water passing each Project. In their draft BA, the licensee estimated a correction factor to account for different flow exceedence levels at each Project (Table 18). Although these estimates did not incorporate the updated passage efficiency data (the Model C* condition), it is assumed that the variation is on the order of what has been estimated for Model C.

Table 18. Impacts Due to Variation in the Monthly River Flow to the Whole Station Survival Estimates for Atlantic Salmon Smolts Passing the Weston, Shawmut, Lockwood and Brunswick Projects.

		Percent of Time Flow is Exceeded				
Project	Model	***BASE*** [1]	**10%**	**25%**	**75%**	**90%**
Weston	A	93%	2%	1%	-2%	-1%
	B	92%	3%	2%	-1%	0%
	C	90%	4%	3%	-2%	-2%
Shawmut	A	91%	3%	2%	-2%	-2%
	B	90%	4%	2%	-2%	-2%
	C	90%	4%	2%	-1%	-1%
Lockwood	A	94%	2%	1%	-1%	-1%
	B	93%	2%	1%	-1%	-2%
	C	92%	2%	2%	-2%	-2%

	A	95%	1%	0%	0%	0%
Brunswick	B	93%	2%	1%	0%	0%
	C	93%	2%	1%	0%	0%

A desktop analysis provides an estimate of survival and does not assess potential impacts resulting from migratory delays, non-lethal injuries, or latent death. Therefore, actual survival of smolts is most likely less than what was reported in the FERC's BA. This conclusion is supported by the analyses conducted by Randy Bailey and Jeffrey Hutchings in their declarations to the US District Court in Maine in March of 2013. In his declaration, Bailey (2013) enumerated the reasons why these estimates likely overestimate actual survival through the Weston, Shawmut, Lockwood and Brunswick Projects. Among the reasons were:

- The Franke Model was designed for use with Kaplan turbines and, thus, likely underestimates the effect of the Francis turbines at these projects;
- The estimates are based on a range of fish lengths that is not necessarily representative of what has been found in the Kennebec River watershed; and
- The estimates do not account for mortality that occurs more than 48-hours after smolt passage.

For these reasons, we expect that the survival estimates included in FERC's BA may overestimate smolt survival through these Projects. The smolt studies that will be conducted by the licensee between 2013 and 2015 will determine actual survival rates at the Projects.

The potential for delays in the timely passage of smolts encountering hydropower dams is evident in some tracking studies on the Penobseot. At the Mattaceunk Dam, the average time needed for hatchery smolts to pass the dam, after being detected in the forebay area, was 15.6 hours (range 0 to 72 hours), 39.2 hours (range 0 to 161 hours), 14.6 hours (range 0 to 59.4 hours) and 30 hours (range 0.2 to 226 hours) in four different study years (GNP 1995, GNP 1997, GNP 1998, GNP 1999). At the West Enfield Dam, the median delay was 0.86 hours (range 0.3 to 49.7 hours) for hatchery smolts in 1993 (BPHA 1993), and approximately 13 hours (range 0.2 to 102.9 hours) for wild smolts in 1994 (BPHA 1994). At the Orono Dam, the median delay between release and passage of smolts was 3.4 hours (range 0.6 to 33.3 hours) in 2010 (Aquatic Science Associates, Inc 2011). While these delays can lead to direct mortality of Atlantic salmon from increased predation (Blackwell *et al.* 1998), migratory delays can also reduce overall physiological health or physiological preparedness for seawater entry and oceanic migration (Budy *et al.* 2002). Various researchers have identified a "smolt window" or period of time in which smolts must reach estuarine waters or suffer irreversible effects (McCormick *et al.* 1999). Late migrants lose physiological smolt characteristics due to high water temperatures during spring migration (McCormick *et al.* 1999). 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 so, then these delays may reduce smolt survival (McCormick *et al.* 1999).

Atlantic salmon kelts

Very limited studies of kelt passage have been conducted on the Kennebec or Androscoggin rivers. Kelt studies conducted in the lower Penobscot River documented that most kelts passed the dams in spilled water, typically over the spillways, but also through gates and sluices (Hall and Shepard 1990). Observation of the initial approach of kelts at the Veazie and Milford projects reflected the distribution of flow, whereby the proportion of kelts that approached spillways was correlated with spillway flow (Hall and Shepard, 1990). Shepard (1989) made a similar finding at the confluence of the Stillwater Branch and the mainstem Penobscot, where kelts followed routes in approximate proportion to flow in the two channels.

Lacking site specific kelt passage data on the Androscoggin and Kennebec rivers, the licensee conducted a detailed assessment of the mortality potential for outmigrating Atlantic salmon kelts for the Weston, Shawmut, and Lockwood Projects on the Kennebec River and the Brunswick Project on the Androscoggin River. At each individual project, downstream passage of outmigrating kelts must occur via one of three routes:1) unregulated spillage, 2) permanent or interim downstream bypass facilities, or 3) the Project turbines. These three potential routes of passage were considered and incorporated into the whole station kelt survival model for each project. Prior to construction of the whole station kelt survival models, information related to kelt run timing, spill effectiveness, downstream bypass effectiveness, trash rack screening, and survival rates for kelts passed via spill and turbine units at each project was obtained.

Site-specific injury and mortality rates for Atlantic salmon kelts passed via unregulated spill or via a downstream bypass were not available for the Weston, Shawmut, Lockwood, or Brunswick projects. As a result, estimates for passage survival of Atlantic salmon smolts through project spillways and downstream bypasses, developed based on existing empirical studies conducted at other hydroelectric projects with similar characteristics, were used as a surrogate. Since the principal causes of potential injury and mortality for fish passed through either a spillway or bypass sluice are shear forces, turbulence, rapid deceleration, terminal velocity, impact against the base of the spillway, scraping against the rough concrete face of the spillway and rapid pressure changes, empirical studies related to spillway and bypass survival were pooled into a single data set. A delayed (48-hr) survival rate for Atlantic salmon kelts passed via spill of 96.3% was assumed for the generation of whole station kelt survival estimates for each of the four projects.

Estimates for passage survival of Atlantic salmon kelts through Francis, Kaplan and propeller units were made using the Advanced Hydro Turbine model developed by Franke *et al.* (1997). The Franke blade strike model predicts the probabilities of leading edge strikes, considered the primary mechanism of mortality when fish pass through turbines (Eicher Associates Inc. 1987, Cada 2001). Turbine passage survival was calculated using site-specific turbine parameters and for a range of body lengths considered to be representative of outmigrating salmon kelts in Maine rivers as well as not physically excluded by project trashracks. The average survival of salmon kelts passing through a particular turbine type was determined by averaging the modeled survival estimates for each similar type unit at a project.

The licensee calculated whole station kelt survival for each of the Projects by integrating river flows, project operating flows, spill effectiveness, downstream bypass effectiveness rates, turbine entrainment rates and spillway and turbine survival rates. The estimates of whole station kelt survival at Weston, Shawmut, Lockwood, and Brunswick Projects under median flow conditions (i.e. the value with 50% flow exceedence) are 73%, 89%, 88%, and 85%, respectively. As with smolts, whole station kelt survival increases with increasing river flow (i.e. those exceeded only

10 or 25% of the time) as a greater number of kelts are passed via spill. In contrast, when the monthly flow rate decreases to less than median flow conditions (i.e., those exceeded 75 and 90% of the time), a decrease in whole station kelt survival is observed.

6.2.2. Atlantic Salmon Critical Habitat

As discussed in Section 3.2, critical habitat for Atlantic salmon has been designated in the Kennebec and Androscoggin Rivers including the sections of river in the vicinity of the Lockwood, Shawmut, Weston, and Brunswick Projects. Within the action area of this consultation, the PCEs for Atlantic salmon include: 1) sites for spawning and rearing; and, 2) sites for migration (excluding marine migration). The analysis presented in Section 3 shows several habitat indicators are not properly functioning, and biological requirements of Atlantic salmon are not being met in the action area. We expect that the Projects considered in this Opinion will continue to harm these already impaired habitat characteristics. We expect the continued operations of these Projects to cause adverse effects to some essential features of critical habitat, including water quality, substrate, migration conditions, and forage in a similar manner as present in the environmental baseline. However, designated critical habitat in the Kennebec and Androscoggin River watersheds is anticipated to improve for Atlantic salmon with the construction and operation of permanent upstream and downstream fishways.

The licensee has proposed to provide upstream passage facilities at the Lockwood, Shawmut, and Weston Projects, which will significantly improve migration habitat for pre-spawn Atlantic salmon. In addition, the KHDG Agreement requires that permanent downstream fishways be operational at the same time as the upstream fishways. To that end, the existing downstream passage facilities will be studied as part of the proposed ISPP, and will be improved upon as necessary to achieve the high levels of survival that would be expected of a "permanent" downstream fishway. This will improve the migration habitat for Atlantic salmon smolts and kelts. Table 19 below summarizes the condition of essential features of Atlantic salmon critical habitat following implementation of the ISPP at the Lockwood, Shawmut, Weston, and Brunswick Projects.

Table 19. Atlantic salmon critical habitat essential features following the implementation of the proposed ISPP.

Pathway/Indicator	Life Stages Affected	PCEs Affected	Effect	Population Viability Attributes Affected
Access to Historical Habitat	Adult, smolt, juvenile	Migration	Improved upstream passage will reduce delays to spawning habitat. Improved downstream passage will reduce direct and delayed mortality of smolts and kelts	Adult abundance and productivity

The Lewiston Falls Project is licensed to operate with up to four feet of impoundment fluctuation to allow for peaking under normal conditions. No studies have been conducted to determine the effects of peaking at Lewiston Falls on downstream habitat. As there is minimal spawning and rearing habitat in the mainstem of the Androscoggin River below the project, it is anticipated that fluctuating water levels will only effect the migration PCE for Atlantic salmon. The current minimum flow of 1,430 cfs approximates the USFWS' New England Aquatic Base Flow (ABF). The ABF, which equates to the median August flow, is intended to represent limiting water quality and quantity conditions for aquatic life (USFWS 1999). According to USFWS, the ABF method establishes baseline flow for the protection and propagation of aquatic life. Therefore, flows lower than ABF may not be suitable for fish protection and propagation. Since the minimum flow requirement of 1,430 cfs at Lewiston Falls equates to the ABF, we would not expect Atlantic salmon passage impediments in the reach of river downstream of the Lewiston Falls Project. However, given the potential for effects the licensee should conduct a flow demonstration assessment during this interim period to document the effects of peaking on the availability and quality of downstream habitats.

6.2.3. Shortnose and Atlantic Sturgeon

It is believed that prior to dam construction, shortnose and Atlantic sturgeon ranged as far as the site of the Lockwood Project on the Kennebec River and the Brunswick Project on the Androscoggin River (Houston *et al.* 2007). We believe, therefore, that both species currently can access the entirety of their historic mainstem habitat in these two rivers. However, as described previously, it is expected that both species could be present downstream of the Brunswick and Lockwood Project at certain times of year and, therefore, could be affected by Project operation. Operations could directly affect the species due to 1) potential stranding in the downstream pools during the maintenance and /or replacement of flashboards in the spring, 2) entrapment in fishways, and 3) entrainment in the units when they are shut down and dewatered for annual maintenance (Brunswick only). In addition to these direct effects, the operation of the Brunswick and Lockwood Projects may affect suitable spawning habitat, flow fluctuations, and water quality in the Rivers.

As discussed previously, spawning has been documented downstream of both the Brunswick and Lockwood Projects. In the Kennebec River, spawning of shortnose and Atlantic sturgeon has been documented primarily downstream of Gardiner, approximately 20 miles downstream of the Lockwood Project. In the Androscoggin River, spawning has been documented approximately 500 meters downstream of the Brunswick Project. Both Projects operate as run of river facilities, which minimizes the scouring of habitats and the likelihood of pulsed discharges that could result in the stranding of adult or early life stage Atlantic and shortnose sturgeon. Based on this, we do not expect that operations of Lockwood and Brunswick will affect the ability of shortnose or Atlantic sturgeon to spawn successfully in the vicinity of these Projects or that the operation of these projects will affect the successful development of early life stages of shortnose or Atlantic sturgeon that may be present in the action area.

6.2.3.1. Direct Effects

Stranding

Once a year, the impoundments of the Lockwood and Brunswick Projects are lowered to a point where the flashboards can safely be replaced, resulting in a short period (a few hours) of receded flows downstream. There is potential during these low flow periods 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. While no sturgeon have been documented in the Lockwood pools since 2003, and none have ever been documented in the ledges below the Brunswick Dam, they have access to both Projects, and could be in the action area at the time of flashboard maintenance (April-June). As described previously, there is a ledge drop at the outlet of the large pool downstream of the Brunswick spillway that likely precludes sturgeon from accessing the ledges near the spillway under most conditions. However, there is still a small chance that an adult could make it into the pool at high tide and become stranded under low flow conditions. It is expected that these falls are impassable to juvenile sturgeon.

Data from the Holyoke Hydroelectric project on the Connecticut River can help in assessing the likely effects of stranding on sturgeon. In general, at this facility, several shortnose sturgeon are removed from pools at the base of the dam each year when spill over the dam ceases. Shortnose sturgeon that have been rescued from these 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.

Without the development of a rescue procedure for the Lockwood and Brunswick Projects, shortnose and Atlantic sturgeon stranded in the pools at the base of the dams would likely suffer injuries and possibly be killed. The licensee has been implementing a sturgeon handling plan at Lockwood since 2005 for shortnose sturgeon. In the proposed Sturgeon Handling and Protection Plan, they have proposed to implement the plan for Atlantic sturgeon, as well. There has not been an approved plan in place for either species of sturgeon at the Brunswick Project. Therefore, the implementation of a Sturgeon Handling and Protection Plan will reduce the likelihood of injury and will eliminate this potential source of mortality in the Androscoggin 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 should have no effect on the survival of the fish. Based on the occurrence of one shortnose sturgeon stranding in the bypass reach at the Lockwood Project in the last ten years (2003-2013), we anticipate that one shortnose sturgeon is likely to be stranded every ten years at each Project. Likewise, no more than one Atlantic sturgeon is likely to become stranded every ten years at the Brunswick and Lockwood Projects. The implementation of a handling plan and the use of proper handling techniques will minimize the potential for 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.

Upstream Passage Facilities

The fishways at the Lockwood and Brunswick fishways will be operational during the time of year (April - June) when shortnose and Atlantic sturgeon are likely to be present downstream. 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. Similarly, no sturgeon have ever been detected in the fishway at the Brunswick Project. Data on the effects of the fish lift at the Holyoke Hydroelectric Project on the Connecticut River suggest that fish lifts that successfully attract other species (i.e, shad, salmon etc.) do a poor job of attracting sturgeon. Attraction and lifting efficiencies for shortnose sturgeon at the Holyoke Project have been estimated at approximately 11%. As the fishways at the Lockwood and Brunswick Projects were not designed to pass sturgeon, they are unlikely to achieve as high passage efficiencies as Holyoke. In addition, shortnose sturgeon at the Holyoke Dam are actively seeking to migrate upstream to spawning and overwintering habitat while the sturgeon at the Lockwood and Brunswick Dams are not expected to be experiencing this behavioral drive. Given this information, we anticipate that no more than one shortnose sturgeon every ten years will become entrapped in the fishways at the Lockwood and Brunswick projects.

Similar to shortnose sturgeon, Atlantic sturgeon are rarely found to use fishways. No Atlantic sturgeon have been trapped in the fishways at the Lockwood or Brunswick Projects since they began operating in 2006. Similarly, in the 31 years that records have been kept at the Holyoke Project, only a single Atlantic sturgeon has ever been trapped in the fishway. Given the low usage of fishways by Atlantic sturgeon in the Northeast, it is anticipated that only one Atlantic sturgeon every ten years will be trapped at the Lockwood and Brunswick Projects over the terms of their existing licenses.

Because it is possible, although remotely so, that a shortnose or Atlantic sturgeon may enter the fishways at Lockwood or Brunswick, 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 fish lift 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, or injured in the process of returning them below the dam.

Unit Maintenance

In May 2010, several sturgeon were attracted into portions of the Brunswick Project Unit #1 when the unit was shut down for annual inspection. Specifically, Unit 1 was shut down on the morning of May 10, 2010 to commence the annual inspection of the unit. This work requires dewatering of the internal components of the unit. To accomplish this work, the headgates upstream of the unit and the tailrace gates downstream of the units were installed and personnel then proceeded to drain the unit, a two day effort. In mid-morning of May 12, 2010, when it was safe to enter, personnel observed five live and two dead sturgeon in the scroll case (between the turbine and head gate). They immediately contacted NextEra environmental personnel trained in shortnose sturgeon handling, who arrived on site with a handling plan in the afternoon of May 12, 2010. During the recovery process, the five live sturgeon were rescued from the scroll case and the two dead sturgeon were collected from the wicket gate area. Additionally, twenty seven live sturgeon were found and all were rescued from the sump chamber. On May 13, 2010, the sump chamber was re-inspected and an additional four live sturgeon were recovered. After the last sturgeon was collected from the sump, the pipe leading to the sump was visually inspected then closed to prevent sturgeon from accessing the sump chamber. All 36 live sturgeon were released back into the Androscoggin River, just below the Project in the vicinity of the fishway entrance, and appeared to be in good condition at the time of release.

To prevent any similar occurrences in the future, the licensee immediately consulted with us to discuss measures that would be undertaken during similar maintenance work planned for Units 2 and 3, and to also put in place measures to substantially reduce the potential for such events in the future. The licensee proposed, and we approved, the following procedures for when dewatering of the units becomes necessary:

1. For areas inside the turbine cavern/pit that are accessible to maintenance crew, a survey will be conducted to determine the presence of sturgeon. If sturgeon are present the Sturgeon Handling and Protection Plan will be implemented, and
2. The licensee will not schedule planned outages or maintenance activities at the Brunswick Project during the sturgeon spawning season (April-May).

In addition, the licensee installed a screen over the ten inch station sump pipe that discharges into the Unit #1 tailrace. This modification will prevent sturgeon from entering this pipe and the sump, as occurred during the May 2010 event.

The procedures and modifications implemented at the Brunswick Project since the 2010 incident will significantly reduce the probability of sturgeon becoming entrapped during unit dewatering. Therefore, no more than one shortnose sturgeon and one Atlantic sturgeon a year are anticipated to be captured when units are dewatered.

6.3. Effects of Fish Handling

6.3.1. Trapping and Handling of Atlantic Salmon

Trapping, handling and trucking fish causes them stress. The primary contributing factors to stress and death from handling are excessive doses of anesthetic, 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. Debris buildup at traps can also kill or injure fish if the traps are not monitored and cleared on a regular basis.

Until volitional upstream fishways have been completed at the four lower most dams on the Kennebec River, Atlantic salmon will continue to use the fish lift and trap at the Lockwood Project. These fish will be trapped and then released in the suitable spawning and rearing habitat in the Sandy River. The handling and trucking of these fish will be conducted by MDMR, which holds a section 10(a)(1)(A) research permit under the USFWS's regional endangered species blanket permit (No. 697823) which authorizes the handling of listed Atlantic salmon. Therefore, the effects of handling and transporting are not considered as part of the proposed action.

However, all migrating adult Atlantic salmon in the mainstem will be affected by the Project as they will be trapped and potentially delayed by the dam and its fish passage facilities.

6.3.2. Trapping and Handling of Sturgeon

Atlantic and shortnose sturgeon could be trapped in the fish lift at the Lockwood Project, or in the vertical slot fishway at the Brunswick Project. As the spawning habitat in the Kennebec and Androscoggin Rivers is below Ticonic and Brunswick Falls, it is unlikely that sturgeon will be motivated to pass the Projects. However, it is possible that a few sturgeon per year will be attracted to the Lockwood and Brunswick Projects, and become trapped. Likwise, there is a small chance that sturgeon could become entrapped within the turbines when they are dewatered for maintenance. These fish will be handled as proposed in the Sturgeon Handling and Protection Plan, and will be released downriver of the Projects as soon as possible. They will not be transported in trucks and the handling will be minimized to the extent possible.

As described above, when flashboards are replaced at the Lockwood and Brunswick Projects, or other operations cause no-spill or no-leakage conditions, there is a possibility that sturgeon may become stranded in pools below the dams. When these activities occur trained staff will survey isolated pools downstream and transport trapped fish back into the river. Handling time is anticipated to be minimal; therefore, it is anticipated that all sturgeon will be moved back to the river without significant injury or mortality.

6.3.3. Effects of Aquatic Monitoring and Evaluation

Under the proposed action, measures will be implemented to minimize project effects on Atlantic salmon passage in the Kennebec and Androscoggin Rivers. These measures include the construction of fish passage facilities and the implementation of an adaptive management strategy to maximize passage and survival at the Weston, Shawmut, Lockwood, and Brunswick Projects. In order to determine the effectiveness of these measures, the licensee proposes to conduct downstream survival studies and upstream effectiveness studies.

Proposed Studies

In order to determine the effectiveness of the upstream and downstream fish passage facilities, the licensee proposes to conduct downstream survival studies for Atlantic salmon kelts and smolts at the Weston, Shawmut, Lockwood, and Brunswick Projects, as well as an upstream passage efficiency study for pre-spawn adults at the Brunswick and Lockwood Projects during the interim period. Upstream passage studies will be conducted at the Weston and Shawmut Projects once volitional upstream fishways have become operational at the lower four dams in the River (2020).The handling and implantation of radio tags will injure all of the fish used in the studies, and a small proportion will likely be killed.

The downstream smolt survival studies will involve obtaining Atlantic salmon smolts from GLNFH, surgically implanting radio transmitter tags, and then conducting paired releases in groups up and downriver of the Projects. The handling and implantation of radio tags will injure all of the fish used in the studies, and a small proportion will likely be killed. The licensee will monitor and evaluate the effectiveness of the downstream fish passage facilities for up to three years at all four projects. It is expected that 100 to 200 smolts will be used per year per Project, which includes fish released upriver and downriver of each Project and fish used in tag retention studies. This equates to up to 2,400 smolts being used as part of the three year study (200 smolts x 4 projects x 3 years).

Upstream passage efficiency studies will be conducted using adult Atlantic salmon trapped at the Brunswick and Lockwood Projects. The adult fish will be radio tagged prior to being released downstream. Topsham Hydro, the operator of the Pejepscot Project, will be tagging up to 40 upstream migrants a year between 2013 and 2015 to monitor passage at the Pejepscot Project. It is anticipated that the licensee will utilize the same fish for the monitoring of the upstream fishway at Brunswick on the Androscoggin River. Therefore, the monitoring of upstream passage at the Brunswick Project will not involve any additional handling and tagging effects to *adult Atlantic salmon.*

The licensee will conduct a similar study at the Lockwood Project between 2016 and 2018. It is expected that they will trap and tag up to 40 pre-spawn salmon a year over the three year period prior to returning them downstream of the dam. As upstream fish passage will not be available at the Shawmut and Weston Projects at this time, salmon will not be released into the Lockwood headpond during the study, but will be trapped and trucked to the Sandy River. As it is expected that some proportion of test fish will not be able to relocate and use the fishway, only male salmon will be used as part of these studies.

The licensee will also conduct downstream passage studies involving kelts between 2013 and 2015 at the Lockwood, Shawmut, Weston and Brunswick projects. The intent of these studies is to determine passage routes and the existing downstream survival for Atlantic salmon kelts at each of the four projects. The studies will be up to three years in length and will coincide with smolt monitoring. It is anticipated that these studies will involve the handling and radio-tagging of no more than 20 male kelts per project per year. The licensee will consult with us on the development of study plans for these efforts.

Tagging

Techniques such as PIT tagging, coded wire tagging, fin-clipping, and the use of radio transmitters are common to many scientific research efforts using listed species. All sampling, handling, and tagging procedures have an inherent potential to stress, injure, or even kill the marked fish. Radio telemetry will be used as the primary technique for the proposed studies.

There are two techniques used to implant fish with radio tags and they differ in both their characteristics and consequences. First, a tag can be inserted into a fish's stomach by pushing it past the esophagus with a plunger. Stomach insertion does not cause a wound and does not interfere with swimming. This technique is benign when salmon are in the portion of their spawning migrations during which they do not feed (Nielsen 1992). In addition, for short-term studies, stomach tags allow faster post-tagging recovery and interfere less with normal behavior than do tags attached in other ways. This is the technique that the licensees will likely use on adult Atlantic salmon for the upstream passage studies.

The second method for implanting radio tags is to surgically place them within the body cavities of (usually juvenile) salmonids. These tags do not interfere with feeding or movement. However, the tagging procedure is difficult, requiring 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 and Hubert 1985, Mellas and Haynes 1985). This is the technique that the licensees propose to use on Atlantic salmon smolts for the downstream passage studies.

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. 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 and Hoyt 1982, Matthews and Reavis 1990, Moring 1990). Tagging may also reduce fish growth by increasing the energetic costs of swimming and maintaining balance.

All fish used in the proposed studies will be subject to handling 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 a 100% of the fish that are handled and tagged will suffer injury, and some of these will die due to immediate and long term effects of being trucked, handled and tagged.

All 2,400 Atlantic salmon smolts used in the downstream survival studies will be harassed and injured. In addition, a proportion of the smolts are anticipated to be killed due to handling and tagging, as well as to the direct and indirect effects associated with dam passage. 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 two weeks of being held in pools, only two (0.3%) of these fish were subject to delayed mortality. 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.* (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 per year during the proposed downstream monitoring. The proportion of smolts anticipated to be injured and killed due to the effects of downstream passage is addressed in Section 6.2.1.2.

All adult Atlantic salmon used in the upstream and downstream passage studies will be harassed and injured due to handling and tagging. However, long term effects of handling and tagging on adult salmon appear to be negligible. Bridger and Booth (2003) indicate that implanting tags gastrieally 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 can be killed 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 2% represents a conservative estimate of tagging mortality in the adult salmon being used in the passage studies at the Weston, Shawmut, Lockwood, and Brunswick Projects. Given the small number of Atlantic salmon being tagged and that adult salmon are less likely than yearling Chinook salmon to be significantly injured by tag implantation, it is not expected that any adult Atlantic salmon will be killed as part of the upstream passage studies. Similarly, it is not expected that any kelts that are released as part of a downstream kelt study will be killed by the insertion of radio tags. Injuries are expected to be minimized by having trained professionals conduct the procedures using established protocols. The proportion of kelts anticipated to be injured and killed due to the effects of downstream passage is addressed in Section 6.2.1.2.

In an effort to monitor smolt outmigration timing, the licensee will be trapping Atlantic salmon smolts in a rotary screw trap in the Sandy River (2013-2015). Captured smolts will be anesthetized and measured, and scale samples will be taken. These fish will then be allowed to recover prior to being released back into the River downstream of the trap. All of the trapped fish will be harassed and harmed as a result of this treatment, and some may be subjected to injury or death. No mortalities were observed in 2012, the first year the RST was operated at this location (R. Richter, Brookfield Renewable Power, pers. comm., 2013), however, there is still a chance that a small proportion of salmon smolts could be injured or killed between 2013 and 2015 due to the effects of being trapped, handled, and anesthetized. Through investigation and summarization of NMFS RST data in the GOM DPS, Music *et al.* (2010) determined that under normal operating conditions RST function and environmental conditions within the live-car are not a significant source of mortality at a population level. Between 2005 and 2012, NMFS and MDMR captured 32,551 salmon smolts in seven RSTs placed in the Sheepscot and Narraguagus Rivers. Of these, 240 smolts, or 0.74% of fish trapped, were killed due to trapping and handling. It should be noted that 79% of the smolts that were killed died in a single event on the Narraguagus River. These fish had been stocked the day before and were, therefore, likely subject to stocking stress as well as to being trapped. Therefore, we consider 0.74% a conservative estimate of the proportion of smolts trapped in the Sandy River RST that could be subject to mortality.

7. CUMULATIVE EFFECTS

Cumulative effects are defined in 50 CFR §402.02 as 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.

The effects of future state and private activities in the action area that are reasonably certain to occur are continuation of recreational fisheries, discharge of pollutants, and development and/or construction activities resulting in excessive water turbidity and habitat degradation.

Impacts to shortnose sturgeon, Atlantic sturgeon and Atlantic salmon from non-federal activities are largely unknown in the Kennebec and Androscoggin Rivers. It is possible that occasional recreational fishing for anadromous fish species may result in incidental takes of these species. There have been no documented takes of shortnose sturgeon from fisheries in the action area although one Atlantic sturgeon was captured by an angler in 2005, and two others were reported as being captured in 2011 (MDMR 2012). The operation of these hook and line fisheries and other fisheries could result in future sturgeon or Atlantic salmon mortality and/or injury.

In December 1999, the State of Maine adopted regulations prohibiting all angling for sea-run salmon statewide. A limited catch-and-release fall fishery (September 15 to October 15) for Atlantic salmon in the Penobscot River was authorized by the MASC for 2007. The fishery was closed prior to the 2009 season. Despite strict state and federal regulations, both juvenile and adult Atlantic salmon remain vulnerable to injury and mortality due to incidental capture by recreational anglers and incidental catch in commercial fisheries. The best available information indicates that Atlantic salmon are still incidentally caught by recreational anglers. Evidence suggests that Atlantic salmon are also targeted by poachers (NMFS 2005). An adult female salmon was poached downstream of the Worumbo Project in the Androscoggin River in 2011 (MDMR 2012). Commercial fisheries for elvers (juvenile eels) and alewives may also capture Atlantic salmon as bycatch. No estimate of the numbers of Atlantic salmon caught incidentally in recreational or commercial fisheries exists.

Pollution from point and non-point 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). Contaminants introduced into the water column or through the food chain, eventually become associated with the benthos where bottom dwelling and feeding species like shortnose and Atlantic sturgeon are particularly vulnerable. Atlantic salmon are also vulnerable to impacts from pollution and are also likely to continue to be impacted by water quality impairments in the Kennebec and Androscoggin Rivers and their tributaries.

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 shortnose sturgeon, Atlantic sturgeon and Atlantic salmon will continue to be affected by contaminants in the action area in the future.

Industrialized waterfront development will continue to impact the water quality in and around the action area. Sewage treatment facilities, manufacturing plants, and other facilities present in the action area are likely to continue to operate. Excessive water turbidity, water temperature variations and increased shipping traffic are likely with continued future operation of these facilities. As a result, shortnose and Atlantic sturgeon foraging and/or distribution in the action area may be adversely affected.

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

In the discussion below, we consider whether the effects of the proposed action reasonably would be expected, directly or indirectly, to reduce appreciably 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, shortnose sturgeon and the NYB and GOM DPSs of Atlantic sturgeon. The purpose of this analysis is to determine whether the proposed action, in the context established by the status of the species, environmental baseline, and cumulative effects, would jeopardize the continued existence of the GOM DPS of Atlantic salmon, shortnose sturgeon and the NYB and GOM DPSs of Atlantic sturgeon. In addition, the analysis will determine whether the proposed action will adversely modify designated critical habitat for Atlantic salmon.

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." Below, for the GOM DPS of Atlantic salmon, shortnose sturgeon and the NYB and GOM DPSs of Atlantic sturgeon, the listed species that may be affected by the proposed action, we summarize the status of the species and consider whether the proposed action will result in reductions in reproduction, numbers or distribution of that species and then considers whether any reductions in reproduction, numbers or distribution resulting from the proposed action would reduce appreciably the likelihood of both the survival and recovery of that species, as those terms are defined for purposes of the Federal Endangered Species Act.

We have determined that the proposed action will result in harm or harassment to Atlantic salmon, shortnose sturgeon and Atlantic sturgeon in the action area. While lethal injuries and/or mortalities are being reduced by adhering to construction BMPs and the provisions of the ISPP, it is anticipated that some Atlantic salmon will be injured or killed as a result of the continued operations of the five hydroelectric projects considered in this Opinion. Whereas, no Atlantic sturgeon or shortnose sturgeon are expected to be injured or killed by the action.

8.1. Atlantic Salmon

GOM DPS Atlantic salmon currently exhibit critically low spawner abundance, poor marine survival, and are 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 (approximately 6% over the last ten years) and is continuing to decline. 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.

We recognize that the operation of the Lockwood, Shawmut, Weston , Brunswick, and Lewiston Falls Projects pursuant to amended licenses that incorporate the proposed ISPP will lead to an improvement in upstream passage for Atlantic salmon as compared to current operations. Additionally, existing obligations under the existing licenses and KHDG Agreement that require the operation of permanent downstream passage facilities are anticipated to improve downstream passage and survival past the Projects. However, the Projects will continue to affect the abundance, reproduction and distribution of salmon in the Kennebec and Androscoggin Rivers by delaying, injuring and killing upstream migrating pre-spawn adults, as well as outmigrating smolts and kelts. While FERC will require that the licensee implement several measures to reduce adverse impacts of project operation, all Atlantic salmon in the Kennebec and Androscoggin River watersheds will be adversely affected by continued operation of these facilities.

Summary of Upstream Passage Effects

Only two of the five projects (Lockwood and Brunswick) considered in this Opinion currently provide upstream passage to pre-spawn Atlantic salmon. Furthermore, even when operated pursuant to the amended licenses, it is unlikely that these fishways are 100% effective at passing all Atlantic salmon that are motivated to access habitat upriver. Adult salmon that are not passed at these Projects will either spawn in downstream areas, return to the ocean without spawning, or die in the river. These salmon are significantly affected by the stress, injury and mortality associated with locating and successfully passing these fishways. Although no studies have looked directly at the fate of fish that fail to pass through upstream fish passage facilities on the Kennebec and Androscoggin Rivers, we convened an expert panel in 2010 to provide the best available information on the fate of these fish in the Penobscot River. The panel was comprised 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 2011). Dams that do not have fishways were not considered to have baseline mortality, as fish are not subject to the stresses of upstream passage (although they may be subjected to significant delays).

Assuming that the existing fishway at the Lockwood Project is at least 40% effective, it is anticipated that 0.6% (1% mortality x 60% that fail to pass) of Atlantic salmon that attempt to pass the Lockwood Project will die. The remaining 59.4% will either spawn in habitat downstream of the Project or leave the river without spawning. Likewise, assuming that the existing fishway at the Brunswick Project is at least 61% effective, it is anticipated that 0.4% (1% mortality x 39% that fail to pass) of Atlantic salmon that attempt to pass the Brunswick Project will die. The remaining 38.6% will either spawn in habitat downstream of the Project, migrate to the Kennebec River to spawn, or leave the river without spawning.

Although the Shawmut and Weston Dams are not currently accessible to upstream migrating Atlantic salmon, it is assumed that 100% of Atlantic salmon that approach the Lewiston Falls Dam on the Androscoggin River could experience adverse effects due to delay. As no upstream passage facilities are proposed, these conditions will continue to be experienced even when FERC issues amended licenses. Therefore, these adverse effects will continue during the entirety of the interim period.

As Atlantic salmon cannot access spawning habitat above Lewiston Falls, returning salmon will not be homing to the upper river. However, it is anticipated that some salmon that are homing to habitat lower in the River may stray to the area immediately below the Lewiston Falls Dam. Over the last ten years, 22 Atlantic salmon have successfully passed the Worumbo Project, the first dam downstream of Lewiston Falls (average=2 salmon/year). Although many of these fish may not have been motivated to continue their migrations, this represents a conservative estimate of the number of Atlantic salmon affected between 2003 and 2012 by the lack of passage facilities at Lewiston Falls. Therefore, it is anticipated that the Project adversely affects an average of two pre-spawn Atlantic salmon per year by blocking passage and by contributing to migratory delay. Although the duration of the delay is not known, it is expected that these fish will be delayed for some amount of time prior to dropping back into the lower river. We believe that a delay in migration of more than two days per project could affect a salmon's ability to migrate successfully to suitable spawning habitat. The licensee will assess the level of delay that is resulting due to project operations. FERC is proposing to implement a license article requiring the licensee to meet with us every five years to discuss the operation of the project in relation to listed species. If significant delay is occurring, possible solutions will be discussed at that time.

The existing hydroelectric projects result in a certain amount of delay in upstream migration. Numerous studies collectively report a wide range in time needed for individual adult salmon to pass upstream of various dams in the Penobscot River once detected in the vicinity of a spillway or tailrace. The yearly pooled median passage time for adults at Milford Dam ranged from 1.0 days to 5.3 days over five years of study, while the total range of individual passage times over this study period was 0.1 days to 25.0 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). It is unknown what level of delay occurs at the Lockwood, Brunswick, and Lewiston Falls Projects, although it is anticipated to be similar to what has been observed at other dams. The proposed upstream passage studies at Brunswick will quantify the amount of significant delay (greater than 48 hours) between 2013 and 2015. If levels of delay are deemed excessive, measures will be incorporated in order to minimize this effect. Upstream studies will be conducted as part of the final SPP at the Shawmut and Weston Projects.

Upstream Distribution Effects

The operation of new upstream volitional fishways at the Lockwood, Shawmut, and Weston Projects will significantly improve the distribution of Atlantic salmon throughout the Kennebec River watershed. However, these fishways will not become accessible to upstream migrating salmon until fishways at all four of the dams in the lower Kennebec River become operational (anticipated in 2020). Therefore, the distribution of the species is not anticipated to improve over the timeframe of the ISPP (2013-2019).

Until 2018, the only operational upstream fishway for Atlantic salmon on the Kennebec River is the Lockwood Project. Of the Atlantic salmon that fail to pass this fishway, the vast majority are assumed to stray to other habitat and spawn. The expert panel convened by us in 2010 addressed this issue, and determined that the presence of the dams would cause the majority of straying Atlantic salmon to spawn in habitat downriver of the dam that halted their migration. For Lockwood, this would mean that 100% of the fish that stray would fall back in the river, and would potentially spawn in the mainstem Kennebec, or in one of its tributaries. Of the Atlantic salmon that fail to pass Brunswick, it is assumed that some proportion drop back down into Merrymeeting Bay and then continue their migrations in the Kennebec River. There is no mapped spawning habitat below the Brunswick Dam on the Androscoggin River. This forced straying of a small proportion of migrating Atlantic salmon may lead to a gradual shift downriver in the distribution of the species in the Merrymeeting Bay SHRU.

Atlantic salmon are prevented from accessing approximately 80,000 habitat units in the upper Androscoggin River (NMFS 2009a). This habitat represents approximately 83% of the potential spawning and rearing habitat within the Androseoggin drainage. The Lewiston Falls Project itself only prevents passage to the next upstream barrier, the Deer Rips Dam about 4.40 kilometers upriver and, on its own, is not preventing access to a significant quantity of habitat. However, straying caused by dams leads to increased energy expenditure and delay, which could prevent salmon from accessing suitable spawning habitat.

Summary of Downstream Passage Effects

A significant proportion of Atlantic salmon smolts and kelts are injured or killed while passing dams during their downstream migration. It is assumed for this Opinion that the existing downstream passage rates will be maintained throughout the interim period (2013-2019).

Atlantic salmon smolts outmigrate to the estuary in the spring after rearing in freshwater streams. Under current operations, the licensee has estimated that 48-hour smolt survival rates (based on median flows) on the Kennebec River are 94%, 95%, and 94% at the Lockwood, Shawmut, and Weston Projects, respectively. As described previously, these estimates likely overestimate actual survival; however, they represent the best available information of survival rates past the these Projects. Therefore, cumulative survival of the smolts migrating out of the Sandy River over these three dams is anticipated to be approximately 85%.

Atlantic salmon kelts outmigrate in the fall after spawning, or in the spring after overwintering in freshwater. They are subject 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 (Alden Lab 2012). Under current operations, the licensee has estimated survival rates for outmigrating kelts to be 73%, 89%, and 88% at the Weston, Shawmut, and Lockwood Projects, respectively. Therefore, cumulative survival of kelts through all three Projects in the Kennebec is 57%.

It is not known how many smolts outmigrate past the Brunswick Project on the Androscoggin River every year, but it is anticipated to be very few given the lack of accessible spawning habitat upriver. A portion of these smolts will be injured or killed while passing downstream at the Brunswick Project. Based upon information in FERC's BA, it is estimated that 48-hour survival rates for smolts would be approximately 93%. Survival of kelts is estimated to be approximately 85% at the Brunswick Project.

Similar to migrating pre-spawn adults, outmigrating smolts and kelts are subject to delay by the presence of hydroelectric dams. While these delays can lead to mortality of Atlantic salmon from increased predation (Blackwell *et al.* 1998), migratory delays can also reduce overall physiological health or physiological preparedness for seawater entry and oceanic migration (Budy *et al.* 2002). Various researchers have identified a "smolt window" or period of time in which smolts must reach estuarine waters or suffer irreversible effects (McCormick *et al.* 1999). Late migrants lose physiological smolt characteristics due to high water temperatures during spring migration (McCormick *et al.* 1999). 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 so, then these delays may reduce smolt survival (McCormick *et al.* 1999).

We expect that 24 hours provides adequate opportunity for smolts and kelts 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. Passage times in excess of 24 hours would result in unnatural delay for migrants leading to increased predation and reduced fitness in the freshwater to saltwater transition. Therefore, any smolt or kelt documented to take longer than 24 hours to pass a downstream passage facility during downstream survival studies will be considered to have failed in their passage attempt.

In addition to the direct and indirect mortality associated with dam passage for smolts and kelts, there is also the possibility of additional dam-related mortality occurring in the early marine phases of the salmon's life history. For Pacific salmon species, this concept is known as the hydrosystem-related delayed-mortality hypothesis (Budy *et al.* 2002, Schaller and Petrosky 2007). This delayed mortality is thought to be attributable to physiological stress associated with dam passage that affects smolts and post-smolts experiencing the challenges of transitioning to the marine environment (osmoregulation, novel predators, etc.). Very recently, Haeseker *et al.* (2012) provided evidence supporting this hypothesis for Snake River Chinook salmon and steelhead. At this time, it is impossible to quantify how much (if any) early marine mortality of Atlantic salmon may be attributable to similar mechanisms in the Kennebec and Androscoggin River watersheds. However, it is reasonable to assume that some level of delayed (and as yet undocumented) early marine mortality of Atlantic salmon is ultimately due to earlier hydrosystem experience.

8.1.1. Survival and Recovery Analysis

Jeopardy is defined by USFWS and NMFS (1998) 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." Therefore, to determine if the proposed action will jeopardize the GOM DPS of Atlantic salmon, an analysis of the effects on survival and recovery must be conducted. The ISPP and this Opinion are valid for a seven-year period and expire in 2019. Therefore, the following section analyzes whether interim operation of the projects will jeopardize the GOM DPS of Atlantic salmon during this seven-year period. In 2019, this Opinion will no longer be valid and consultation under section 7 will need to be reinitiated by FERC.

Survival Analysis

The first step in conducting this analysis is to assess the effects of the proposed project on the survival of the species. Survival can be 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).

While implementing the proposed ISPP will result in the loss of Atlantic salmon smolts and kelts, the relatively short time frame of the action (seven years) will greatly reduce the potential of the project to affect the long-term survival potential of the species. Almost all production of Atlantic salmon in the Kennebec River is the result of egg planting in the Sandy River. Hutchings (2013) estimated that approximately 19,762 Atlantic salmon smolts would be outmigrating through the Kennebec River in 2013. Not all of these smolts will pass through the Weston, Shawmut, Hydro-Kennebec, and Lockwood Dams due to natural instream mortality (e.g., predation). However, based on the estimated survival rates (Weston-94%, Shawmut-95%, Hydro-Kennebec-92% (NMFS 2012), Lockwood (94%)) of the dams in the lower river, we can estimate how hydroelectric operations are cumulatively affecting the number of smolts reaching the estuary and, correspondingly, the number of pre-spawn adult salmon that return to the river. At the above survival rates, the operation of the four dams on the lower Kennebec would be expected to kill approximately 23% of outmigrating smolts every year. Three of these projects (Weston, Shawmut, and Lockwood) are being considered as part of this consultation. If these three projects were not operating, it is expected that approximately 8% of smolts would be killed by the remaining Project in the lower River. Therefore, conceptually the operation of these three Projects leads to a 15% reduction in cumulative smolt survival. We would expect this level of mortality to be reduced once the final SPP is implemented using data collected as part of the ISPP process.

Hutchings (2013) estimated that in 2013, 964 smolts would be outmigrating in the Androscoggin

River. The licensee has estimated that the Brunswick Project kills approximately 7% of migrating smolts at median flows. Most, if not all, of the current smolt production in the watershed occurs in the Little River, a tributary upstream of the Pejepscot Project. Topsham Hydro has estimated downstream smolt mortality at the Pejepscot Project at 8.40%. At the above survival rates, the operation of the two dams on the lower Androscoggin would be expected to kill approximately 15% of outmigrating smolts every year. If the Brunswick Project was not operating, it is expected that approximately 8.40% of smolts would be killed by the remaining Project downstream of spawning habitat in the lower River. Therefore, conceptually the operation of the Brunswick Project leads to a 7% reduction in cumulative smolt survival in the Androscoggin River. We would expect this level of mortality to be reduced once the final SPP is implemented using data collected as part of the ISPP process.

The licencee's proposed project is expected to significantly benefit the distribution of the species by improving upstream and downstream passage at the Projects. The construction and operation of new volitional upstream fishways at the Lockwood, Shawmut, and Weston Projects will improve reproduction since the effects of transporting adult Atlantic salmon around the projects will be eliminated. Although these effects will not come into effect until after 2020, the actions that are proposed for the interim period will facilitate these improvements over the long term. The operation of effective permanent downstream passage facilities at the Weston, Shawmut, Lockwood, and Brunswick Projects, as required under the KHDG Agreement and the existing licenses, is expected to increase the number of smolts surviving in the Kennebec and Androscoggin Rivers, which will lead to increased number of adults returning to the River. We also expect current stocking practices to continue during the ISPP period which will help insure the survival of Atlantic salmon in the action area. Therefore, we have determined that the loss of Atlantic salmon smolts, kelts, and prespawn adults over a seven year period under the proposed action will not appreciably reduce the likelihood that the species will survive in the wild.

Recovery Analysis

The second step in conducting this analysis is to assess the effects of the proposed project on the recovery of the species. 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). As with the survival analysis, there are three criteria that are evaluated under the recovery analysis; reproduction, numbers and distribution. In the recovery analysis, the same measures are used to evaluate these criteria as are used in the survival analysis. However, unlike with survival, the recovery analysis requires an adjustment to the existing freshwater and marine survival rates to allow for a population that has a positive growth rate. The recovery condition includes existing dam passage rates, but does not include hatchery supplementation as it is assumed that in a recovered population, stocking will not be necessary to sustain a viable population.

In certain instances, an action may not appreciably reduce the likelihood of a species survival (persistence) but may affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed action will not 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. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate.

Section 4(a)(1) of the ESA requires listing of a species if it is in danger of extinction throughout all or a significant portion of its range (i.e., "endangered"), or likely to become in danger of extinction throughout all or a significant portion of its range in the foreseeable future (i.e., "threatened") because of any of the following five listing factors: (1) The present or threatened destruction, modification, or curtailment of its habitat or range, (2) overutilization for commercial, recreational, scientific, or educational purposes, (3) disease or predation, (4) the inadequacy of existing regulatory mechanisms, (5) other natural or manmade factors affecting its continued existence.

At existing freshwater and marine survival rates (the medians have been estimated by NMFS as 1.1% and 0.4%, respectively), it is unlikely that Atlantic salmon will be able to 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 5, the dot represents current marine and freshwater survival rates; 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 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 and, therefore, most likely, path to achieving a self-sustaining population that is trending towards recovery.

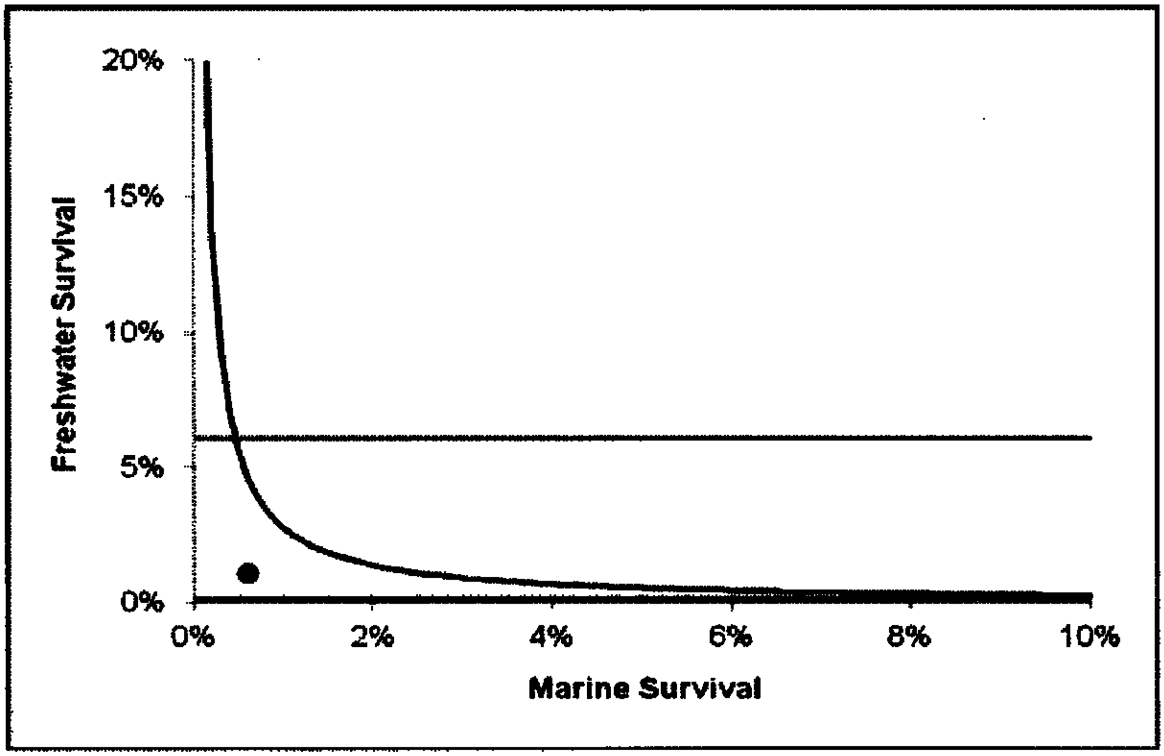

Figure 5. NMFS (2010) conceptual model depicting marine and freshwater survival relative to recovery of the GOM DPS of Atlantic salmon (Note: The dot represents current conditions, the curved line represents recovery, and the horizontal lines are the historic maximum and minimum freshwater survival).

While implementing the proposed ISPP will result in the loss of Atlantic salmon smolts and adults, the relatively short time frame of the action (seven years) will greatly reduce the potential of the project to affect the long-term recovery potential of the species. In addition, the proposed ISPP will significantly benefit the distribution of the species by improving upstream passage at the Projects. Improved upstream passage is also expected to improve reproduction of the species since the effects of transporting adult Atlantic salmon around the Projects will be eliminated. Therefore, we have determined that the proposed action will not appreciably reduce the likelihood that Atlantic salmon will recover in the wild.

Summary of Effects of the Proposed Action to Atlantic Salmon

In this section, we summarize the effects of the proposed action on the GOM DPS of Atlantic salmon in conjunction with the environmental baseline. Based on the information provided above, the proposed action will not appreciably reduce the likelihood of survival for Atlantic salmon 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). While juvenile and adult Atlantic salmon mortality associated with dam passage at the Lockwood, Shawmut, Weston and Brunswick Projects will continue to have an adverse effect on Atlantic salmon in the Kennebec and Androscoggin Rivers for a relatively short period (seven years), we believe that the loss will not be sufficient to appreciably diminish the species ability to achieve recovery. As such, there is not likely to be an appreciable reduction in the likelihood of survival and recovery in the wild of the Kennebec and Androscoggin River populations or the species as a whole.

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 it will not result in effects to the environment which 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 improvement in the reproduction and distribution of Atlantic salmon. This is the case because: 1) the new upstream fishways will reduce injury to adult Atlantic salmon that were transported upstream via trap and truck; 2) increased passage will improve the distribution of the species in the Kennebec River; and 3) improved access will increase reproduction in high quality spawning habitat in the upper Kennebec River and thus increase the number of returning Atlantic salmon.

Despite the threats faced by individual Atlantic salmon inside and outside of the action area, the proposed action will not increase the vulnerability of individual Atlantic salmon 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 Atlantic salmon in the action area or how the species will adapt to climate change-related environmental impacts, no additional effects related to climate change to Atlantic salmon in the action area are anticipated over the life of the proposed action (seven years). 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. Atlantic Salmon Critical Habitat

Critical habitat for Atlantic salmon has been designated in the Kennebec and Androscoggin Rivers including the sections of river in the vicinity of the Lockwood, Shawmut, Weston, and Brunswick Projects. Critical habitat has also been designated downstream of the Lewiston Falls Project. Within the action area of this consultation, the PCEs for Atlantic salmon include: 1) sites for spawning and rearing; and, 2) sites for migration (excluding marine migration). Although there is a small amount of spawning and rearing habitat in the mainstem of the Kennebec River, the habitat in the proposed project area primarily functions as a migration corridor for migrating pre-spawn adults, as well as for outmigrating smolts and kelts

Summary of Construction Effects

Construction related effects are anticipated to occur at the Shawmut and Weston Projects where a small amount of in-water work will likely be required for the construction of the new fishways. This habitat does not currently function as migratory habitat for pre-spawn Atlantic salmon because all Atlantic salmon are trapped at the Lockwood Project downstream and trucked upstream to the Sandy River. The work will occur outside of the time of year when smolts and kelts would be outmigrating through the River, so effects to the migration PCE are anticipated to be discountable.

Summary of Upstream Passage Effects

The proposed upstream fishways at the Lockwood, Shawmut, and Weston Projects on the Kennebec River will improve migratory conditions in the action area by improving volitional access to approximately 70,000 habitat units in the Kennebec River watershed, including 37,105 units in the Sandy River and 32,739 units in the mainstem and small tributaries downstream of the Anson and Abenaki Projects in Madison (Wright *et al.* 2008). Passage conditions will not be improved until Atlantic salmon have volitional passage all the way to the Sandy River, which is not anticipated to occur until 2020. During the interim period, passage will continue to occur via trap and truck at the Lockwood Project. It is expected that the existing fishway is not 100% effective and that its presence in the river will continue to negatively affect Atlantic salmon migration by increasing straying behavior and delay.

On the Androscoggin, upstream passage will continue through the Brunswick Project during the interim period. Passage studies will be conducted and modifications will be considered and implemented to minimize Project effects to the migratory PCE. However, like Lockwood, the Brunswick Dam is not 100% effective at passing fish and its presence in the River will continue to negatively affect Atlantic salmon migration by increasing straying behavior and delay.

Summary of Downstream Passage Effects

The proposed downstream survival studies are a component of an adaptive management strategy that will improve migratory conditions in the action area by allowing more Atlantic salmon smolts and kelts to survive downstream passage through the Weston, Shawmut, Lockwood, and Brunswick Projects. A significant proportion of Atlantic salmon smolts and kelts are injured or killed while passing dams during their downstream migration. Although no performance standards have been proposed at this time, it is anticipated that they will be developed as part of a final SPP and that these fishways will need to be highly effective.

We expect that the proposed project would continue to harm the PCEs in the action area. We expect the continued operations of these Projects to cause adverse effects to some essential features of critical habitat, including water quality, substrate, migration conditions, and forage in a similar manner as present in the environmental baseline. However, designated critical habitat in the Kennebec and Androscoggin River watersheds is anticipated to improve for Atlantic salmon with the implementation of improved upstream and downstream passage as outlined in the proposed ISPP. During the seven year interim period the effects of hydroelectric operations to the migration PCE will be reduced by improving passage conditions and reducing delay for both upstream and downstream migrating Atlantic salmon. Therefore, the proposed project is not likely to adversely modify or destroy Atlantic salmon critical habitat.

8.3. Shortnose sturgeon

Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. Today, only 19 populations remain. The shortnose sturgeon residing in the Kennebec and Androscoggin Rivers come from one of these nineteen populations. The present range of shortnose sturgeon is disjunct, with northern populations separated from southern populations by a distance of about 400 kilometers. Population sizes range from under 100 adults in the Cape Fear and Merrimack Rivers to tens of thousands in the St. John and Hudson Rivers. As indicated in Kynard (1996), adult abundance is less than the minimum estimated viable population abundance of 1,000 adults for five of 11 surveyed northern populations and all natural southern populations. The only river systems likely supporting populations close to expected abundance are the St John, Hudson and possibly the Delaware and the Kennebec (Kynard 1996), making the continued success of shortnose sturgeon in these rivers critical to the species as a whole.

Future operations of the Shawmut, Weston, and Lewiston Falls Projects are not likely to result in negative effects to shortnose sturgeon as they are located upstream of what is believed to be the historic range of shortnose sturgeon in the Kennebec and Androscoggin Rivers, and no shortnose sturgeon will be exposed to effects of Project operations. The Lockwood and Brunswick Projects are located at what is believed to be the upstream extent of the historic range of shortnose sturgeon and, therefore, they are not considered barriers to upstream migration. Shortnose sturgeon are known to utilize habitat downstream of these projects, potentially for spawning. Therefore, it is possible that the operation of the facilities could impact shortnose sturgeon and its habitat downriver of these two dams.

We have determined that the proposed action will affect shortnose sturgeon by resulting in the capture of one adult every ten years in the fishways at the Lockwood and Brunswick Projects. Additionally, the stranding of one shortnose sturgeon at each of the two Projects every ten years is expected in pools downstream of the spillways during the replacement or maintenance of flashboards. Over the terms of the existing licenses, therefore, it is anticipated that four sturgeon (two trapped in the fishway and two stranded in downstream pools) could become trapped at both the Lockwood and Brunswick Projects. 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 in the fishways will be temporarily delayed from carrying out spawning activities. However, given that monitoring will be continuous 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 one shortnose sturgeon every ten years at the Brunswick and Lockwood Projects, and an additional one stranded at each of the two Projects every ten years in pools during flashboard replacement, is not likely to result in any 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 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; and (4) the projects will continue to operate in run of river mode thus there is no potential for pulsed flows which could disrupt spawning or rearing.

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, as shortnose sturgeon will have access to the entirety of its historic range.

Based on the information provided above, the proposed action 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, genctic 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) the action will not result in the mortality of any shortnose sturgeon (2) as the action will not result in the mortality of any individuals, the action is not likely to have an effect on the levels of genctic 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 distribution of shortnose sturgeon in the action area or beyond the action area (i.e., throughout its range); (6) 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; (7) the operations of the project will not affect the ability of shortnose sturgeon to successfully spawn or for eggs and larvae to successfully develop and, (9) the action will have no effect on the ability of shortnose sturgeon to shelter or forage.

In certain instances an action may not appreciably reduce the likelihood of a species survival (persistence) but may affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that shortnose sturgeon will survive in the wild. Here, we consider the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate.

Section 4(a)(1) of the ESA requires listing of a species if it is in danger of extinction throughout all or a significant portion of its range (i.e., "endangered"), or likely to become in danger of extinction throughout all or a significant portion of its range in the foreseeable future (i.e., "threatened") because of any of the following five listing factors: (1) The present or threatened destruction, modification, or curtailment of its habitat or range, (2) overutilization for commercial, recreational, scientific, or educational purposes, (3) disease or predation, (4) the inadequacy of existing regulatory mechanisms, (5) other natural or manmade factors affecting its continued existence.

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 utilize shortnose sturgeon for recreational, scientific or commercial purposes, affect the adequacy of existing regulatory mechanisms to protect this species, or affect their continued existence. 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 threets 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.

8.4. Atlantic sturgeon

We have estimated that the proposed project may interact with New York Bight and GOM DPSs of Atlantic sturgeon. As explained in the "Effects of the Action" section, the operation of fishways at the Lockwood and Brunswick Projects and the lowering of water levels during flashboard maintenance is expected to directly affect adult Atlantic sturgeon. We anticipate that one Atlantic sturgeon will become stranded at each of the two Projects every ten years through the end of the existing Project licenses. Likewise, we anticipate that one Atlantic sturgeon will become trapped in the fishways at the two Projects every ten years over the same timeframe. (Table 20). As described previously, we expect Atlantic sturgeon to occur at the following frequencies in the action area: St. John River (Canada) 7%; Gulf of Maine DPS 92% and New York Bight DPS 1%. As eight Atlantic sturgeon are anticipated to be affected by the proposed actions, seven of those are expected to come from the GOM DPS, and one is expected to be from the St. John River. Given the small number of NYB fish anticipated to be in the action area, it is not anticipated that any of the affected fish will originate from that DPS. Therefore, impacts from the anticipated interaction and capture of several individual Atlantic sturgeon that could originate from the GOM DPS are described below.

Table 20. Number of Atlantic Sturgeon expected to be affected by the proposed project.

Project	***Source***	***Duration***	***Total***
Lockwood	Trapping	2013-2036	2

	Stranding		2
Brunswick	Trapping	2013-2029	2
	Stranding		2

8.4.1 Gulf of Maine DPS of Atlantic Sturgeon

While Atlantic sturgeon occur in several rivers in the Gulf of Maine, recent spawning has only been documented in the Kennebec River and Androscoggin River. Future operations of the Shawmut, Weston, and Lewiston Falls Projects are not likely to result in negative effects to Atlantic sturgeon as they are located upstream of what is believed to be the historic range of Atlantic sturgeon in the Kennebec and Androscoggin Rivers, and no Atlantic sturgeon will be exposed to effects of project operations. The Lockwood and Brunswick Projects are located at what is believed to be the upstream extent of the historic range of Atlantic sturgeon and, therefore, they are not considered barriers to upstream migration. Atlantic sturgeon are known to utilize habitat downstream of these Projects, potentially for spawning. Therefore, it is possible that the operation of the facilities could impact Atlantic sturgeon and its habitat downriver of these two dams. As both projects operate as run of river facilities, we do not expect that operations of Lockwood and Brunswick will affect the ability of Atlantic sturgeon to spawn successfully in the vicinity of these projects or that the operation of these projects will affect the successful development of early life stages that may be present in the action area.

We have determined that the proposed action will affect Atlantic sturgeon by resulting in the capture of one adult per Project every ten years in the fishways at the Lockwood and Brunswick Projects. As outlined in Table 16, over the term of the FERC license this equates to the capture of no more than four Atlantic sturgeon at the Lockwood Project. Likewise, no more than four Atlantic sturgeon are expected to be captured at the Brunswick Project over the term of its license. The licensee will adhere to a Sturgeon Handling and Protection Plan to ensure that any GOM DPS Atlantic sturgeon captured in the fish lifts, or in isolated pools, are removed promptly and returned safely downstream. It is possible that some captured GOM DPS Atlantic sturgeon could experience minor injuries, such as abrasions, due to contact with the concrete surface of the fishways. GOM DPS Atlantic sturgeon captured in the fishways will be temporarily delayed from carrying out spawning activities. However, given that monitoring will be continuous 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 traps, or in the pools, and subsequent removal and placement back downstream of the fishway would cause an individual Atlantic sturgeon to abandon their spawning attempt. Considering this analysis, the capture of GOM DPS Atlantic sturgeon at the Lockwood and Brunswick Projects, is not likely to result in any 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 GOM DPS 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; (3) there is not anticipated to be any reduction in the number of eggs spawned or the fitness of any eggs or larvae; and (4) the project will continue to operate in run of river mode thus there is no potential for pulsed flows which could disrupt spawning or rearing.

The action is also not likely to reduce the numbers of GOM DPS Atlantic sturgeon in the action area as there will be no mortality of any individuals and no reason they would abandon the action area during the spawning season. The distribution of GOM DPS Atlantic sturgeon within the action area will not be affected by the action, as they will have access to the entirety of their historic range.

Based on the information provided above, the proposed action will not appreciably reduce the likelihood of survival for GOM DPS 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 GOM DPS 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 which would prevent Atlantic sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the action will not result in the mortality of any GOM DPS Atlantic sturgeon (2) as the action will not result in the mortality of any individuals, the action is not likely to have an effect on 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 distribution of Atlantic sturgeon in the action area or beyond the action area (i.e., throughout its range); (6) 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; (7) the operations of the project will not affect the ability of Atlantic sturgeon to successfully spawn or for eggs and larvae to successfully develop and, (9) the action will have no effect on the ability of Atlantic sturgeon to shelter or forage.

In certain instances an action may not appreciably reduce the likelihood of a species survival (persistence) but may affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that GOM DPS Atlantic sturgeon will survive in the wild. Here, we consider the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate.

Section 4(a)(1) of the ESA requires listing of a species if it is in danger of extinction throughout all or a significant portion of its range (i.e., "endangered"), or likely to become in danger of extinction throughout all or a significant portion of its range in the foreseeable future (i.e., "threatened") because of any of the following five listing factors: (1) The present or threatened destruction, modification, or curtailment of its habitat or range, (2) overutilization for commercial, recreational, scientific, or educational purposes, (3) disease or predation, (4) the inadequacy of existing regulatory mechanisms, (5) other natural or manmade factors affecting its continued existence.

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 GOM DPS Atlantic sturgeon in the action area and since it will not affect the overall distribution of Atlantic sturgeon other than to cause temporary changes in movements throughout the action area. The proposed action will not utilize Atlantic sturgeon for recreational, scientific or commercial purposes, affect the adequacy of existing regulatory mechanisms to protect this species, or affect their continued existence. 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 GOM DPS Atlantic sturgeon can be brought to the point at which they are no longer listed as endangered or threatened.

Despite the threats faced by individual Atlantic sturgeon inside and outside of the action area, the proposed action will not increase the vulnerability of individual GOM DPS Atlantic 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 GOM DPS Atlantic 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 GOM DPS Atlantic 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.

9. CONCLUSION

After reviewing the best available information on the status of endangered and threatened species under our jurisdiction, the environmental baseline for the action area, the effects of the action, and the cumulative effects, it is our biological opinion that the proposed action may adversely affect but is not likely to jeopardize the continued existence of shortnose sturgeon, the GOM DPS of Atlantic sturgeon, the New York Bight DPS of Atlantic sturgeon or the GOM DPS of Atlantic salmon. Furthermore, the proposed action is not expected to result in the destruction or adverse modification of critical habitat designated for the GOM DPS of Atlantic salmon.

10. INCIDENTAL TAKE STATEMENT

Section 9(a)(1) of the ESA prohibits any taking (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in any such conduct) of endangered species without a specific permit or exemption. We interpret the term ''harm'' as an act which actually kills or injures fish or wildlife. It is further defined to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as spawning, rearing, feeding, and migrating (50 CFR §222.102; NMFS 1999b). We have not defined the term "harass"; however, it is commonly understood to mean to annoy or bother. In addition, legislative history helps elucidate Congress' intent that harassment would occur where annoyance adversely affects the ability of individuals of the species to carry out biological functions or behaviors: "[take] includes harassment, whether intentional or not. This would allow, for example, the Secretary to regulate or prohibit the activities of birdwatchers where the effect of those activities might disturb the birds and make it difficult for them to hatch or raise their young" (HR Rep. 93-412, 1973). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity by a Federal agency or applicant (50 CFR §402.02). Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the ESA, provided that such taking is in compliance with the terms and conditions of the incidental take statement.

The prohibitions against incidental take are currently in effect for the GOM DPS of Atlantic salmon, shortnose sturgeon, and all DPSs of Atlantic sturgeon except the threatened GOM DPS. A final section 4(d) rule for the GOM DPS of Atlantic sturgeon will apply the appropriate take prohibitions. The proposed 4(d) rule for the GOM DPS was published on June 10, 2011 (76 FR 34023) and includes prohibitions on take with very limited exceptions. The appropriate prohibitions on take of GOM DPS Atlantic sturgeon will take effect on the date the final 4(d) rule is effective and at that time, the take provided in this ITS will apply to the GOM DPS.

An incidental take statement specifies the amount or extent of any incidental taking of endangered or threatened species. It also provides reasonable and prudent measures that are necessary and appropriate to minimize and/or monitor incidental take and sets forth terms and conditions with which the action agency must comply in order to implement the reasonable and prudent measures. The measures described in this section are nondiscretionary. If the FERC fails to include these conditions in the license articles or the licensee fails to assume and carry out the terms and conditions of this incidental take statement, the protective coverage of section 7(a)(2) may lapse. To monitor the effect of incidental take, the FERC must require the licensee to report the progress of the action and its effect on each listed species to us, as specified in this incidental take statement (50 CFR §402.14(i)(3)).

10.1. Amount or Extent of Take

In Section 6, we described the mechanisms by which ESA-listed anadromous fish and designated critical habitat would likely be affected by the construction of fishways at the Lockwood, Shawmut, and Weston Projects, and the implementation of the licensee's proposed ISPP at the Lockwood, Shawmut, Weston, Brunswick, and Lewiston Falls Projects. The following sections describe the amount or extent of take that we expect would result based on the anticipated effects of the proposed action.

If the proposed action results in take of a greater amount or extent than that described, the FERC would need to reinitiate consultation. The exempted take includes only take incidental to the proposed action.

10.1.1. Amount or Extent of Incidental Take of Atlantic salmon

10.1.1.1. Hydroelectric Operations

We anticipate that the continued operation of the Lockwood, Shawmut, Weston, Brunswick, and Lewiston Falls Projects could potentially harm Atlantic salmon adults and smolts in the mainstem of the Kennebec and Androscoggin Rivers. However, the licensee's proposal to implement the provisions of the ISPP will reduce the number of takes associated with these Projects. The following sections describe the amount or extent of take that we expect would result based on the anticipated effects of the proposed action (Table 21). If the proposed action results in take of a greater amount or extent than what is described, the FERC would need to reinitiate consultation. The exempted take includes only take incidental to the proposed action. The incidental take provided by this Opinion is valid until 2019. In 2020, this Opinion will no longer be valid for Atlantic salmon.

Upstream Passage

As described above, section 9(a)(1) of the ESA prohibits any taking (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in any such conduct) of endangered species without a specific permit or exemption. The Merriam-Webster Dictionary defines "collect" as "to bring together into one body or place". The dictionary further defines "capture" as "to take captive" and "trap" as "to place in a restricted position". The function of a fishway is to temporarily collect, capture and trap all migrating fish that are motivated to pass a dam, and to provide a mechanism for them to do so. Therefore, it is anticipated that 100% of the Atlantic salmon that use the upstream passage facilities at the Lockwood and Brunswick Projects during the interim period are collected, captured and trapped and, therefore, could potentially be exposed to the stress, injury and delay associated with being forced into fishways.

Table 21. Summary of incidental take of Atlantic salmon associated with FERC's authorization of the licensee's proposed project.

Project	Source of Effect	Lifestage	Type of Effect	Mechanism of Effect	Timeframe	Extent
Lockwood	Upstream Passage	Adult	Collect/Capture	Forced straying	2013-2019	40.00%
			Harassment		2013-2019	59.40%
			Mortality			0.60%
	Downstream Passage	Smolt	Mortality	Direct and Indirect	2013-2019	6.00%
		Kelt				12.00%
	Monitoring Studies	Smolt	Harm	Handling/Surgery	2014-2015	400 fish
			Mortality			4 per year
		Adult	Harm	Handling/Surgery	2016-2018	120 fish
		Kelt	Harm	Handlimg/Surgery	3 year study	60 fish
	Stranding	Adult	Harassment	Delay and injury	2013-2019	2 per year
Shawmut	Downstream Passage	Smolt	Mortality	Direct and Indirect	2013-2019	5.00%
		Kelt				11.00%
	Monitoring Studies	Smolt	Harm	Handling/Surgery	2014-2015	400 fish
			Mortality			4 per year
		Kelt	Harm	Handling/Surgery	3 year study	60 fish
Weston	Downstream	Smolt	Mortality	Direct and	2013-2019	6.00%

	Passage	Kelt		Indirect		27.00%
	Monitoring Studies	Smolt	Harm Mortality	Handling/Surgery	2014-2015	400 fish 4 per year
		Kelt	Harm	Handling/Surgery	3 year study	60 fish
Brunswick	Upstream Passage	Adult	Collect/Capture	Forced straying	2013-2019	61.00%
			Harassment			38.60%
			Mortality			0.40%
	Downstream Passage	Smolt	Mortality	Direct and Indirect	2013-2019	7.00%
		Kelt				15.00%
	Monitoring Studies	Smolt	Harm Mortality	Handling/Surgery	2014-2015	400 fish 4 per year
		Kelt	Harm	Handling/Surgery	3 year study	60 fish
Lewiston Falls	Upstream Passage	Adult	Harassment	Stray and Delay	2013-2029	100.00%
	Stranding	Adult	Harassment	Delay and Injury	2013-2019	1 fish

According to the expert panel convened by NMFS (2011), 1% of the salmon that fail to pass upstream of a fishway on the Penobscot River will die. Assuming that this rate is similar to what would occur on the Kennebec and Androscoggin Rivers, it is anticipated that, over the term of the ISPP (seven years), 40% of salmon that are motivated to pass the Lockwood Project, as well as 61% motivated to pass the Brunswick Project, will do so successfully but will be collected, captured, and trapped and that 0.6% and 0.4% will die, respectively. The salmon that are not able to pass the Project but survive (59.4% at Lockwood and 38.6% at Brunswick) will be harassed by being prevented from completing their spawning migration. These fish may spawn in downstream habitat or migrate back out to the ocean without spawning.

Downstream Passage

Operation of the Weston, Shawmut, Lockwood, and Brunswick Projects over the term of the ISPP (seven years) could result in the injury or death of up to 6%, 5%, 6%, and 7% of smolts and 27%, 11%, 12%, and 15% of kelts, respectively, that migrate through each individual Project. As these estimates were based on median river flows, we expect that the mortality rates documented during the survival studies at each project will vary by 1-2% depending on river flow (e.g., low, median, or high). As such, we will consider take to have been exceeded if the average mortality over the three study years exceeds the above mortality rates. Under the terms of the ISPP, this level of take is expected to occur only until 2019.

10.1.1.2. Fish Passage Monitoring

To assess the present level of upstream passage for pre spawn Atlantic salmon at the Lockwood Project, the licensee will conduct an upstream passage study that will involve the radio tagging of up to 40 adults a year for three years. This will result in the injury and harassment of up to 120 adult salmon over the course of the study (2016-2018). No pre spawn adult salmon are anticipated to be killed by the handling and tagging associated with the proposed study. A similar study will be conducted at the Brunswick Project (2013-2015). As the fish that will be monitored at Brunswick will be tagged as part of studies conducted by Topsham Hydro Partners at the Pejepscot Project, it is not anticipated that the licensee will need to tag or handle any additional adult salmon as part of the proposed study. Therefore, the upstream passage study at the Brunswick Project will not lead to any take of pre-spawn Atlantic salmon.

To assess the present levels of smolt survival at the Weston, Shawmut, Lockwood, and Brunswick Projects, the licensee proposes to use up to 200 hatchery smolts per year per Project for three years, for a total of 2,400 fish. All of these fish are anticipated to be injured due to the effects of handling and tag insertion. Four smolts per year per Project (2% x 200) are expected to be killed as a result of the proposed study (2013-2015). As the first year of the study is authorized under a section 10 permit, this ITS will only apply to the studies conducted in 2014 and 2015. Therefore, over the final two years of the study, it is anticipated that a total of 32 (four projects x two years x four fish per year) salmon smolts could be killed due to the handling effects associated with downstream survival studies.

To assess the present levels of kelt survival at the Weston, Shawmut, Lockwood, and Brunswick Projects, the licensee will conduct a downstream kelt study that will involve the tagging of up to 20 kelts per year per Project for three years, for a total of 240 fish. All of these fish are anticipated to be injured due to the effects of handling and tag insertion. No kelts are anticipated to be killed by the handling and surgical procedures associated with this project.

The operation of a rotary screw trap in the Sandy River during the smolt outmigration in 2014 and 2015 is anticipated to capture smolts outmigrating from the system. All of these smolts will be injured and harassed, but fewer than 0.74% of these smolts are anticipated to be killed due to the effects of trapping, handling, and anesthetizing.

There is potential for stranding of Atlantic salmon adults in the ledges downstream of the Lewiston Falls and Lockwood Projects after periods of high flow or during flashboard maintenance and replacement. It is anticipated that no more than one Atlantic salmon will be harassed or injured due to stranding at the Lewiston Falls Project over the seven year interim period. Given the larger number of fish approaching the Lockwood Project, as well as documented occurrences of stranded salmon, it is anticipated that up to two pre-spawn Atlantic salmon a year could become harassed or injured due to stranding.

We believe 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. Amount or Extent of Incidental Take of Shortnose sturgeon

The proposed action has the potential to directly affect shortnose sturgeon by capturing one shortnose sturgeon every ten years at the Lockwood and Brunswick Projects at their upstream fish passage facilities. In addition, the project could result in the capture of one shortnose sturgeon every ten years at the Lockwood and Brunswick Projects in isolated pools downriver of the dams during flashboard maintenance and replacement. Over the term of the amended license, this equates to four shortnose sturgeon being trapped (two in the fishway and two stranded) at the Lockwood Project (license expires in 2036), and another four being trapped (two in the fishway and two stranded) at the Brunswick Project (license expires in 2029). All trapped individuals will be removed from the fish traps, or the isolated pools, and returned downstream. Any captured fish may be harmed by receiving minor injuries due to abrasions on the trap or the pool substrate. Neither mortality nor major injuries of any shortnose sturgeon is anticipated or exempted.

We believe this level of incidental take is a reasonable estimate of incidental take that will occur given the seasonal distribution and abundance of shortnose sturgeon in the action area and the reports of shortnose sturgeon entering fish lifts, or being stranded, in other rivers. In the accompanying biological opinion, we determined that this level of anticipated take is not likely to result in jeopardy to the species.

10.1.3. Amount or Extent of Incidental Take of Atlantic sturgeon

The proposed action has the potential to directly affect GOM DPS Atlantic sturgeon by capturing one every ten years at the Lockwood and Brunswick Projects at their upstream fish passage facilities. In addition, the Projects could result in the capture of one Atlantic sturgeon every ten years at the Lockwood and Brunswick Projects in isolated pools downriver of the dams during flashboard maintenance and replacement. Over the term of the amended license, this equates to four Atlantic sturgeon being trapped (two in the fishway and two stranded) at the Lockwood Project (license expires in 2036), and another four being trapped (two in the fishway and two stranded) at the Brunswick Project (license expires in 2029). All trapped individuals will be removed from the fish traps, or the isolated pools, and returned downstream. Any captured fish may be harmed by receiving minor injuries due to abrasions on the trap or the pool substrate. Neither mortality nor major injuries of any Atlantic sturgeon is anticipated or exempted.

We believe this level of incidental take is a reasonable estimate of incidental take that will occur given the seasonal distribution and abundance of Atlantic sturgeon in the action area and the reports of Atlantic sturgeon entering fish lifts, or being stranded, in other rivers. In the accompanying biological opinion, we determined that this level of anticipated take is not likely to result in jeopardy to the species.

10.2. Reasonable and Prudent Measures

We believe the following reasonable and prudent measures are necessary and appropriate to minimize and monitor incidental take of Atlantic salmon, shortnose sturgeon, and GOM DPS Atlantic sturgeon. These must be included as enforceable terms of any amended operating licenses issued by FERC to the licensees. Please note that these reasonable and prudent measures and terms and conditions are in addition to the measures contained in the March 14, 2013 ISPP that the licensee has committed to implement and FERC is proposing to incorporate into the project licenses. As these measures will become mandatory requirements of any new licenses issued, we do not repeat them here as they are considered to be part of the proposed action.

1. FERC and the ACOE must ensure, through enforceable conditions of the Project licenses, that the licensee conduct all in-water and near-water construction activities in a manner that minimizes incidental take of ESA-listed or proposed species and conserves the aquatic resources on which ESA-listed species depend.

2. FERC must ensure, through enforceable conditions of the Project licenses, that the licensee measure and monitor the provisions contained in the March 14, 2013 Interim Species Protection Plan (SPP) in a way that is adequately protective of listed Atlantic salmon.

3. FERC must ensure, through enforceable conditions of the Project licenses, that the licensee complete an annual monitoring and reporting program to confirm that they are minimizing incidental take and reporting all project-related observations of dead or injured salmon or sturgeon to NMFS.

10.3. Terms and Conditions

In order to be exempt from prohibitions of section 9 of the ESA, FERC must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and which outline required reporting/monitoring requirements. These terms and conditions are non-discretionary. Any taking that is in compliance with the terms and conditions specified in this Incidental Take Statement shall not be considered a prohibited taking of the species concerned (ESA section 7(o)(2)). In carrying out all of these terms and conditions, FERC as lead Federal agency in this consultation, is responsible for coordinating with the other Federal agencies that are party to the consultation, as well as with the licensees. FERC must implement these terms and conditions through enforceable conditions of the project licenses. Where appropriate, the ACOE must require these terms and conditions as enforceable conditions of any permits or authorizations.

1. To implement reasonable and prudent measure #1, FERC and ACOE must require the licensee to do the following:

   a. Hold a pre-construction meeting with the contractor(s) to review all procedures and requirements for avoiding and minimizing impacts to Atlantic salmon and to emphasize the importance of these measures for protecting salmon.

   b. Timing of in-water work: Work below the bankfull elevation should occur outside of the smolt outmigration period (April 1 to June 15) or within a dewatered cofferdam. The licensee must notify NMFS one week before in-water work begins.

   c. Use Best Management Practices that will minimize concrete products (dust, chips, larger chunks) mobilized by construction activities from entering flowing or standing waters. Best practicable efforts shall be made to collect and remove all concrete products prior to rewatering of construction areas.

   d. Employ erosion control and sediment containment devices at the Lockwood, Shawmut, and Weston Dams during in-water construction activities. During construction, all erosion control and sediment containment devices shall be inspected weekly, at a minimum, to ensure that they are working adequately. Any erosion control or sediment containment inadequacies will be immediately addressed until the disturbance is minimized.

e. Provide erosion control and sediment containment materials (e.g., silt fence, straw bales, aggregate) in excess of those installed, so they are readily available on site for immediate use during emergency erosion control needs.

f. Ensure that vehicles operated within 150 feet (46 m) of the construction site waterways will be free of fluid leaks. Daily examination of vehicles for fluid leaks is required during periods operated within or above the waterway.

g. During construction activities, ensure that BMPs are implemented to prevent pollutants of any kind (sewage, waste spoils, petroleum products, etc.) from contacting water bodies or their substrate.

h. In any areas used for staging, access roads, or storage, be prepared to evacuate all materials, equipment, and fuel if flooding of the area is expected to occur within 24 hours.

i. Perform vehicle maintenance, refueling of vehicles, and storage of fuel at least 150 feet (46 m) from the waterway, provided, however, that cranes and other semi-mobile equipment may be refueled in place.

j. At the end of each work shift, vehicles will not be stored within, or over, the waterway.

k. Prior to operating within the waterway, all equipment will be cleaned of external oil, grease, dirt, or caked mud. Any washing of equipment shall be conducted in a location that shall not contribute untreated wastewater to any flowing stream or drainage area.

l. Use temporary erosion and sediment controls on all exposed slopes during any hiatus in work exceeding seven days.

m. Place material removed during excavation only in locations where it cannot enter sensitive aquatic resources.

n. Minimize alteration or disturbance of the streambanks and existing riparian vegetation to the greatest extent possible.

o. Remove undesired vegetation and root nodes by mechanical means only. No herbicide application shall occur.

p. Mark and identify clearing limits. Construction activity or movement of equipment into existing vegetated areas shall not begin until clearing limits are marked.

q. Retain all existing vegetation within 150 fect (46 m) of the edge of the bank to the greatest extent practicable.

2. To implement reasonable and prudent measure #2, FERC must require the licensee to do the following:

a. Prepare in consultation with NMPS a plan to study the passage and survival of migrating Atlantic salmon (adults, smolts, and kelts) at the Lockwood, Shawmut, Weston, and Brunswick Projects.

b. Upstream passage studies at the Lockwood Project should not allow test fish to migrate upstream of the Project until such time as there is volitional passage all the way to the Sandy River.

c. Migratory delay of pre-spawn Atlantic salmon should be monitored downstream of the Lewiston Falls Project as part of the upstream passage studies on the Androscoggin River.

d. Conduct an instream fiow demonstration assessment to evaluate the effects of peaking operations at the Lewiston Falls Project on downstream habitat in the Androscoggin River.

e. The Atlantic salmon Handling and Rescue Plan should be implemented at the Lewiston Falls Project betwcen May 1 and December 31 if salmon are known to be in the vicinity (i.e. if they have passed the Worumbo Project).

f. The licensee should seek comments from NMFS on any fish passage design plans at the 30%, 60%, and 90% design phase.

g. The licensee should allow NMFS staff to inspect fishways at the Projects at least annually.

h. The licensee should inspect the upstream and downstream fish passage facilities at the Lockwood, Shawmut, Weston, and Brunswick Projects daily during from April 1 to December 31, annually. Submit summary reports to NMFS weekly during the fish passage season.

i. Annual maintenance requiring the shutdown 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. If water temperatures make it unsafe to sample Atlantic salmon, they should be allowed to volitionally swim through the fishway without being handled.

   j. Require that the licensee develop, in consultation with NMFS, project specific adaptive management plans to address any downstream passage deficiencies at the Weston, Shawmut, Lockwood, and Brunswick Projects as documented through site-specific survival studies during the period of the ISPP. The plans should include descriptions of: 1. potential measures to be implemented at each project to improve survival 2. the statistical methodology that will be used to interpret study results, and 3. the monitoring studies that will be implemented to verify the efficacy of the permanent downstream fish passage facilities. These plans should be completed no later than January 1, 2014.

3. To implement reasonable and prudent measure #2, FERC must require the licensee to do the following:

   a. Notify NMFS of any changes in operation including maintenance activities and debris management at the project during the term of the ISPP.

   b. Contact NMFS within 24 hours of any interactions with Atlantic salmon, shortnose sturgeon or Atlantic sturgeon including non-lethal and lethal takes (Dan Tierney: by email (Dan.Tierney@noaa.gov) or phone (207) 866- 3755 and the Section 7 Coordinator (incidental.take@noaa.gov).

   c. 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.

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, immediate 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 NMFS the need for possible modification of the reasonable and prudent measures.

Reasonable and prudent measures and their implementing terms and conditions may not alter the basic design, location, scope, duration, or timing of the action, and should involve only minor changes (50 CFR §402.14(i)(2)). The FERC and ACOE have reviewed the RPMs and Terms and Conditions outlined above and have agreed to implement all of these measures as described herein. The discussion below explains why each of these RPMs 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 the FERC.

RPM #1, as well as Term and Condition #1 are necessary and appropriate as they will require the licensee and their contractors to use best management practices and best available technology for construction. This will ensure that take of listed Atlantic salmon is minimized to the extent practical. These procedures represent only a minor change to the proposed action as following these procedures should not increase the cost of the project or result in any delays or reduction of efficiency of the project.

RPM #2, as well as Term and Condition #2, are necessary and appropriate as they describe how the licensee will be required to measure and monitor the success of the proposed measures in the ISPP in order to minimize the effects on Atlantic salmon. These procedures represent only a minor change to the proposed action as following these procedures should not increase the cost of the project or result in any delays or reduction of efficiency of the project.

RPM #3, as well as Term and Condition # 3, 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 NMFS 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.

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 shortnose sturgeon, the GOM DPS of Atlantic salmon and the GOM DPS and NYB DPS of Atlantic sturgeon. To further reduce the adverse effects of the proposed project on shortnose sturgeon, Atlantic sturgeon and Atlantic salmon, we recommend that FERC implement the following conservation measures.

1. If any lethal take occurs, FERC should use its authorities to, and/or direct the licensees to, arrange for contaminant analysis of the specimen. If this recommendation is to be implemented, the fish should be frozen and NMFS should be contacted immediately to provide instructions on shipping and preparation.

2. FERC should use its authorities to implement license requirements for all FERC regulated projects in Maine to provide safe and effective upstream and downstream fish passage for listed Atlantic salmon and other diadromous fish species. For Atlantic salmon, this can be accomplished through station shutdowns during the smolt passage season (April to June) and kelt passage season (October to December and April to June) or the installation of highly effective fishways.

3. FERC should use its authorities to require all FERC regulated hydroelectric projects in Maine to document the effectiveness of station shutdowns or fishways in protecting listed species.

4. FERC should use its authorities to require all FERC regulated hydroelectric projects in Maine to operate in a manner that is protective of NMFS listed species. This can be

accomplished by requiring these facilities to operate in a run-of-river mode to simulate a natural stream hydrograph.

12. REINITIATION NOTICE

This concludes formal consultation concerning FERC's proposal to amend the licenses for the Lockwood, Shawmut, Weston, Brunswick, and Lewiston Falls Projects to incorporate the provisions of the proposed ISPP and Sturgeon Handling and Protection Plan. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has bcen 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 identified action is subsequently modified in a manner that causes an effect to listed species; 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.

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Document Content(s)

155 FERC ¶ 61,185
UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Before Commissioners: Norman C. Bay, Chairman;
Cheryl A. LaFleur, Tony Clark,
and Colette D. Honorable.

Merimil Limited Partnership Brookfield White Pine Hydro, LLC	Project Nos. 2574-069 2574-075 2322-054 2325-077

ORDER AMENDING LICENSES TO REQUIRE INTERIM SPECIES PROTECTION PLAN FOR ATLANTIC SALMON, AND HANDLING AND PROTECTION PLAN FOR SHORTNOSE AND ATLANTIC STURGEON

(Issued May 19, 2016)

1. On February 21, 2013, Brookfield White Pine Hydro, LLC (Brookfield), on behalf of itself and Merimil Limited Partnership (Merimil), filed an application to amend the licenses for three hydroelectric projects on the Kennebec River in Maine to require an interim species protection plan (Interim Plan) for endangered Atlantic salmon. The Interim Plan, for years 2013 through 2019, would require interim measures to avoid and minimize impacts to endangered Atlantic salmon during operation of Merimil's Lockwood Project No. 2574, and Brookfield's Shawmut Project No. 2322 and Weston Project No. 2325.[1] On March 29, 2013, Brookfield amended its application to include a sturgeon handling and protection plan (Sturgeon Plan) that would require

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[1] Merimil is (and has always been) the licensee for the Lockwood Project. Brookfield is the general partner for Merimil, and is responsible for operating the Lockwood Project. Brookfield is the licensee for the other two projects. The Commission originally licensed the Shawmut and Weston Projects to Central Maine Power Company, and approved a transfer of the licenses to FPL Energy Maine Hydro, LLC, on December 28, 1998. *Central Main Power Co.,* 85 FERC ¶ 62,208 (1998). The Commission amended the licenses to reflect the company's new name, Brookfield White Pine Hydro, LLC, on July 29, 2013. *FPL Energy Main Hydro, LLC*, 144 FERC ¶ 62,075 (2013). For convenience, we refer to Brookfield as the licensee throughout this order.

permanent measures to avoid and minimize impacts to endangered shortnose sturgeon and threatened Atlantic sturgeon at the Lockwood Project. Several parties have intervened in opposition to the Interim Plan for Atlantic salmon, contending that it is inadequate and conflicts with an earlier settlement agreement for fish protection measures in the Kennebec River Basin. One intervenor opposes both plans, contending that the Commission should instead require removal of the Lockwood Dam. For the reasons discussed below, we amend the licenses to require both plans.

Background

2. The Commission originally licensed the Lockwood, Shawmut, and Weston projects in the 1960s, and has subsequently relicensed them. The 6.915-megawatt (MW) Lockwood Project is located at river mile 63 in Waterville, Maine, and is the first dam on the mainstem of the Kennebec River.[2] The Hydro-Kennebec Project No. 2611, which is the next dam upriver from the Lockwood Project, is located just upstream at river mile 64. It is not involved in this amendment proceeding but obtained a similar amendment to require an interim plan for Atlantic salmon in 2013.[3] The 8.775-MW Shawmut Project is located at river mile 66.[4] The 14.75-MW Weston Project is the next upstream dam and is located at river mile 82.[5]

3. The Kennebec River supports a varied fish population, including both resident and migratory species. In 1987, licensees of a number of projects on the Kennebec (including

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[2] The Commission issued an original license for the Lockwood Project in 1969, and relicensed the project on March 4, 2005. The license expires in 2036. *See Merimil Limited Partnership,* 110 FERC ¶ 61,240 (2005).

[3] *See Hydro-Kennebec, LLC*, 142 FERC ¶ 62,174 (2013) (approving Interim Species Protection Plan for Atlantic Salmon). As part of that plan, the licensee was required to file final plans and a schedule for construction of upstream fish passage facilities. Commission staff approved the licensee's final design plans for those facilities on March 7, 2016. *Hydro-Kennebec, LLC*, 154 FERC ¶ 62,161 (2016).

[4] The Commission issued an original license for the Shawmut Project in 1964, and relicensed the project on January 5, 1981. *Central Main Power Co.*, 14 FERC ¶ 62,004 (1981). The current license expires in 2021, and the licensee is now involved in the pre-filing phase of the relicensing process.

[5] The Commission issued an original license for the Weston Project in 1964 and relicensed the project on November 25, 1997. *Central Main Power Co.,* 81 FERC ¶ 61,251 (1997). The license expires in 2036.

Lockwood, Shawmut, and Weston) and Sebasticook Rivers[6] and state fisheries agencies entered into an agreement, known as the Kennebec Hydro Developers Group Agreement (KHDG Agreement or Kennebec Agreement), to facilitate the restoration of American shad, alewife, and Atlantic salmon in the Kennebec River Basin. The licensees agreed to provide funding to the state fishery agencies for interim trap and truck operations at the projects, to install and operate permanent downstream and upstream fish passage facilities according to a schedule, and to conduct studies related to the restoration efforts. Among other things, the Kennebec Agreement assumed that fish passage would be provided at the Edwards Project No. 2389, which at the time was the first dam on the Kennebec River, within the next few years.

4. This did not happen, and in 1997 the Commission denied a new license for the Edwards Project and ordered the licensee to file a plan for dam removal.[7] Thereafter, on May 28, 1998, the licensees of the Edwards Project and seven upstream projects (again including Lockwood, Shawmut, and Weston), together with state and federal fisheries agencies and environmental groups, filed an offer of settlement, known as the Lower Kennebec River Comprehensive Settlement Accord.[8] This settlement modified and replaced the earlier agreement, and parties continued to refer to it as the KHDG Agreement.[9] The revised agreement included provisions for removing the Edwards Dam and, on the occurrence of certain triggering events, installing fish passage at the upstream

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[6] The Sebasticook River joins the Kennebec River about half a mile downstream of the Lockwood Project.

[7] *Edwards Manufacturing Co., Inc.*, 81 FERC ¶ 61,255 (1997).

[8] Signatories to the 1998 Kennebec Agreement are: Edwards Manufacturing Company and the City of Augusta, Maine (the licensees for the now-removed Edwards Project); U.S. Fish and Wildlife Service; National Marine Fisheries Service, the State of Maine; Central Maine Power Company (the then licensee for the Fort Halifax Project No. 2552, the Shawmut Project, and the Weston Project); Merimil Limited Partnership (licensee for the Lockwood Project); Hydro Kennebec Limited Partnership (licensee for the Hydro Kennebec Project No. 2611); Benton Falls Associates (licensee for the Burnham Project No. 11472); and a group of intervenors collectively called the Kennebec Coalition, comprising American Rivers, Inc., Atlantic Salmon Federation, Kennebec Valley Chapter of Trout Unlimited, Natural Resources Council of Maine, and Trout Unlimited.

[9] Because the settlement agreement includes a number of parties who are not members of the Kennebec Hydro Developers Group, we refer to it as the Kennebec Agreement in this order.

projects. Later that year, the Commission amended the licenses for these projects to incorporate the new terms of the Kennebec Agreement.[10] The Edwards Project was removed in 1999.

5. In 2005, the Commission issued a new license for the Lockwood Project that continued to require the fish passage measures of the Kennebec Agreement, some of which were already being developed. To implement part of the agreement, Brookfield installed a fish lift and trap and truck facility at the Lockwood powerhouse as an interim upstream fish passage facility and began operating it in 2006. Brookfield also developed operational and effectiveness study plans for the new fish lift in consultation with resource agencies, and the Commission approved these plans on April 26, 2006.

6. The Lockwood, Shawmut, and Weston Projects are located within the range of several species of fish listed as threatened or endangered under the Endangered Species Act (ESA). The Lockwood Project is within the range of endangered shortnose sturgeon and within two Distinct Population Segments (DPS)[11] of Atlantic sturgeon (Gulf of Maine DPS and New York Bight DPS). All three projects (Lockwood, Shawmut, and Weston) are within the range of the endangered Gulf of Maine DPS of Atlantic salmon.

7. Regarding sturgeon, the National Marine Fisheries Service (NMFS) had issued a final recovery plan for shortnose sturgeon in December 1998,[12] and the new license for the Lockwood Project included a shortnose sturgeon handling and protection plan. The listing of Atlantic sturgeon came later. On February 26, 2012, NMFS listed the

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[10] *See Edwards Manufacturing Co., Inc., et al.*, 84 FERC ¶ 61,227 (1998) (incorporating relevant parts of the 1998 Kennebec Agreement in the licenses for the Lockwood, Shawmut, and Weston Projects, among others). The new license for the Lockwood Project, issued in 2005, includes the relevant provisions of the 1998 Kennebec Agreement as a condition of the project's water quality certification. *See Merimil Limited Partnership*, 110 FERC ¶ 61,240 at Appendix B.

[11] A Distinct Population Segment or DPS is the smallest division of a species permitted to be protected under the ESA. It is a population or group of populations that is discrete from other populations of the species and is significant in relation to the entire species. The ESA provides for listing species, subspecies, or distinct population segments of vertebrate species. *See* the joint Fish and Wildlife Service (FWS) and NMFS policy statement, 61 Fed. Reg. 4722 (1996).

[12] Shortnose sturgeon were listed as endangered on March 11, 1967 (32 Fed. Reg. 4001), and remained on the endangered list with the enactment of the ESA in 1973.

Atlantic sturgeon as endangered in the New York Bight DPS[13] and as threatened in the Gulf of Maine DPS.[14]

8. Regarding Atlantic salmon, NMFS and the U.S. Fish and Wildlife Service (FWS; collectively, the Services) listed the Gulf of Maine DPS of Atlantic salmon as endangered on November 17, 2000.[15] At the time, the listing range for the Gulf of Maine DPS of Atlantic salmon did not include areas where the Lockwood, Shawmut, and Weston Projects are located. On June 19, 2009, the Services expanded the listing range for these fish to include these areas.[16] At the same time, NMFS designated critical habitat for the Gulf of Maine DPS of Atlantic salmon that includes the location of all three projects.[17]

9. Concerned that the projects might affect Atlantic salmon, Brookfield initially contacted NMFS in 2009 to discuss obtaining an Incidental Take Permit[18] through a Habitat Conservation Plan[19] under section 10 of the ESA.[20] After preparing a draft Habitat Conservation Plan for review, Brookfield met with NMFS and indicated that instead, it would develop an Interim Plan for Atlantic salmon that could be incorporated in the project licenses as a license amendment. On January 31, 2013, Brookfield requested that the Commission designate it as the Commission's non-federal

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[13] 77 Fed. Reg. 5880 (2012).

[14] 77 Fed. Reg. 5914 (2012).

[15] 65 Fed. Reg. 69,459 (2000).

[16] 74 Fed. Reg. 29,344 (2009).

[17] 74 Fed. Reg. 29,300 (2009).

[18] An Incidental Take Permit is a permit issued under section 10(a)(1)(B) of the ESA to a non-federal party undertaking an otherwise lawful activity that might result in the take of an endangered or threatened species. As defined in ESA section 3(19), the term "take" means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct."

[19] A Habitat Conservation Plan is a plan that outlines ways of maintaining, enhancing, and protecting a given habitat type needed to protect ESA-listed species. A Habitat Conservation Plan is required before an incidental take permit may be issued.

[20] *See* NMFS Biological Opinion at 5-6, which provides a consultation history (filed July 22, 2013).

representatives for the purpose of informal consultation with NMFS on Atlantic salmon. Commission staff agreed and made the requested designation by letter issued on February 7, 2013.

10. On February 21, 2013, Brookfield filed its proposed Interim Plan for Atlantic salmon, together with a draft Biological Assessment of the plan.[21] Brookfield requested that the Commission initiate formal consultation with NMFS on the Interim Plan and incorporate the proposed measures in the project licenses.

11. On March 14, 2013, Commission staff adopted Brookfield's Biological Assessment and initiated formal consultation with NMFS on Atlantic salmon. Based on the analysis in the Biological Assessment, Commission staff concluded that operation of the projects under the Interim Plan may adversely affect Atlantic salmon and the species' designated critical habitat.

12. Meanwhile, on March 4, 2013, Brookfield requested that the Commission designate it as the Commission's non-federal representative to consult informally with NMFS regarding effects of operating the Lockwood Project on endangered shortnose sturgeon and threatened Atlantic sturgeon. Shortly thereafter, in a letter to NMFS dated March 25, 2013, Commission staff made the requested designation.

13. On March 29, 2013, Brookfield filed its Sturgeon Plan and an addendum to its earlier draft Biological Assessment to address effects of operating the Lockwood Project on Atlantic and shortnose sturgeon.[22] Brookfield requested that the Commission initiate formal consultation with NMFS on the Sturgeon Plan and include the plan as part of a single ESA consultation on both the Interim Plan and the Sturgeon Plan to address all three listed species (Atlantic salmon, Atlantic sturgeon, and shortnose sturgeon).

14. On May 1, 2013, Commission staff adopted the addendum to the Biological Assessment and initiated formal consultation with NMFS on shortnose and Atlantic sturgeon. Based on the analysis in the Biological Assessment, Commission staff concluded that operation of the Lockwood Project under the Sturgeon Plan is likely to adversely affect shortnose sturgeon and the Gulf of Maine DPS and New York Bight DPS of Atlantic sturgeon. By letter filed on May 15, 2013, NMFS informed the Commission that it had received all the information needed for formal consultation and

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[21] The Interim Plan appears in Appendix A to Brookfield's draft Biological Assessment (filed February 21, 2013).

[22] The Sturgeon Plan is Attachment A to Brookfield's addendum to the Biological Assessment (filed March 29, 2013).

would prepare a single Biological Opinion addressing both the Interim Plan and the Sturgeon Plan.

15. On July 9, 2013, a group of intervenors collectively called the Kennebec Coalition, comprising American Rivers, Inc., Atlantic Salmon Federation, Kennebec Valley Chapter of Trout Unlimited, Natural Resources Council of Maine, and Trout Unlimited, filed comments opposing the Interim Plan and Commission staff's Biological Assessment for Atlantic salmon. The Kennebec Coalition expressed concern that the Interim Plan is inadequate to protect Atlantic salmon and would conflict with and be less stringent than existing license articles for the three projects and the terms of the Kennebec Agreement, particularly with respect to provisions for downstream passage of endangered Atlantic salmon and other species.

16. On July 22, 2013, NMFS filed its Biological Opinion, addressing not only the Interim Plan for Atlantic salmon at Lockwood, Shawmut, and Weston, but also the Sturgeon Plan for Atlantic and shortnose sturgeon at Lockwood.[23] On September 3, 2013, NMFS filed an amendment to its Biological Opinion, clarifying its consideration of the effects of the Lockwood Project on Atlantic and shortnose sturgeon and adding a condition to the incidental take statement for the project. For Atlantic salmon, NMFS concluded that operation of the Lockwood, Shawmut, and Weston Projects under the Interim Plan may adversely affect but is not likely to jeopardize the continued existence of the Gulf of Maine DPS of Atlantic salmon. NMFS further found that, although these projects would continue to adversely affect essential features of the species' designated critical habitat, the proposed action would improve the functioning of migratory habitat by constructing upstream fishways and by implementing an adaptive management strategy to improve downstream survival. NMFS therefore concluded that the proposed action would not lead to adverse modification or destruction of critical habitat. For sturgeon, NMFS concluded that implementing the Sturgeon Plan may adversely affect but is not likely to jeopardize the continued existence of shortnose sturgeon or the Gulf of

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[23] The Biological Opinion also included an Interim Plan for Atlantic salmon at the Brunswick Project No. 2284 and the Lewiston Falls Project No. 2302, as well as a Sturgeon Plan for Atlantic and shortnose sturgeon at the Brunswick Project. These two projects, which are located on the Androscoggin River, are not at issue in this amendment proceeding. The Androscoggin River joins the Kennebec River near tidewater at Merrymeeting Bay. Commission staff approved the protection plans for these projects on December 13, 2013. *See Brookfield White Pine Hydro, LLC*, 145 FERC ¶ 62,187 (2013) (approving Interim Plan and Sturgeon Plan for the Brunswick Project), and *Brookfield White Pine Hydro, LLC*, 145 FERC ¶ 62,188 (2013) (approving Interim Plan for the Lewiston Falls Project).

Maine or New York Bight DPSs of Atlantic sturgeon, and that the plan would protect listed shortnose and Atlantic sturgeon that occur downstream of the Lockwood Project.[24]

17. On January 29, 2014, the Atlantic Salmon Federation (Atlantic Salmon) and the Natural Resources Council of Maine (Natural Resources) filed a request that, before incorporating the Interim Plan for Atlantic salmon in the licenses for the projects, the Commission should require Brookfield to file a formal application for a license amendment and should issue public notice of the amendment application, when filed. In support, they argued that the Biological Opinion and Interim Plan would require physical changes to the projects if the Interim Plan is included in the licenses.

18. On March 18, 2014, Atlantic Salmon filed a motion to intervene in the proceeding to consider the Interim Plan at Lockwood, Shawmut, and Weston. The Maine Department of Marine Resources (Maine Marine Resources) filed a notice of intervention on May 2, 2014, stating that if the Interim Plan is approved, the Department's efforts to restore American shad and blueback herring to historical habitats above the Lockwood Project will be thwarted or indefinitely delayed. On June 18, 2014, in response to Maine Marine Resources' comments, NMFS filed comments supporting the Interim Plan.

19. On July 17, 2014, Atlantic Salmon, Natural Resources, and Trout Unlimited filed comments objecting to the Biological Opinion and Interim Plan for Atlantic salmon at the projects. They requested that the Commission reject the Biological Opinion and deny any license amendments to incorporate the Interim Plan. On July 28, 2014, Maine Rivers filed similar comments, urging the Commission to reject both the Biological Opinion and the Interim Plan.

20. On August 11, 2014, Natural Resources filed a motion to intervene. On September 5, 2014, Brookfield filed a response to the comments of Maine Marine Resources and others, indicating actions it had taken at the projects to implement provisions of the Kennebec Agreement.

21. On September 5, 2014, Brookfield filed a response to Maine Marine Resources' notice of intervention and comments, noting that while Brookfield did not oppose the intervention, it had already met many of its obligations under the Kennebec Agreement. Brookfield added that it was working with Maine Marine Resources and other resource agencies to design additional fish passage facilities at the Hydro Kennebec and

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[24] *See* letter from John Bullard, NMFS, to Kimberly Bose, Commission Secretary, at 1 (attaching the Biological Opinion and summarizing its conclusions).

Lockwood Projects to ensure that the fish passage needs of all species covered by the agreement are addressed, consistent with the schedule for fishway improvements in the Interim Plan.

22. On January 7, 2015, Atlantic Salmon, Natural Resources, and Trout Unlimited filed additional comments, expressing concern about the failure to meet the biological triggers of the Kennebec Agreement for upstream passage facilities at any of the dams on the mainstem Kennebec River. Among other things, they stated that as provided in the Kennebec Agreement, because the biological triggers for permanent fish passage had not been met by December 2014, they were planning to meet with Brookfield to assess progress in restoring fish species covered by the agreement and would attempt to reach consensus on future fish passage measures. On January 14, 2015, Douglas Watts, an intervenor in the Lockwood Project relicensing proceeding, filed comments expressing concern about the failure of the Lockwood Dam and fish trap to pass American shad. On February 12, 2015, Atlantic Salmon, Natural Resources, and Trout Unlimited filed additional comments opposing the Biological Opinion and Interim Plan.

23. On February 13, 2015, Brookfield filed a request to amend the schedule in the Interim Plan to extend the date for completing construction and beginning operation of the volitional component of the fish lift at Lockwood from May 1, 2016 to May 1, 2017.[25] The company stated that the additional time would allow Brookfield to focus on determining why fewer American shad than expected are captured in Lockwood's fish lift and to work with the agencies and other parties to the Kennebec Agreement to attempt to find a solution. Brookfield attached a record of consultation indicating that NMFS, FWS, Maine Department of Inland Fisheries and Wildlife, Maine Department of Environmental Protection, and Maine Marine Resources supported the request for a delay. In contrast, Atlantic Salmon, Natural Resources, and Trout Unlimited stated that they did not concur with the proposal and reiterated their opposition to the Biological Opinion and Interim Plan.

24. On July 9, 2015, the Maine Council of Atlantic Salmon, Natural Resources, the Kennebec Valley Chapter of Trout Unlimited, and Maine Rivers filed a complaint for a declaratory judgment and injunctive relief in the United States District Court for the District of Maine, seeking judicial review of the Biological Opinion and an injunction directing NMFS to withdraw it.[26] Among other things, they requested that the court

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[25] A volitional component of a fish passage system is a structure, like a fish ladder, that allows but does not force fish to use it.

[26] *See Maine Council of the Atlantic Salmon Federation, et al. v. National Marine Fisheries Service*, No. 2:15-cv-00261-JAW, U.S. Dist. Ct. Maine (filed July 8, 2015). The complaint also seeks judicial review of a 2012 Biological Opinion for a proposed

(continued...)

direct NMFS to reinitiate consultation with the Commission and prepare a new Biological Opinion that complies with the ESA.

25. On August 27, 2015, Commission staff issued a public notice of Brookfield's application to amend the licenses for the Lockwood, Shawmut, and Weston Projects to incorporate the Interim Plan, and to amend the license for the Lockwood Project to incorporate the Sturgeon Plan. The notice established a deadline for filing comments, motions to intervene, and protests by September 27, 2015.[27]

26. On September 8 and 9, 2015, Mr. Watts filed additional information on American shad for consideration in the proceeding. On September 14, 2015, Mr. Watts filed a motion to intervene. NMFS filed a notice of intervention on September 18, 2015. On September 24, 2015, Maine Marine Resources filed comments, noting its earlier comments and intervention opposing the Interim Plan and including additional information on fish passage effectiveness at the Lockwood Project. On September 25, 2015, the U.S. Department of the Interior filed a letter stating that it had no comments on the application.

27. On September 28, 2015, Atlantic Salmon, Natural Resources, Trout Unlimited, and the Kennebec Valley Chapter of Trout Unlimited, collectively, filed a motion to intervene in opposition to the amendment. Among other things, they objected to the fish passage provisions in the Interim Plan and requested that, in light of their suit challenging the Biological Opinion, the Commission defer action on the amendment application pending resolution of that litigation. On September 29, 2015, Mr. Watts filed comments on the proposed amendment applications, contending that because of the failure to pass American shad at the Lockwood Project, the Commission should reject the Interim Plan and require that the Lockwood Dam be breached to provide effective passage for not only American shad but also Atlantic and shortnose sturgeon and striped bass.

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amendment to incorporate an interim species protection plan for Atlantic salmon in the license for the Hydro-Kennebec Project No. 2611. As noted, Commission staff granted that amendment request in 2013. *See* note 3, *supra*. The complaint asks the court to direct Brookfield to request that the Commission revoke this license amendment.

[27] Because September 27, 2015, was a Sunday, the filing deadline was Monday, September 28, 2015. *See* 18 C.F.R. § 385.2007(a)(2) (2015). Thus, all interventions were timely, including those filed before the notice was issued. If the proceeding is one for which intervention is permitted, a party can intervene once the application is filed, even if Commission staff has not yet accepted the application or issued notice of it. *See Central Nebraska Public Power and Irrigation District*, 43 FERC ¶ 61,225, at 61,578 & n.8 (1988).

28. On February 16, 2016, Mr. Watts filed additional information regarding American shad passage at Commission-licensed dams in Maine.

29. On March 29, 2016, Brookfield filed an annual report of its activities to implement the Interim Plan. Brookfield's cover letter accompanying the report indicates, among other things, that it has been conducting studies and meeting with NMFS and other resource agencies regarding progress under the plan and other issues concerning Atlantic salmon.[28] Brookfield states that it met with resource agencies on February 25, 2016 to discuss the results of shad-related studies conducted at the Lockwood Project in 2015. Brookfield further states that, at that meeting, it was decided that Brookfield should proceed with the engineering design and construction of the new upstream volitional fish passage component for the existing Lockwood fish lift. Brookfield adds that at this time, it anticipates that the engineering design will take place in 2016 and construction will begin in 2017.

Discussion

30. Before turning to the parties' arguments, we provide a brief review of the major provisions of the Kennebec Agreement. We then review the actions contemplated in the Interim Plan for Atlantic salmon and the Sturgeon Plan, and review the incidental take provisions of the Biological Opinion. Finally, we address the parties' arguments concerning the two protection plans and explain our reasons for amending the licenses to include them.

A. The Kennebec Agreement

31. In 1998, the Commission amended the Lockwood, Shawmut and Weston Project licenses to include the relevant provisions of the Kennebec Agreement.[29] The agreement provides a process and schedule for installing interim and permanent upstream and downstream fish passage facilities for American shad, alewife, blueback herring, Atlantic salmon, and American eel at a series of hydroelectric projects on the Sebasticook and Kennebec Rivers, including the Lockwood, Shawmut, and Weston Projects. The schedule is based on the anticipated growth of the American shad population in the Kennebec River. However, the State of Maine's goal to restore anadromous fish upstream of the Lockwood Project also includes restoring Atlantic salmon, alewife, and blueback herring above the Lockwood, Hydro Kennebec, Shawmut, and Weston Projects.

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[28] Letter from Kelly Maloney, Brookfield, to Kimberly Bose, Commission Secretary, at 7 (filed March 29, 2016).

[29] *See* note 10, *supra*.

If the growth of Atlantic salmon, alewife, or blueback herring populations requires a different approach for triggering fishway installation (that is, one not based on American shad), the licensees and resource agencies[30] will meet to attempt to reach consensus on the need, timing, and design of permanent upstream passage facilities at the four projects. The interim upstream passage facilities were installed and operational at Lockwood by May 2006.

32. Under the Kennebec Agreement, interim downstream passage is to be accomplished through a combination of controlled spills, turbine shutdown, and sluicing. New structures are not required. If turbine passage is pursued as an alternative, the licensees must conduct qualitative and quantitative studies demonstrating that passage through the turbines does not cause significant mortality. Before installing permanent downstream passage facilities, passage studies are required to determine the effectiveness of various techniques and alternatives.

33. Permanent upstream and downstream passage must be installed and operating within two years after 8,000 American shad are captured at the interim Lockwood fish trap in a single season, or the licensees and resource agencies determine that upstream passage is warranted based on an alternative approach, whichever occurs earlier. To date, neither condition has occurred.[31]

34. The Kennebec Agreement further provides that, if by December 2014 the biological triggers for permanent upstream passage facilities have not been met at one or more of the dams covered by the agreement, the parties will meet to assess the progress in restoring the species covered by the agreement and will attempt to reach consensus on future fish passage measures. Any disputes are to be handled through the Commission's

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[30] Section I of the Kennebec Agreement identifies the resources agencies as the National Marine Fisheries Service, Maine Department of Inland Fisheries and Wildlife, Maine Marine Resources, Maine State Planning Office, and the U.S. Fish and Wildlife Service.

[31] The Kennebec Agreement provides for the possibility of a biologically-based trigger based on the status and growth of Atlantic salmon or river herring (river herring refers collectively to alewives and blueback herring). Thus, under the agreement, an alternative trigger for permanent passage facilities could be based on a biological review of the status of Atlantic salmon. In this case, however, the licensees and resource agencies did not adopt an alternative trigger for installing permanent passage facilities under the Kennebec Agreement. Instead, the status of Atlantic salmon as endangered, together with expansion of its geographic range, provided the trigger for development of the Interim Plan to protect Atlantic salmon at these projects.

process. As noted, the parties have initiated discussions under this provision but have not reached consensus.

B. Existing Upstream Fish Passage Facilities

35. In accordance with the license and the Kennebec Agreement, in 2006 Brookfield completed construction of a fish lift and an interim trap, sort, and transport system at the Lockwood Project to trap and truck fish upstream of the Lockwood, Shawmut, and Weston Projects. The Lockwood fish lift facility is located on the west side of the powerhouse adjacent to Unit 7. The lift operates with an attraction flow of up to 150 cubic feet per second (cfs), and has a cycle time of about 10 minutes.

36. The attraction flow attracts the fish through the fish lift entrance gate into the lower flume of the fish lift. The fish then swim through a vee-gate crowder and remain in the lower flume of the lift. The vee-gate crowder closes to hold the fish in a 1,800-gallon water-filled hopper. The hopper lifts the fish to the holding tank elevation and the fish are sluiced into a 2,500-gallon discharge tank. The sorting and trucking portion of the facility includes: the discharge tank, which collects fish discharged from the hopper; two 1,250-gallon holding tanks that sluice fish into Maine Marine Resources' stocking trucks; and a 250-gallon holding tank for Atlantic salmon. The discharge tank is also equipped with piping that can discharge fish back into the tailrace.

C. Existing Downstream Fish Passage

37. Currently, downstream passage at the Lockwood Project is accomplished by a surface sluice installed in the forebay canal. An angled 300-foot-long floating guide boom is installed seasonally and is operated from April 1 to June 15 and from November 1 to December 15. A 32-foot-long section of the floating boom supports a 10-foot-deep metal punch plate screen to guide downstream migrants to the surface sluice.[32] In addition to the guide boom and surface sluice, downstream passage is also provided through three orifices, each 3-feet long by 8-inches high, cut into the flashboards along the spillway. The orifices pass approximately 50 cfs, and provide downstream passage routes along the spillway even when the project is not spilling water over the top of the flashboards. In addition, river flows exceed the turbine capacity for much of the time period that downstream fish migrations occur, thus providing substantial fish passage capability over the spillway whenever water is spilling over the dam.

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[32] A metal punch plate screen is a metal sheet with holes that functions as a net but is more sturdy.

38. At the Shawmut Project, downstream fish passage is provided through a surface sluice located on the right-hand side of the intake structure next to Unit 6. With all three stoplogs removed, the sluice passes flows between 30 and 35 cfs. Flows from this sluice discharge over the face of the dam and drain into a 3-foot-deep plunge pool below the dam. In addition, there is a 7-foot-high, 10-foot-wide Taintor gate located next to this sluice that can pass 600 cfs. This gate is used to pass debris and excess flows, which also discharge over the face of the dam into a shallow plunge pool connected to the river.

39. Downstream fish passage at the Weston Project is provided by a 300-foot-long floating guidance boom with 10-foot-deep sections of 5/16-inch metal punch plate screens suspended from the boom. The boom leads to the log sluice gate, which in turn discharges by way of an existing concrete flume to a plunge pool below the dam. During the downstream migration period, the gate is opened to pass 6 percent of turbine unit flow to attract fish to the log sluice. The gate is opened for smolt and kelt passage[33] generally from April 1 through June 15 and between November 1 and December 31, if river and ice conditions allow. The gate is capable of discharging up to 2,250 cfs, which is approximately 38 percent of turbine unit flow.

D. Interim Plan for Atlantic Salmon

40. The Interim Plan identifies measures necessary to avoid and minimize the effects of operating the Lockwood, Shawmut, and Weston Projects on federally-listed Atlantic salmon. It covers a 7-year period, from 2013 through 2019, and contemplates that a final protection plan will be developed and filed for Commission approval in 2019 to cover the remaining period from 2020 to expiration of the project licenses in 2036.[34] The Interim Plan provides for installing new upstream fishways at the three projects and conducting upstream and downstream passage and survival studies for Atlantic salmon. These studies are to be conducted as part of an adaptive management strategy designed to achieve high passage and survival rates for Atlantic salmon through the Lockwood, Shawmut, and Weston Projects. As described in its annual reports of activities under the Interim Plan, Brookfield has implemented some parts of the plan, such as studies, that could be accomplished consistent with the existing license terms.

1. Upstream Passage of Atlantic Salmon

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[33] A smolt is a young salmon when it becomes covered with silvery scales and first migrates from fresh water to the sea. Kelts are salmon that have spawned. Kelts require downstream passage because Atlantic salmon can spawn more than once.

[34] Because the Shawmut Project license expires in 2021, the final plan would be considered in that project's relicensing proceeding.

41. Under the Interim Plan, Brookfield proposes to continue to operate the Lockwood Project fish lift during upstream migration periods for Atlantic salmon from about May 1 through October 31 and to increase the daily number of lifts from the current range of three to five lifts per day to the proposed range of five to eight lifts per day. The exact timing would continue to be determined in consultation with Maine Marine Resources. Brookfield proposes to: (1) trap and sort all fish species, including Atlantic salmon; (2) capture and hold Atlantic salmon for Maine Marine Resources to transfer them to sites or facilities as determined by the fishery management agencies; (3) undertake measures necessary to keep the fish lift in good operating condition; (4) if the fish lift breaks down during the migration period, repair and return it to service as soon as it can safely and reasonably be done; and (5) maintain records of all fish trapped or moved in the fish lift, and allow Maine Marine Resources to continue to collect data on the size, age, and condition of all Atlantic salmon captured in the fish lift.

42. Brookfield also proposes to design a volitional component to the upstream passage facility at Lockwood, and to install it in 2016 and begin operating it in 2017.[35] Although this component is not yet designed, Brookfield has indicated that it will involve a modification of the existing fishway.[36] Once the volitional component has been installed, Brookfield would conduct Atlantic salmon adult upstream passage effectiveness studies for up to three years. The licensee would: (1) continue to use underwater cameras in and around the fish lift to observe Atlantic salmon behavior and identify any issues with Atlantic salmon movement into the fish lift; (2) monitor areas of the tailrace that can be visually observed for the presence of holding Atlantic salmon and collect information on numbers and time periods, and monitor angler activity near the fish lift and collect available information on numbers of Atlantic salmon accidentally captured or observed; (3) monitor the bypass reach ledge area during flashboard replacement; (4) with Maine Marine Resources' assistance, collect adult Atlantic salmon for transfer to the Sandy River[37] or release back into the Kennebec; and (5) collaborate with Hydro Kennebec Project personnel to gather visual observation data on Atlantic salmon that may migrate to the Hydro Kennebec Project via the Lockwood spillway section.

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[35] The Interim Plan provides that this volitional component of the upstream fishway will be operational in 2016. As noted earlier, however, Brookfield requested a delay to allow time for the agencies to consider issues concerning passage of American shad.

[36] *See* Biological Opinion at 19 (filed July 22, 2013).

[37] The Sandy River is a tributary to the Kennebec River and enters the Kennebec several miles upstream of the Weston Project.

43. Under the Interim Plan, Brookfield would continue to use the existing Lockwood fish lift and trap and truck system to provide interim upstream passage for Atlantic salmon past the Shawmut and Weston Projects. The company would also design new upstream passage facilities at the Shawmut and Weston projects, in consultation with the fisheries agencies, incorporating the biological needs of Atlantic salmon, in 2016 and 2017, respectively. Brookfield anticipates starting construction of the upstream fish passage facilities in 2017 at the Shawmut Project and in 2019 at the Weston Project. These facilities would then be completed and operating at Shawmut and Weston, respectively, during the 2018 and 2020 upstream migration seasons.

2. **Downstream Passage of Atlantic Salmon**

44. For downstream passage, Brookfield proposes to expand operation of the downstream passage facilities at the Lockwood, Shawmut, and Weston Projects from April 1 to December 31 for use by adult and juvenile Atlantic salmon. The sluice gates at each project would be operated to maintain an interim flow of 6 percent of station unit flow through each of the gates during evening passage hours. As applicable at Lockwood and Weston, Brookfield would undertake measures necessary to keep the guidance booms in place and in good operating condition. If the guidance booms become dislodged or damaged, the company would repair or replace them as soon as the work could be safely and reasonably done.

45. Spill flows are an important aspect of downstream fish passage at the projects. Flows in excess of total turbine capacity would be spilled in accordance with the projects' high water guidelines and reservoir fluctuation limits, unless Brookfield determines in consultation with NMFS that additional spill is needed for downstream passage. At flows less than the projects' total hydraulic capacity, downstream passage would be provided through the sluice gates, unless Brookfield determines in consultation with NMFS that additional spill is needed.

3. **Atlantic Salmon Passage Studies**

46. Under the Interim Plan, Brookfield would study downstream smolt passage from 2013 to 2015 at the projects. The study at each project would use between 100 and 200 smolts each year obtained from the Great Lakes National Fish Hatchery. The company would use a paired release study design. Using radio-tagged smolts released upstream of each project and detections at the upstream side of each dam, radio telemetry would record tagged smolts' arrival and passage through the projects. Survival through each project's dam spillway, turbines, or downstream fishway would be determined by the number of smolts known to have arrived alive at each project minus the number of smolts detected alive downstream of the project. An overall survival rate for out-migrating smolts in the Kennebec River would be calculated as the product of each project's individual survival rate. To estimate mortality unrelated to dam passage and occurring within the downstream river reach of each project, a release of tagged smolts

would be conducted in each project's tailrace and compared to the smolts arriving at the next downstream project. An overall survival rate for out-migrating smolts in the Kennebec River would be calculated as the product of each project's individual survival rate. Brookfield would consult with NMFS, FWS, and Maine Marine Resources to develop a detailed study plan. In addition to the adult and smolt passage studies, Brookfield also proposes to conduct downstream passage studies of kelts for up to three years between 2015 and 2017 to determine the downstream survival of Atlantic salmon kelts.[38] The company would consult with NMFS to develop a detailed study plan for this effort as well.

4. Adaptive Management and Reporting

47. Adaptive management is an integral part of the Interim Plan. Measures included in the plan would be subject to revision after agency consultation and, if necessary, Commission approval. To that end, Brookfield would prepare an annual report, describing the previous year's activities under the Interim Plan and the company's progress on implementing the plan's measures. Brookfield would provide a draft report to the agencies by January 31 of each year and would then meet with the agencies to discuss the draft report, implementation of the Interim Plan, and any other issues related to Atlantic salmon restoration and management activities in the Kennebec River. Brookfield would file a final report with the resource agencies and the Commission by March 31 of each year.

E. Sturgeon Handling and Protection

48. Sturgeon are not present in the Kennebec River in the vicinity of the Shawmut and Weston projects, but are found downstream of the Lockwood Project. Sturgeon will not be passed upstream of Lockwood because the dam location is thought to be the historical upper limit of upstream migration for sturgeon on the Kennebec River and because of concerns about the safety of downstream passage for these fish.[39] To protect Atlantic and shortnose sturgeon downstream of the Lockwood Project, Brookfield proposes to implement its Sturgeon Handling and Protection Plan (Sturgeon Plan). The purpose of the plan is to protect sturgeon from effects associated with the operation and maintenance of the Lockwood Project and fish lift.

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[38] On February 7, 2014, the licensees amended the Interim Plan to postpose the downstream kelt passage studies to 2015 based on a shortage of available kelts.

[39] *See* Biological Opinion at 20.

49. For each sturgeon found in the fish lift, Brookfield would scan the fish for an existing tag and record river flow, bypassed reach minimum flow, and water temperature. Any live, uninjured sturgeon would be returned to the Kennebec River downstream of the project, and Brookfield would report this to NMFS within 24 hours. If any injured sturgeon are found, the licensee would measure, photograph if possible, and report them to NMFS within 24 hours. Brookfield would retain any severely injured fish until notified by NMFS of instructions for potential rehabilitation. Any dead sturgeon would be recovered and preserved in a freezer until after the licensee notifies NMFS and discusses disposal procedures.

50. The project's flashboards are replaced about once a year. Sturgeon may potentially be stranded in the pools below the dam whenever the flashboards are replaced. Sturgeon found in the pools would be removed by dip net or other appropriate equipment. Alive, injured, or dead sturgeon would be handled in generally the same manner as fish found in the fish lift, as discussed above.

F. Endangered Species Act Consultation

51. Section 7(a)(2) of the ESA requires federal agencies to ensure, in consultation with NMFS or FWS as appropriate, that their actions are not likely to jeopardize the continued existence of federally-listed threatened and endangered species, or destroy or adversely modify critical habitat established for those species. NMFS is the lead agency for Atlantic salmon protection under the ESA in Maine.

52. As noted, Commission staff consulted formally with NMFS on Brookfield's request to include the Interim Plan in the licenses for the Lockwood, Shawmut, and Weston Projects to protect Atlantic salmon, and to include the Sturgeon Plan in the license for the Lockwood Project to protect Atlantic and shortnose sturgeon. The Biological Opinion that NMFS filed with the Commission assumes that the measures provided in these two plans are part of the proposed action and that the Commission will require them in the licenses for these projects.[40]

53. The Biological Opinion includes an incidental take statement, which specifies the amount of incidental take of Atlantic salmon that can occur through 2019 as a result of project operations and the activities that will take place under the Interim Plan. The incidental take statement also specifies the amount of incidental take of Atlantic sturgeon and shortnose sturgeon that can occur at the Lockwood Project as a result of activities under the Sturgeon Plan. Unlike the Interim Plan, however, the Sturgeon Plan applies throughout the remainder of the license term.

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[40] Biological Opinion at 152.

54. The incidental take statement includes three reasonable and prudent measures (RPM) to avoid or minimize incidental take of the species, as well as terms and conditions to implement those measures. NMFS states that these terms and conditions are non-discretionary actions that the Commission must require in order to comply with the take prohibitions of section 9 of the ESA.[41] NMFS adds that these terms and conditions are in addition to the measures provided in the two protection plans.[42] The terms and conditions of the Biological Opinion are set out in Appendix A and are adopted as conditions of this order by ordering paragraph (C).

55. RPM 1 requires the Commission to ensure, through enforceable conditions of the project license, that the licensee conducts all in-water and near-water construction activities in a manner that minimizes incidental take of ESA-listed species or those proposed for listing and conserves the aquatic resources on which ESA-listed species depend. To implement RPM 1, the Biological Opinion lists 17 terms and conditions related to: (a) contractor education; (b) timing of construction; (c) erosion control and protection of water quality; (d) storage and staging of materials and construction equipment; and (e) riparian vegetation management.

56. Under RPM 2, the Commission must ensure, through enforceable conditions, that Brookfield measures and monitors the provisions contained in the Interim Plan in a way that adequately protects listed Atlantic salmon, shortnose sturgeon and Atlantic sturgeon. To implement RPM 2, the Biological Opinion includes 10 terms and conditions for the Lockwood, Shawmut, and Weston Projects. Under these conditions, Brookfield is required to: (a) prepare plans to study the passage and survival of migrating salmon; (b) not allow test fish to migrate upstream of the project until volitional fish passage is provided at all dams downstream of the Sandy River; (c) provide NMFS the opportunity to comment on any fishway design at various design phases; (d) allow NMFS to inspect the fishways at least annually; (e) inspect the fishways each day between April 1 and December 31; (f) conduct maintenance requiring shutdown of the upstream fishways during the first two weeks of August; and (g) develop project specific adaptive management plans to address any downstream passage deficiencies at the project, documented through site-specific survival studies during the period of the Interim Plan. Three of the ten terms and conditions are not applicable to the Lockwood, Shawmut, or Weston Projects because they pertain to operation of the Lewiston Falls Project No. 2302

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[41] Section 9 of the ESA prohibits any taking of listed species unless the take is authorized in an incidental take statement after formal consultation under ESA section 7, or in an incidental take permit issued under ESA section 10.

[42] Biological Opinion at 153.

or the Brunswick Project No. 2574. These terms and conditions are omitted from Appendix A.

57. Under RPM 3, the Commission must ensure, through enforceable conditions, that Brookfield completes an annual monitoring and reporting program to confirm that it is minimizing incidental take and is reporting to NMFS all project-related observations of dead or injured salmon or sturgeon. To implement RPM 3, the Commission must require the licensee to: (a) notify NMFS of any changes in operation, maintenance activities, and debris management; (b) contact NMFS within 24 hours of any interactions with Atlantic salmon or sturgeon, including any non-lethal and lethal takes; (c) in the event of lethal take, to photograph, measure, and preserve any dead salmon or body parts until after discussing disposal with NMFS; and (d) follow specific procedures when collecting fin clips of any sturgeon captured at the Lockwood Project.

58. NMFS also included four conservation recommendations in its Biological Opinion.[43] The first conservation recommendation provides guidance for contaminant testing of any salmon or sturgeon involved in lethal take at the projects. While Brookfield may choose to implement this recommendation, we will not require it, because there is no direct link between the recommendation and project operations or protection of salmon and sturgeon at the projects.

59. The remaining three recommendations address operation of all Commission-licensed hydroelectric projects in Maine that are within the range of federally-listed Atlantic salmon. First, NMFS recommends that the Commission use its authorities to implement license requirements for all of these projects to provide safe and effective upstream and downstream passage for listed Atlantic salmon and other diadromous species. NMFS notes that, for Atlantic salmon, this can be accomplished through station shutdowns during the smolt passage season (April to June) and kelt passage season (October to December and April to June) or by installing highly effective fishways. Second, NMFS recommends that the Commission require all licensed projects in Maine to document the effectiveness of station shutdowns or fishways in protecting listed species. Third, NMFS recommends that the Commission require all licensed projects in Maine to operate in a manner that protects listed species. NMFS notes that this can be accomplished by requiring these projects to operate in a run-of-river mode to simulate a natural stream hydrograph.

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[43] Conservation recommendations are discretionary agency activities intended to minimize or avoid effects to listed species or critical habitat, to help implement recovery plans, or to develop information.

60. These last three recommendations are not specific to the Lockwood, Shawmut, or Weston Projects and are therefore not included in these licenses. The Commission considers project-specific recommendations in its licensing and amendment proceedings, and must review and balance a range of public interest considerations, both developmental and environmental, in doing so. We are unable to adopt general recommendations for a broad class of projects.[44] The proposed amendments include provisions for upstream and downstream passage for Atlantic salmon and other species, monitoring and studies of their effectiveness, and measures to protect listed species. Nothing further is required in this case.

G. Comments and Objections Concerning the Interim Plan

61. As noted earlier, several members of the Kennebec Coalition request that the Commission defer action on the Interim Plan while their petition for judicial review of the Biological Opinion is pending.[45] We deny this request. Because NMFS has listed the Gulf of Maine DPS of Atlantic salmon as endangered and has designated critical habitat for the species, any taking of the species is prohibited unless authorized by an incidental take permit under ESA section 10 or an incidental take statement after formal consultation under ESA section 7. Brookfield prepared the Interim Plan in consultation with NMFS and requested these license amendments in order to obtain that authorization for any incidental harm that its projects may cause. If we were to delay our approval of the amendment pending judicial review, this would also delay the interim protection for Atlantic salmon and designated critical habitat that the Interim Plan and Biological Opinion are designed to provide.[46]

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[44] In addition, section 6 of the FPA, 16 U.S.C. § 798 (2012), limits the Commission's ability to unilaterally alter project licenses.

[45] *See* motion to intervene of Atlantic Salmon, Natural Resources, Trout Unlimited, and the Kennebec Valley Chapter of Trout Unlimited at 6 (filed September 28, 2015).

[46] In addition, it is unclear whether judicial review of the Biological Opinion is available now in federal district court, or must instead await review of this amendment order in the court of appeals. *See* 16 U.S.C. § 825*l*(b) (2012); *City of Tacoma, Washington v. FERC*, 460 F.3d 53, 76 (D.C. Cir. 2006) (observing that when a Biological Opinion is prepared in the course of a Commission proceeding, the only means of challenging its validity is on review of the Commission's decision in the court of appeals).

62. We encourage our licensees to take a proactive approach and consult informally with the Services to protect listed species if ongoing operation of their projects may affect the species or their critical habitat. We do so because ongoing operation of a licensed hydroelectric project is not considered federal agency action under the ESA, but rather is private action that does not trigger formal consultation.[47] If the licensee and the Service can agree on what actions are needed to protect listed species and their critical habitat, the licensee can then request a license amendment, thus providing the necessary federal agency action (approval of the amendment) to trigger formal ESA consultation. In this case, we consulted formally with NMFS on Brookfield's Interim Plan and are now in a position to approve the amendment and incorporate the terms and conditions of the incidental take statement in the Biological Opinion. If any changes to the plan are ultimately required as a result of the court review, we can consider them in a future amendment proceeding. We see no basis for doing nothing now, simply because of the possibility that some future action might be required.

63. In their comments and objections, intervenors raise three main concerns with the Interim Plan: that it is inadequate to protect and recover endangered Atlantic salmon, that it relies on fish passage facilities that are ineffective to pass American shad and other fish species, and that it violates the Kennebec Agreement. We address these arguments in turn.

64. The Kennebec Coalition,[48] several of its members (Atlantic Salmon, Natural Resources, and Trout Unlimited),[49] and Maine Rivers[50] contend that the projects harm Atlantic salmon and that the measures in the Interim Plan are inadequate to protect and restore these fish. The Coalition argues that the proposed upstream fishways at the Lockwood Project will not work to restore Atlantic salmon upstream of the project, because there has been no study of upstream passage efficiency, the Biological Opinion

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[47] *See California Sportfishing Protection Alliance v. FERC*, 472 F3d 593 (9th Cir. 2006).

[48] *See* Kennebec Coalition's Comments (filed July 9, 2013). This is the only filing on behalf of all five members of the Kennebec Coalition. Subsequent filings include three or four of the five. For convenience, we consider these comments together and refer to the Coalition in discussing them, while noting the subsequent filings of the various Coalition members.

[49] *See* comments of Atlantic Salmon, Natural Resources, and Trout Unlimited (filed July 17, 2014, January 7, 2015, and February 12, 2015, respectively).

[50] *See* Maine Rivers' comments (filed July 28, 2014).

does not explain why the estimated 40 percent passage efficiency will be adequate to restore Atlantic salmon, and there are no performance standards for upstream and downstream passage. The Coalition also maintains that the passage studies proposed in the Interim Plan rely on an unrealistically high estimate of the number of smolts available for the study and provide no estimate of the number of fish needed to draw statistically valid conclusions. Similarly, Maine Rivers contends that the Interim Plan provides no evidence that it will improve Atlantic salmon recovery. Maine Rivers is also concerned that investing millions of dollars on inefficient and non-functional fishways will make it difficult to correct these problems in the future.

65. As discussed above, Brookfield developed the Interim Plan in consultation with NMFS to provide interim measures to protect Atlantic salmon and avoid or minimize incidental take as a result of project operation. The plan includes adding a volitional component to upstream fish passage facilities, upstream and downstream passage studies, and adaptive management to revise these measures, as needed. Commission staff consulted formally with NMFS under section 7 of the ESA on the Interim Plan, and NMFS determined in its Biological Opinion that, if the plan is implemented, the projects may adversely affect but are not likely to jeopardize the continued existence of the Gulf of Maine DPS of Atlantic salmon. NMFS further concluded that the projects will continue to adversely affect essential features of designated critical habitat for the species over the interim period. However, NMFS concluded that the plan is anticipated to improve the functioning of migratory habitat by constructing three volitional upstream fishways, and by implementing an adaptive management strategy to improve downstream survival of Atlantic salmon smolts and kelts in the Kennebec River. NMFS therefore concurred in Commission staff's determination that the proposed action will not lead to adverse modification or destruction of critical habitat.

66. The Coalition faults the Biological Opinion for failing to set performance standards for upstream and downstream passage. However, this is an interim plan, and NMFS states that the passage and survival studies, together with adaptive management, will be used to make any needed changes to the study design, project structures, or project operation during the interim period, and to establish performance standards that will be incorporated in the final protection plan.[51]

67. The Interim Plan outlines a process by which Brookfield will study upstream and downstream Atlantic salmon passage at the projects. Under the Interim Plan, the license would study downstream smolt passage through telemetry to determine smolt passage

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[51] *See* Biological Opinion at 13.

routes, out-migration travel time and movement rates through the Lockwood, Shawmut, and Weston Projects and determine project-related mortality of downstream migrating smolts for the three projects.

68. For upstream passage of adult salmon under the Interim Plan, the licensee would continue to use an underwater camera to monitor salmon behavior in and around the fish lift, as well as angler activity, and would conduct upstream passage effectiveness studies by telemetry.

69. The purpose of the Interim Plan is to develop studies designed to address many of the concerns expressed by the Coalition and Maine Marine Resources, such as determining the adequacy of any zone of passage leading to the fish lift entrance, and passage efficiency and effectiveness. Through the knowledge gained by these studies, Brookfield, after consulting with NMFS and other resource agencies, should be able to design, construct and operate efficient and effective passage for Atlantic salmon that can be included in the final species protection plan for these projects.

70. NMFS is the expert agency charged with implementing the ESA for these fish, and is therefore in the best position to make discretionary factual determinations about what measures might be needed to protect them. Although the Commission is ultimately responsible for ensuring, in consultation with NMFS, that its actions are in compliance with the ESA, the Commission is entitled to defer to that agency's expertise, and need not undertake a separate, independent analysis of the issues addressed in a Biological Opinion.[52] In any event, based on our review and adoption of Brookfield's draft Biological Assessment in this case, we have no basis for concluding that the Interim Plan is inadequate to protect Atlantic salmon.

71. The Coalition and Maine Marine Resources contend that the Interim Plan will undermine the Kennebec Agreement because it applies only to Atlantic salmon rather than shad, blueback herring, and alewife. Maine Marine Resources[53] further maintains that the plan will thwart or indefinitely delay the agency's efforts to restore shad, alewife, and blueback herring to the Kennebec River upstream of the Lockwood Project. Maine Marine Resources contends that the Lockwood fish lift is ineffective at passing shad upstream and the Interim Plan does not address the failure of the fish lift to attract shad to the fish lift's entrance. Maine Marine Resources is also concerned that under the Interim

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[52] *See City of Tacoma, Washington v. FERC*, 460 F.3d at 75-76.

[53] *See* Maine Marine Resources' Motion to Intervene (filed May 2, 2015).

Plan, permanent downstream passage for species other than Atlantic salmon would not be quantitatively tested to ensure safe, efficient, and effective passage of other fish species. Mr. Watts expresses similar concerns, and provides information for the record on shad passage at other dams in Maine as compared to Lockwood.

72. As Brookfield has acknowledged, since 2006 when the Lockwood fish lift began operating, it has captured very few American shad despite an apparently increasing shad population in the Kennebec River below the project.[54] Beginning in February 2014, Brookfield began consulting with Maine Marine Resources, NMFS, FWS, and Atlantic Salmon to identify studies and operational measures to improve shad passage at the project.[55] In 2014, Brookfield operated the fish lift with the maximum attraction flow of 170 cfs, made underwater video observations of shad in the tailrace, and collected addition bathymetric data of the tailrace. In 2015, the licensee again operated the fish lift with a maximum attraction flow of 170 cfs and made underwater video observations in the tailrace. Brookfield also agreed to use underwater acoustics to survey for project-related sounds that may negatively affect shad use of the lift, to develop a 2-dimensional hydraulic model of the tailrace and spillway area, and to conduct a telemetry study of shad behavior in the project tailrace and spillway area to determine if any operational changes may improve fish passage at the project. Maine Marine Resources reports that, as of September 2015, only the telemetry study had been completed and that despite these efforts, interim upstream passage of shad continues to be ineffective.[56]

73. The Kennebec Agreement provides that, if by December 2014 the biological triggers for permanent upstream passage facilities have not been met (i.e., the earlier of either 8,000 American shad captured in a single season at the Lockwood interim fish trap, or a different biological assessment trigger is developed for Atlantic salmon, alewife, or blueback herring), parties to the agreement will meet to assess progress and attempt to reach consensus on future fish passage measures. To date, neither condition has been met; that is, very few shad have been captured at Lockwood each year, and an alternative biological trigger has not been developed. Therefore, Brookfield and the other parties began consulting as contemplated in the agreement. This effort is separate from Brookfield's development of the Interim Plan, which deals exclusively with endangered Atlantic salmon as a result of the expanded geographic range for the Gulf of Maine DPS of Atlantic salmon.

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[54] *See* Brookfield's request for a one-year delay in the schedule for providing volitional passage at the Lockwood Project at 1 (filed February 13, 2015).

[55] *See* Maine Marine Resources' Comments at 1 (filed September 25, 2015).

[56] *Id*. at 1-2.

74. As NMFS points out,[57] the Interim Plan did not cause the lack of fish passage improvements at the projects and would not preclude Maine Marine Resources from seeking fish passage improvements at any hydro projects on the Kennebec River, including those which are part of the Interim Plan. We see no reason why the parties cannot continue to consult under the Kennebec Agreement on ways to improve fish passage at the projects for American shad, alewife, and blueback herring while improvements and studies are underway to protect endangered Atlantic salmon. Therefore, we conclude that the Interim Plan and the Kennebec Agreement are not in conflict. More importantly, however, Atlantic salmon are listed as endangered, and the other fish species addressed in the Kennebec Agreement are not. As a result, the Commission must give priority to protection of Atlantic salmon in the event of any conflict, whether actual or perceived, with the Kennebec Agreement.

75. Mr. Watts[58] states that, to achieve the long-term fish passage and recovery goals of the Kennebec Agreement, the Lockwood Project Dam must be breached. He argues that the recent approval of 185 MW of wind generation to be sited near the Kennebec River in Bingham, Maine and adjacent towns makes the 5-MW capacity of the Lockwood Project inconsequential, while the project's negative effects on fish restoration are severe. Mr. Watts states that the licensee has had over 17 years to develop efficient adult shad passage at the project, and failure of shad passage at Lockwood would ensure passage failure at the upstream projects. He maintains that the low numbers of shad, alewife, and blueback herring passed upstream at the project are a fraction of the number he estimates to be in the spillway area and attempting to move upstream. Mr. Watts also states that he observed a sturgeon attempting to ascend the Kennebec River in the spillway area. He believes that, if not for the presence of the dam, sturgeon would have continued to ascend the Kennebec River upstream of the Lockwood Project, and that the geographic range for both ESA-listed sturgeon species must be extended.[59] In summary, Mr. Watts contends

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[57] *See* NMFS Comments at 2 (filed June 18, 2014).

[58] *See* comments of Douglas Watts at 3 (filed September 29, 2015).

[59] Mr. Watts also contends that before construction of dams on the Kennebec, sturgeon historically migrated farther upstream than the location of the Lockwood Project, which NMFS recognized in its Biological Opinion as the historic upper migration limit for sturgeon. In support, Mr. Watts cites the results of an archaeological excavation of a food cache some 35 miles upstream of the Lockwood Project that included one sturgeon bone. *Id*. at 7-8. Lacking any information about how the bone ended up in this food cache, we find this information insufficient to support a conclusion that sturgeon historically migrated past the location of the Lockwood Project.

that the fish lift's poor history of passing Atlantic salmon, shad, blueback herring and alewife makes the Lockwood Project a public nuisance that must be removed.

76. These comments are beyond the scope of this amendment proceeding. Moreover, they are insufficient to suggest a need to initiate a proceeding to reopen and amend the license for the Lockwood Project to consider possible dam breach or removal. The Commission can consider whether to reopen and amend a license if a project has unanticipated, serious impacts on fishery resources.[60] In this case, the project's effects on fishery resources are both anticipated and addressed in the Kennebec Agreement, which provides that if the triggering condition for permanent upstream fish passage is not met by December 2014, the parties will consult and attempt to reach a consensus on future fish passage measures. As noted, Brookfield began this consultation in January 2015. Any additional studies or fish passage measures that may be needed can be considered as part of that consultation. In these circumstances, we believe it is appropriate to allow the Kennebec Agreement process to proceed.

77. Apart from Mr. Watt's arguments concerning sturgeon migration and the possible need for dam breach or removal, no party commented on Brookfield's Sturgeon Plan. We find that the Sturgeon Plan provides appropriate protection for Atlantic and shortnose sturgeon, and there is no need to provide upstream passage for those species. To the contrary, NMFS provides in its Biological Opinion that if sturgeon are found in the fish lift, they are to be returned unharmed to the river downstream of the Lockwood Project.

Conclusion

78. For the above reasons, we conclude that Brookfield's Interim Plan will help improve conditions for Atlantic salmon and will avoid or minimize incidental take of Atlantic salmon at the Lockwood, Shawmut, and Weston Projects. The licensee began implementing the Interim Plan in 2013 in consultation with NMFS and other resource agencies. Work under the Interim Plan involves designing and building upstream fish passage facilities, planning upstream passage effectiveness studies, and conducting studies of existing downstream passage facilities. The Interim Plan would also help to ensure compliance with the ESA. We therefore approve the Interim Plan and amend the licenses for those projects to require Brookfield to implement the plan.

79. We also conclude that Brookfield's Sturgeon Plan will provide adequate protection for Atlantic and shortnose sturgeon that may be affected by operation of the Lockwood fish lift and replacement of the project's flashboards. We therefore approve

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[60] *See Hoopa Valley Tribe v. FERC*, 629 F.3d 209 (D.C. Cir. 2010).

the Sturgeon Plan and amend the license for the Lockwood Project to require the licensee to implement it.

80. The licensee must follow the terms and conditions of the incidental take statement included with NMFS's July 22, 2013 Biological Opinion that apply to the Lockwood, Shawmut, or Weston Projects and the supplemental term and condition filed September 3, 2013, to ensure exemption from the take prohibitions of Section 9 of the ESA. Therefore, these terms and conditions are attached to this order as Appendix A, and are incorporated in the project licenses by ordering paragraph (C).

81. Under the Interim Plan and the terms and conditions of NMFS's incidental take statement, the licensee will design and install upstream fish passage facilities at the projects. The Commission must review and approve final plans and schedules related to this work to ensure that they are consistent with Commission regulations. Therefore, the final plans and schedule for upstream fish passage facilities must be filed for Commission approval, prior to the start of construction, as provided in ordering paragraph (D).

The Commission orders:

(A) The Interim Species Protection Plan (Interim Plan) filed on February 21, 2013, by Brookfield White Pine Hydro LLC (Brookfield), on behalf of itself as licensee for the Shawmut Hydroelectric Project No. 2322 and the Weston Hydroelectric Project No. 2325, and on behalf of Merimil Limited Partnership, licensee for the Lockwood Hydroelectric Project No. 2574, is approved. The licensee must implement the Interim Plan at the Lockwood, Shawmut, and Weston Projects.

(B) The Sturgeon Handling and Protection Plan (Sturgeon Plan) filed on March 29, 2013, by Brookfield on behalf of Merimil Limited Partnership, licensee for the Lockwood Hydroelectric Project No. 2574, is approved. The licensee must implement the Sturgeon Plan at the Lockwood Project.

(C) The terms and conditions of the incidental take statement included with the National Marine Fisheries Service's July 22, 2013 Biological Opinion are hereby incorporated in the licenses for the Lockwood, Shawmut, and Weston Projects. The terms and conditions are attached to this order as Appendix A.

(D) Prior to the start of construction, the licensee must file, for Commission approval, final plans and a schedule for construction of upstream fish passage facilities at the Lockwood, Shawmut, and Weston Projects. The plans and schedule shall be accompanied by evidence that the National Marine Fisheries Service has approved them. The filing shall include copies of comments and recommendations from the U.S. Fish and Wildlife Service, Maine Department of Marine Resources, and the Maine Department of Inland Fisheries and Wildlife, or evidence that these agencies were given at least 30 days to provide comments and chose not to do so. If the licensee does not adopt an agency recommendation, the plan should include the licensee's reasons, based on site-specific information.

(E) The licensee must file, for Commission approval, plans for Atlantic salmon adult upstream passage effectiveness monitoring studies, Atlantic salmon kelt downstream passage monitoring studies, and any remaining Atlantic salmon smolt downstream passage studies for 2016 through 2019. The Commission must approve the study plans before the studies begin. The study plans must be accompanied by evidence that the National Marine Fisheries Service has approved them, and copies of comments and recommendations from the U.S. Fish and Wildlife Service, Maine Department of Marine Resources, and the Maine Department of Inland Fisheries and Wildlife, or evidence that these agencies were given at least 30 days to provide comments and chose not to do so. If the licensee does not adopt any agency recommendations, the plans should include the licensee's reasons, based on site-specific information.

(F) The licensee must file any remaining annual reports described in the Interim Species Protection Plan (Interim Plan) by March 31 of each year for activities completed during the preceding calendar year, beginning on March 31, 2017, for calendar year 2016. Each annual report must include, at minimum: (1) results of fish passage studies, and a summary of progress on the elements described in the Interim Plan; (2) a summary of consultation and other correspondence with the National Marine Fisheries Service (NMFS) and other resource agencies regarding progress on the elements in the Interim Plan, as well as any other pertinent issues regarding Atlantic salmon; (3) anticipated schedules associated with the elements in the Interim Plan; and (4) descriptions of any issues that arise that may affect the timely completion of the elements in the Interim Plan, and how the issues are being addressed in consultation with NMFS, the U.S. Fish and Wildlife Service (FWS), Maine Department of Marine Resources (Maine DMR), and the Maine Department of Inland Fisheries and Wildlife (Maine DIFW). The annual reports should also describe any plans and schedules discussed with NMFS regarding revisions to the Interim Plan and preparation of a Final Species Protection Plan. Copies of the annual reports should be provided to NMFS, FWS, Maine DMR, and Maine DIFW at the same time they are filed with the Commission.

(G) The licensee must inform Commission staff, via telephone or email, as soon as possible after contacting the National Marine Fisheries Service (NMFS) regarding any issue pursuant to the terms and conditions of the incidental take statement included with the NMFS July 22, 2013 Biological Opinion. The licensee must then file a written report on the issue with the Commission within 15 days of the issue.

(H) Article 406 of the license for the Lockwood Hydroelectric Project No. 2574 is amended by adding Atlantic sturgeon to the Shortnose Sturgeon Handling and

Protection Plan; referencing the terms and conditions of the incidental take statement filed by the National Marine Fisheries Service (NMFS) on July 22, 2013, and the supplement filed by NMFS on September 3, 2013; and omitting the requirement to file annual revisions to the sturgeon handling plan; to read as follows:

> Article 406. Sturgeon Handling and Protection Plan. Pursuant to the terms and conditions of the incidental take statement filed by the National Marine Fisheries Service (NMF) on January 1, 2005, the incidental take statement filed by NMFS on July 22, 2013, and the supplement filed by NMFS on September 3, 2013, the licensee must implement the Sturgeon Handling and Protection Plan for the Lockwood Project. Within 24 hours of any interactions with shortnose or Atlantic sturgeon (lethal and non-lethal), the licensee must notify NMFS by email or phone, complete the Sturgeon Reporting Sheet for the Lockwood Project, and mail and fax the completed form to the attention of the NMFS Endangered Species Coordinator.
>
> The Commission reserves the right to require changes to the plan. Any updates to the plan that would result in long-term changes to project operations or facilities may not be implemented without prior Commission authorization granted after the filing of an application to amend this license.

(I) The licensee shall file with the Commission, by March 31st of each year, an annual report of the licensee's actions undertaken in the previous calendar year to implement the project's Sturgeon Handling and Protection Plan. Copies of the annual reports must be provided to NMFS, the U.S. Fish and Wildlife Service, Maine Department of Marine Resources, and Maine Department of Inland Fisheries and Wildlife at the same time they are filed with the Commission.

(J) This order constitutes final agency action. Any party may file a request for rehearing of this order within 30 days from the date of its issuance, as provided in section 313(a) of the Federal Power Act, 16 U.S.C. § 825*l* (2012), and the Commission's regulations at 18 C.F.R. § 385.713 (2015). The filing of a request for rehearing does not operate as a stay of the effective date of this order, or of any other date specified in this order. The licensee's failure to file a request for rehearing shall constitute acceptance of this order.

By the Commission.

(S E A L)

Nathaniel J. Davis, Sr.,
Deputy Secretary.

APPENDIX A

DEPARTMENT OF COMMERCE
NATIONAL MARINE FISHERIES SERVICE

REASONABLE AND PRUDENT MEASURES AND TERMS AND CONDITIONS OF THE INCIDENTAL TAKE STATEMENT INCLUDED IN THE BIOLOGICAL OPINION FOR THE LOCKWOOD HYDROELECTRIC PROJECT NO. 2574, SHAWMUT HYDROELECTRIC PROJECT NO. 2322, AND WESTON HYDROELECTRIC PROJECT NO. 2325

Filed July 22, 2013, and supplemented September 3, 2013

Reasonable and Prudent Measures

1. FERC and the ACOE [Army Corps of Engineers] must ensure, through enforceable conditions of the Project licenses, that the licensee conduct all in-water and near-water construction activities in a manner that minimizes incidental take of ESA-listed or proposed species and conserves the aquatic resources on which ESA-listed species depend.

2. FERC must ensure, through enforceable conditions of the Project licenses, that the licensee measure and monitor the provisions contained in the March 14, 2013 Interim Species Protection Plan (SPP) in a way that is adequately protective of listed Atlantic salmon.

3. FERC must ensure, through enforceable conditions of the Project licenses, that the licensee complete an annual monitoring and reporting program to confirm that they are minimizing incidental take and reporting all project-related observations of dead or injured salmon or sturgeon to NMFS.

Terms and Conditions

1. To implement reasonable and prudent measure #1, FERC and ACOE must require the licensee to do the following:

    a. Hold a pre-construction meeting with the contractor(s) to review all procedures and requirements for avoiding and minimizing impacts to

Atlantic salmon and to emphasize the importance of these measures for protecting salmon.

b. Timing of in-water work: Work below the bankfull elevation should occur outside of the smolt outmigration period (April 1 to June 15) or within a dewatered cofferdam. The licensee must notify NMFS one week before in-water work begins.

c. Use Best Management Practices that will minimize concrete products (dust, chips, larger chunks) mobilized by construction activities from entering flowing or standing waters. Best practicable efforts shall be made to collect and remove all concrete products prior to rewatering of construction areas.

d. Employ erosion control and sediment containment devices at the Lockwood, Shawmut, and Weston Dams during in-water construction activities. During construction, all erosion control and sediment containment devices shall be inspected weekly, at a minimum, to ensure that they are working adequately. Any erosion control or sediment containment inadequacies will be immediately addressed until the disturbance is minimized.

e. Provide erosion control and sediment containment materials (e.g., silt fence, straw bales, aggregate) in excess of those installed, so they are readily available on site for immediate use during emergency erosion control needs.

f. Ensure that vehicles operated within 150 feet (46 m) of the construction site waterways will be free of fluid leaks. Daily examination of vehicles for fluid leaks is required during periods operated within or above the waterway.

g. During construction activities, ensure that BMPs are implemented to prevent pollutants of any kind (sewage, waste spoils, petroleum products, etc.) from contacting water bodies or their substrate.

h. In any areas used for staging, access roads, or storage, be prepared to evacuate all materials, equipment, and fuel if flooding of the area is expected to occur within 24 hours.

i. Perform vehicle maintenance, refueling of vehicles, and storage of fuel at least 150 feet (46 m) from the waterway, provided, however, that cranes and other semi-mobile equipment may be refueled in place.

j. At the end of each work shift, vehicles will not be stored within, or over, the waterway.

k. Prior to operating within the waterway, all equipment will be cleaned of external oil, grease, dirt, or caked mud. Any washing of equipment shall be conducted in a location that shall not contribute untreated wastewater to any flowing stream or drainage area.

l. Use temporary erosion and sediment controls on all exposed slopes during any hiatus in work exceeding seven days.

m. Place material removed during excavation only in locations where it cannot enter sensitive aquatic resources.

n. Minimize alteration or disturbance of the streambanks and existing riparian vegetation to the greatest extent possible.

o. Remove undesired vegetation and root nodes by mechanical means only. No herbicide application shall occur.

p. Mark and identify clearing limits. Construction activity or movement of equipment into existing vegetated areas shall not begin until clearing limits are marked.

q. Retain all existing vegetation within 150 feet (46 m) of the edge of the bank to the greatest extent practicable.

2. To implement reasonable and prudent measure #2, FERC must require the licensee to do the following:

   a. Prepare in consultation with NMFS a plan to study the passage and survival of migrating Atlantic salmon (adults, smolts, and kelts) at the Lockwood, Shawmut, and Weston Projects [reference to the Brunswick Project omitted].

b. Upstream passage studies at the Lockwood Project should not allow test fish to migrate upstream of the Project until such time as there is volitional passage all the way to the Sandy River.

c. [omitted]

d. [omitted]

e. [omitted]

f. The licensee should seek comments from NMFS on any fish passage design plans at the 30%, 60%, and 90% design phase.

g. The licensee should allow NMFS staff to inspect fishways at the Projects at least annually.

h. The licensee should inspect the upstream and downstream fish passage facilities at the Lockwood, Shawmut, and Weston Projects daily during from April 1 to December 31, annually [reference to the Brunswick Project omitted]. Submit summary reports to NMFS weekly during the fish passage season.

i. Annual maintenance requiring the shutdown 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. If water temperatures make it unsafe to sample Atlantic salmon, they should be allowed to volitionally swim through the fishway without being handled.

3. Require that the licensee develop, in consultation with NMFS, project specific adaptive management plans to address any downstream passage deficiencies at the Weston, Shawmut, and Lockwood Projects [reference to the Brunswick Project omitted] as documented through site-specific survival studies during the period of the ISPP. The plans should include descriptions of: 1. potential measures to be implemented at each project to improve survival, 2. the statistical methodology that will be used to interpret study results, and 3. the monitoring studies that will be used to verify the efficacy of the permanent downstream fish passage facilities. These plans should be completed no later than January 1, 2014. To implement reasonable and prudent measure #3, FERC must require the licensee to do the following:

a. Notify NMFS of any changes in operation including maintenance activities and debris management at the project during the term of the ISPP.

b. Contact NMFS within 24 hours of any interactions with Atlantic salmon, shortnose sturgeon or Atlantic sturgeon including non-lethal and lethal takes (Dan Tierney: by email (Dan.Tierney@noaa.gov) or phone (207) 866- 3755 and the Section 7 Coordinator (incidental.take@noaa.gov).

c. 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.

d. Ensure that fin clips are taken from any sturgeon at the Lockwood Project and that the fin clips are submitted to the NOAA repository in Charleston, SC for genetic analysis [reference to the Brunswick Project omitted]. A 1 cm2 fin clip from one of the pelvic fins from living sturgeon should be taken and placed in a labeled vial with an o-ring caps containing 95% nondenatured ethyl alcohol (EtOH) for genetic analysis (the pelvic fin is regarded at the least intrusive, particularly for small individuals) (following the procedures described in Damon-Randall et al. 2010). Fin clips of mortalities must be taken prior to preservation of other fish parts or whole bodies.

Document Content(s)