NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT
BIOLOGICAL OPINION

Agency: Federal Energy Regulatory Commission (FERC)

Activity Considered: Proposed amendment of the license for the Worumbo Project (P-3428)
F/NER/2016/13814
GARFO-2016-00327

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

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1. INTRODUCTION AND BACKGROUND

This constitutes the biological opinion (Opinion) of NOAA's National Marine Fisheries Service (NMFS) issued under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531-1543) concerning the effects of the Federal Energy Regulatory Commission's (FERC) approval of an application to amend the operating license for the incorporation of provisions described in a proposed species protection plan (SPP) to cover the period between 2017 and the issuance of a new license expected in 2025. The Worumbo Project is an existing hydroelectric project located on the Androscoggin River in Maine.

By letter filed with FERC on July 6, 2016, Brown Bear II Hydro. Inc. requested that FERC amend the license for the Worumbo Project to incorporate the provisions of a nine-year SPP for Atlantic salmon (2017-2025). On October 14, 2016, FERC submitted a Biological Assessment to NMFS seeking our biological opinion on the proposed license amendment. This Opinion only considers the effects of the Project on salmon for the duration of this period, as the license expires on December 1, 2025. Issuance of a new license is a separate Federal action that will require a new consultation and issuance of a new Opinion. Therefore, the take exemption included in the Incidental Take Statement included with this Opinion is only in effect for the period in which the facility would be operated in accordance with the SPP. In a letter dated March 24, 2016, FERC designated the licensee as their non-federal representative to conduct informal ESA consultation with us. It is our expectation that upon receipt of this Opinion, FERC will issue a license amendment, which incorporates the measures contained in the SPP.

This Opinion is based on information provided in FERC's October 14, 2016 Biological Assessment and SPP, as well as Brown Bear's study reports from 2013 through 2015. A complete administrative record of this consultation will be maintained at our Maine Field Office in Orono, Maine. Formal consultation was initiated on October 14, 2016.

1.1. Consultation History

- **October 18, 2012** – We issued a Biological Opinion on Miller Hydro Group's[1] interim SPP that expired at the end of 2016, as well as on an emergency spillway repair that occurred prior to consultation.

- **May 31, 2013** – FERC issued an order approving the interim SPP and associated study plans for Atlantic salmon.

- **March 24, 2016** – FERC designated Brown Bear to act as its non-federal representative in conducting informal consultation under section 7 of the ESA regarding federally listed Atlantic salmon at the Worumbo Project.

- **April 22, 2016** – Brown Bear submitted their draft SPP and BA to the state and federal agencies for review and comment.

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1 Miller Hydro Group was the previous licensee of the Project. FERC issued an order amending the license on April 28, 2015 to change the name of the licensee to Brown Bear II Hydro. Inc.

- **May 17, 2016** – We met with Brown Bear and the Maine Department of Marine Resources (DMR) to discuss the draft SPP and BA.

- **May 26, 2016** – We submitted comments to Brown Bear on the draft SPP and BA.

- **July 6, 2016** – Brown Bear filed their draft BA and SPP with FERC.

- **July 26, 2016** – We had a conference call with Brown Bear to discuss aspects (e.g. performance standard, study schedule) of the final SPP.

- **October 14, 2016** – FERC adopted the BA and requested formal section 7 consultation with us for the proposal to amend the current project license to incorporate the provisions of the SPP.

- **October 26, 2016** – We met with Brown Bear staff to clarify aspects of the SPP , including the study schedule and the measurement of the performance standard.

- **February 1, 2017** -- We submitted a letter to FERC indicating that all of the information required to initiate a formal consultation for the project had been received. In this letter, we noted that the date that Brown Bear met with NMFS to discuss the final SPP (October 26, 2016) will serve as the commencement of the formal consultation process. We requested, and FERC agreed to, a two-week extension on the submittal of this Opinion.

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 October 14, 2016 initiation letter and attached BA and SPP in support of formal consultation under the ESA; 2) annual reports filed with FERC by Brown Bear during the ISPP period; 3) the 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) Draft Recovery Plan for Atlantic salmon (March, 2016)

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 Worumbo Project was constructed prior to the listing of any endangered species under our jurisdiction and is currently licensed by FERC to operate until November 30, 2025. While the ESA provides broad authority to protect threatened and endangered species in the U.S., we must consider the action at hand in the context of a section 7 consultation. In this matter, the proposed action triggering the section 7 consultation involves the proposed amendment of an existing FERC license to incorporate specific measures to protect endangered Atlantic salmon at the hydroelectric dam. The proposed action is not the issuance of a new license by FERC to operate the dam, as the dam is already licensed to operate. It is, therefore, necessary to draw a distinction in our analysis between certain ongoing effects of the dam that are part of the environmental baseline versus effects of the proposed action. For instance, some effects of the dam are associated with the lawful existence of a physical structure in the river. As FERC does not have discretionary authority to decommission or remove the dam outside of a relicensing proceeding (60 FR 339 1995), some effects (e.g. the existing impoundment, sediment loading, water quality) must be considered as part of the environmental baseline. Therefore, the effects associated with the proposed amendment to alter aspects of the dam and the facility's operation to protect Atlantic salmon (e.g. passage effectiveness, passage survival, migratory delay) and the implementation of studies (e.g. handling, tagging) are considered effects of the proposed action.

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 physical and biological features of that critical habitat. As defined by NMFS and USFWS, destruction or adverse modification "means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species.

Such alterations may include, but are not limited to, those that alter the physical and biological features essential to the conservation of a species or that preclude or significantly delay development of such features." (81 FR 7214; Feb.11, 2016).

2. PROJECT DESCRIPTION AND PROPOSED ACTION

2.1. Project Facilities and Operation

FERC is proposing to amend the license held by Brown Bear for the Worumbo Project to incorporate provisions of an SPP for Atlantic salmon. The amended license will require Brown Bear to: (1) operate upstream and downstream fishways for the safe, timely, and effective passage of diadromous fish; (2) operate a floodgate in years when Atlantic salmon smolts are expected to be outmigrating in order to provide an additional passage route; (3) conduct a study to test smolt survival at the Project; (4) conduct mapping of Atlantic salmon habitat within the Little River; (5) conduct an upstream passage study should sufficient numbers of adults become available; and, (6) operate the facility to comply with a downstream survival standard for smolts. The license amendment will be effective for the remaining term of the existing operating license (2017-December 1, 2025). This Opinion will no longer be valid when the existing license expires; therefore, the section 7 consultation will need to be reinitiated by FERC to consider the effects of operating the project through the term of the new license.

The Worumbo Hydroelectric Project (FERC No. 3428) is located at the historic head of the Ten Mile Falls on the Androscoggin River at Lisbon Falls, Maine. The Project is owned and operated by Brown Bear. Historically, the dam was associated with the Worumbo woolen mill, which was constructed in 1864. The mill burned down in 1987, and soon after, the dam was developed for hydropower production. The Project went online in February 1989, with a nameplate capacity of approximately 18 megawatts (MW). In 1999, the FERC license was amended to increase the Project gross head from 28.0 feet to 29.5 feet with the addition of mechanical and pneumatic flashboards. The increase in head increased the nameplate capacity rating to the current 19.4 MW capacity.

The Worumbo Project consists of three concrete gravity dam sections, a gated spillway, a two unit powerhouse, a non-overflow abutment, upstream and downstream fish passage facilities, and a flood wall connecting the powerhouse to Mill Island (Figure 1). The series of overflow dam sections and gated spillway section extend across the Androscoggin River from the Durham river bank on the south side of the river, to a powerhouse on Mill Island in Lisbon Falls on the north side of the river. At the Durham river bank, the first dam section consists of an approximate 350-foot long concrete spillway equipped with a pneumatic flashboard system. This section of the pneumatic system comprises 17 panels 2.17 feet high, 8 panels 1.75 feet high, and a mechanically adjustable eel weir built into the second panel away from the Durham bank (Figure 2).

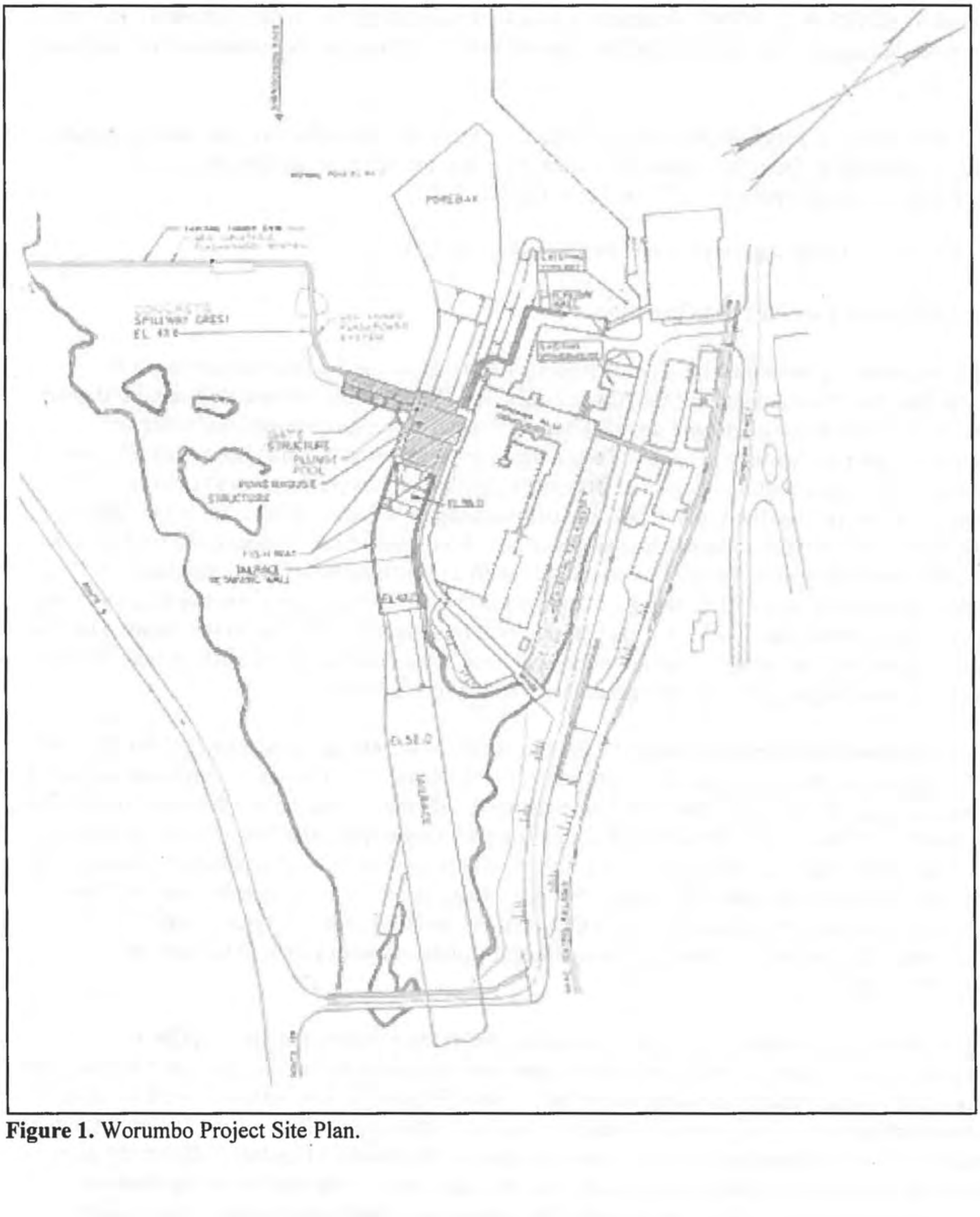


Figure 1. Worumbo Project Site Plan.

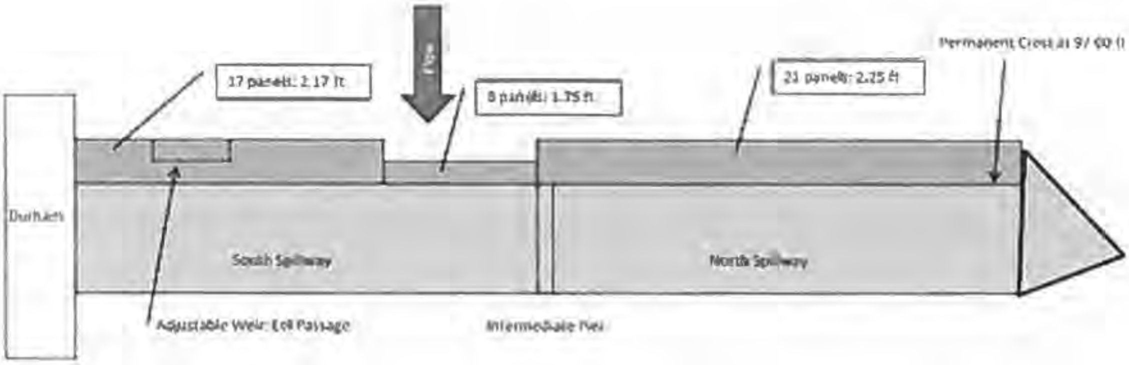


Figure 2. Panel height overview of the Worumbo Dam.

The first dam section joins the next dam section, which is about 170 feet long and consists of a concrete spillway and a pneumatic flashboard system with 21 panels 2.25 feet high (Figure 2). The new dam and spillway construction was completed in January 2012. Next is a 139-foot long concrete gravity section with a square crest profile and a mechanical hinged flashboard system. This is followed by a 94-foot long concrete gravity section with an ogee crest profile and a hinged flashboard system. The next section consists of a 92-foot long, gated spillway section that extends to the powerhouse.

The gated spillway contains four 23-foot-high by 19.25-foot-wide vertical slide gates, which are operated by an overhead gantry crane for flood control purposes. The two-unit powerhouse is located adjacent to the gated spillway section. Spillway capacity is provided by the overflow spillway dam sections and gated spillway section. The overflow spillway is comprised of the dam sections extending from the Durham side of the Androscoggin River to the gated spillway section near the powerhouse. The top of the hinged flashboard systems are at elevation 99.0 feet and are operated on a non-overflow basis under normal operating conditions. These flashboards will fail when overtopped under high flow conditions. Overtopping flow will continue thereafter until river flows recede to a point that the flashboards can be manually reset, and normal operating conditions can resume. The 2.25-foot pneumatic flashboards atop the center river concrete spillway operate in a manner similar to the hinged flashboards. The height and angles of the panels can be manipulated to provide these alternative flow patterns with the licensed bypass flow and while maintaining the pond elevation as a function of flow as defined by the Project's FERC license.

The powerhouse is a reinforced concrete structure constructed in 1989 and measures 105 feet wide by 150 feet long. Trash racks (5 inch clear spacing) cover the entire depth of the intakes, approximately 40 feet (elevation 41.75 to 82.2 feet). The concrete intake structure is integral with the powerhouse structure and contains two vertical slide gates operated by the same gantry crane that operates the spillway gates. The vertical slide gates are normally open and are only closed for equipment maintenance. A hydraulic trash rake is located on the intake deck. In addition to the two steel vertical slide gates that service the intake, a separate set of steel vertical slide gates service the draft tubes of the powerhouse for maintenance purposes. The powerhouse has two horizontal axis, low speed, four-bladed bulb turbine generators. The turbine generators have a nameplate capacity of 9.7 MW each and a maximum hydraulic capacity of approximately

4,800 cubic feet per second (cfs) each. The turbines are full Kaplans[2] with a runner diameter of 4.25 meters and a low rotational speed of 120 revolutions per minute (rpm).

The Project is equipped with upstream and downstream fish passage facilities for anadromous species including Atlantic salmon. Several federal and state agencies were involved with the review and approval of the fishways prior to construction including the U.S. Fish and Wildlife Service (USFWS), MDMR, Maine Department of Inland Fisheries and Wildlife (MDIFW), Maine Department of Environmental Protection (MDEP), NMFS, and the Maine Atlantic Salmon Commission. The upstream fish passage that was constructed in 1988 consists of a vertical lift system with the following components: two entry way gates, a connecting gallery, four attraction flow pumps, a moving crowder, a cable operated lift, a headwater canal, fish viewing and counting room, an electrically operated gate at the downstream end of the counting window, an attraction flow diversion pipe from the headwater canal to the crowder area, and a head pond trashrack. The hydraulic capacity of the attraction flow pumps is 40 cfs each. The hydraulic capacity of the diversion pipe is 30 to 80 cfs, but is maintained at 35 cfs. The counting and viewing room also contain the air compressors and control system for the pneumatic flashboards and an air blower for de-icing the four flood gates.

The downstream fish passage consists of the following components: three entry way gates with trashracks (12-inch clear spacing) located at the surface of head pond 11.30 feet above the top of the turbine intakes, sectional gates to close individual entrances, a connecting gallery between the entrances, a 36 inch diameter downstream passage pipe, a plunge pool that measures 30-feet by 20-feet and is kept at a depth of 10-feet under normal operating conditions. Downstream fishway flows range from a minimum 119 cfs to 131 cfs under controlled pond conditions. The plunge pool is equipped with two sectional gates that may be manipulated to control the depth of water in the plunge pool. The project gantry crane is equipped with a special boom for servicing the downstream plunge pool. In addition, the Durham side spillway has been modified to facilitate downstream passage of Atlantic salmon as described above.

The Worumbo downstream fishway consists of three inlet systems located on the upstream face of the inlet deck area starting at elevation 93.0 to 101.0 feet by 36 inches wide. Each inlet consists of the following items:

- Six inlet stop log gates;
- Two 36" wide by 12" tall;
- Two 36" wide by 18" tall; and
- Two 36" wide by 24" tall.

A set of trash racks is mounted just inside the upstream opening. Each inlet area then channels the water/fish into a 36-inch diameter pipe which all three downstream inlets are connected to. This pipe then discharges the water/fish into a plunge pool area located on the river side of the station just below the fish viewing room. The water inside the plunge pool then exits by way of a weir gate. This weir gate is adjusted to maintain the water level inside the plunge pool area above the 36-inch discharge pipe opening.

2 A Kaplan unit is a propeller type turbine with blades that can be adjusted.

The Project is licensed to maintain a crest elevation between pond elevations of 97.0 and 98.5 feet under normal operating conditions. In actual practice, the plant operates as primarily run-of-river with the exception of power system emergencies when Brown Bear is called upon for maximum output or under maintenance exceptions. Brown Bear attempts to maintain a pond elevation between 98.66 and 98.85 in order to provide the required seasonally variable instream flow to the bypass reach. Under normal operations, the Project maintains the preset pond level by opening and closing the turbine gates and blades. Under drawdown conditions where de-watering of the bypass reach is not intended, the crest gates are lowered in order to maintain the bypass flow. Dewatering of the bypass is only for maintenance purposes and is subject to consultation with MDMR and MDIFW.

Historically, the licensee opened the upstream fishway upon notice from MDMR that the upstream migratory fish run had begun at the Brunswick Dam, which is the lowermost dam on the River. This notification normally took place in early to mid-May. The upstream fish lift historically operated according to a fixed schedule during daylight hours until the end of the alewife run in July or early August, when river temperatures reached 22°C. Under the direction of the MDMR, a second operational season was conducted mid- to late September until mid- to late October. However, since 2010, the fishway has been operated continuously, i.e. from 9:00am to 5:00pm, seven days a week, from May to October except for maintenance/cleaning activities. Brown Bear personnel physically count the fish using the fishlift as well as recording each "lift" of the fishway bucket on videotape/DVR. After the alewife run, counting is only by videotape/DVR, which is then provided to MDMR for review upon request.

To provide downstream passage for anadromous species including Atlantic salmon smolts and post-spawned adults (i.e., kelts) migrating in the Androscoggin River system, the downstream fishway is normally opened on April 1, or as soon thereafter as flow and ice conditions permit. The downstream fishway is run continuously until December 31 or when the river starts freezing over unless maintenance conditions require a temporary outage. Currently the downstream fishway operates with the river side gate fully open (with a high intensity light fixture inside the opening to help attract fish) and the two other gates fully closed at the direction of the USFWS (letter from Licensee to FERC dated January 26, 2011).

For the protection and enhancement of fisheries resources, Brown Bear is required by its FERC license (Article 31 as amended) to discharge from the Worumbo Dam minimum habitat flows, as measured immediately downstream from the dam, according to the following schedule:

- September 1 to October 31, 200 cfs;
- November 1 to November 30, 50 cfs (unless the downstream fishway is operational, in which case 85 cfs);
- December 1 to April 15, 50 cfs;
- April 16 to May 31, 300 cfs;
- June 1 to June 30, 200 cfs; and
- July 1 to August 31, 100 cfs.

The bypass habitat flow of 300 cfs released from April 16 to May 31 equals the sum of downstream fishway flow (119 to 131 cfs under controlled pond conditions) plus overtopping flow (169 to 181 cfs). Minimum flow conditions are required except during approved maintenance activities, extreme hydrologic conditions, emergency electrical conditions, or upon agreement with the appropriate resource agencies.

In addition to general facility maintenance, such as debris management, the maintenance of the fish passage facilities is completed in the winter months. The attraction pumps for the upstream fish passage facility are removed, tested, and inspected. Repairs are made as needed and all four pumps have been replaced between 2006 and 2009. The pumps and attraction flows consist of:

- Four Flygt submersible electric motor attraction pumps are included in the collection gallery. Pump 1 is mounted upstream and Pump 4 downstream. The pumps take water from the tailrace and discharge the water into the collection gallery. The number of attraction pumps online at any given time is based on the station output generation. The schedule is as follows:
    - i. 0.0 MW to 7.9 MW - pumps #1 and #4 are on line;
    - ii.8.0 MW to 9.9 MW - pumps #1, #3, and #4 are on line; and
    - iii. 10.0 MW and up - all four pumps are on line.
- Each pump is designed to provide 40 cfs of attraction flow.
- Excluding the attraction pumps, a designed flow rate of 30-50 cfs flows into the lower lift area, upstream of the hopper.

The pumps are stored in the powerhouse until they are reinstalled in March. The lift, hopper, and other metal parts are inspected and replaced or repaired as needed. The lift motor is inspected and tested, as are all the cables. The downstream weirs have trashracks (12-inch clear spacing) in front of the weirs and these trashracks can be plugged by large debris during high flows. The trashracks are maintained with a manually operated hydraulic rake, and the debris is cleared as soon as river conditions allow safe access.

2.2. Proposed Action

As explained above, FERC is proposing to amend Brown Bear's operating license to incorporate measures outlined in the Species Protection Plan. These measures will replace measures required by a previous license amendment which incorporated provisions of an Interim Species Protection Plan. Other than the requirements outlined in the new SPP and associated license amendment, the project will operate as authorized under its existing license. This license expires on December 1, 2025; after which, a new license is required to continue operations.

2.2.1. Species Protection Plan

The amended license, incorporating the measures of the proposed SPP will be valid until 2025 when the existing FERC license expires. The amended license will require Brown Bear to undertake the following activities:

- Operate upstream and downstream fishways to provide safe, timely and effective passage for Atlantic salmon;
- Conduct downstream survival studies on Atlantic salmon smolts;
- Conduct an upstream passage study for adult Atlantic salmon;

- Map salmon habitat within the Little River using MDMR protocols; and
- Prepare an annual report on fishway operation.

Upstream Fishway Operations

Brown Bear will operate the Worumbo upstream fishway from May 1 to November 15 from 9:00am to 5:00pm, river conditions permitting, or if an alternate date is approved by MDMR, USFWS, and NMFS. The fishway typically requires a maintenance check and temporary shutdown during the fishway season. Brown Bear will schedule this activity to occur between the end of July and mid-August, while maintaining needed flexibility to respond to emergency repairs that may occur outside this scheduled window. Any shutdown of upstream fishway operation will be limited to the time needed to make the necessary repairs. The fishway will restart operations as soon as the repairs have been completed. Brown Bear will coordinate with MDMR and confirm with us that any modified fishway operational dates are approved. Brown Bear has proposed to manage the operation of their upstream fishway adaptively, that is, they will make modifications if testing proves that the fishway is ineffective.

Downstream Fishway Operations

Brown Bear will operate the Worumbo downstream fishway from April 1 to December 31 each year, river conditions (i.e. ice) permitting. This will ensure that the Worumbo Project fishway is open when anadromous species may be present near the Project. Brown Bear will coordinate with us and MDMR prior to modifying the fishway operational dates.

The 2013-2015 downstream smolt passage studies provided valuable site-specific information to evaluate whole station survival and assist in developing additional measures to increase downstream passage survival. In 2014 and 2015, various floodgate settings were tested to evaluate if these scenarios increased downstream bypass effectiveness by offering another downstream passage route to reduce passage through the powerhouse. These studies showed that smolts did pass through the floodgate and at a higher rate when the floodgate was at its lowest flow discharge setting. While the floodgate was tested using multiple openings or releases and passage rates varied, as noted, the general trend was for a higher rate of smolt passage at the lower releases. Therefore, Brown Bear has proposed to operate the floodgate at its lowest setting as an additional passage route nightly (the hours were not identified) between May 7 and May 21 of each year. This represents a significant increase in non-turbine flow. Combined with bypass flow (300 cfs), this proposal would allow for an expected passage flow of 800 cfs. However, Brown Bear has proposed that this measure will only be implemented if it is known that at least two adult Atlantic salmon were passed upstream two years prior (and thus may have successfully spawned and produced outmigrating smolts), or if an Atlantic salmon stocking program is established upstream of the Project.

Downstream Performance Standard

Based on the results of three years of smolt survival studies monitoring passage from 200 meters upstream of the dam, Brown Bear has proposed that the Project and fish passage facilities be operated to meet a minimum performance standard for the survival of downstream migrating

Atlantic salmon of 87 percent survival, evaluated by being within the lower and upper 95 percent confidence limit. This means that the project will be considered to be in compliance with the amended license when 87% of the downstream migrating Atlantic salmon survive between a point 200 meters upriver of the trashracks to a point sufficiently downriver where the effects of dam passage are no longer measureable.

Downstream Passage Study

Brown Bear has proposed to conduct a smolt survival study in 2025 to verify that the standard is being met, and to monitor take at the project. Additionally, they indicate that if the standard is not achieved, they "…will evaluate additional measures designed to direct migrating salmon to the most effective passage routes, and will then monitor passage survival again the year following…". As the study was proposed for the final year of the SPP, we assume that this additional study year, if it is necessary, would occur under the term of the next license, which is not being considered in this Opinion. Therefore, we will only consider the effects of Brown Bear conducting a single year of study. Based on previous smolt survival studies conducted within the GOM DPS, we anticipate that up to 200 smolts will be tagged with radio tags for the purpose of measuring survival and migratory delay at the Project.

Upstream Passage Study

Brown Bear has proposed to continue the current practice of monitoring adult upstream migrating Atlantic salmon using the fish lift throughout the entire fishway operation season. Based on documented returns monitored at the Brunswick fishway, Brown Bear believes there are too few adult Atlantic salmon migrating into the Androscoggin River to conduct a scientifically rigorous and defensible fish passage effectiveness study at this point. However, the use of PIT and/or radio tagging at Brunswick and tracking equipment at the Worumbo Project will provide valuable information on the number and timing of upstream migration by individual Atlantic salmon in the Project area

As part of the proposed action, Brown Bear proposes to implement an adaptive management approach if 40 adult Atlantic salmon are collected in two consecutive years at the Brunswick Project and released upstream. When this occurs, Brown Bear proposes to consult with the agencies to develop a detailed study plan to conduct upstream and downstream adult Atlantic salmon passage monitoring studies the following year (i.e., in the third year following two years of at least 40 adult returns). This will allow time to secure the appropriate tags and monitoring equipment and have everything in place for the next season. The study is expected to use PIT and/or radio tagging and tracking methodology. Installation of tracking equipment at the Project fish lift entrance and exit will track salmon successfully using the fishway to migrate upstream. Although these studies are part of the proposed action, the specific monitoring methodology and locations will be determined during development of the detailed study plan. Tagging will be done concurrent with current collection activities at the Brunswick Project fishway so as not to increase handling stress. Brown Bear will provide the tags and tagging equipment to the MDMR or the Brunswick Project licensee or contractor for the study for tagging of the salmon. Brown Bear has indicated that they would install monitoring equipment to monitor the downstream passage of kelts through late fall, as well.

Habitat Mapping

Brown Bear is proposing to conduct a detailed Atlantic salmon habitat survey in the Little River following MDMR protocols. The survey data is expected to be suitable for inclusion in the salmon habitat GIS database. This survey will also provide additional and updated information on potential barrier removals, culvert replacements, and suspected point source pollution sources. These data would be valuable in selecting and prioritizing habitat improvement opportunities in the Little River, and this is consistent with the recovery actions described in the updated *SHRU Recovery Workplan-2016* (Activity Number M11; UFSWS and NOAA Fisheries 2016b). Data would be valuable for identifying areas of quality salmon spawning and rearing habitat units that need protection, estimating salmon production potential in the river, and for selecting and prioritizing habitat improvement opportunities in the Little River Basin. Brown Bear will coordinate this mapping effort with Brookfield Renewable (the licensee for the two downstream hydro projects), and MDMR staff. At this point, Brown Bear is not proposing any habitat improvement projects.

Annual Reporting

Currently, by Order Approving Recommendations on Fish Passage Studies (FERC order dated November 12, 1998), the Licensee must conduct annual meetings and submit fishway status reports to FERC. These annual reports describe dates of fishway operations as directed by MDMR and fishway maintenance activities for the Project. Brown Bear has requested approval to replace the annual fishway status meetings and reporting with the broader annual reporting under the SPP. The annual SPP reports will be submitted to FERC and provided to us, USFWS, and MDMR by the end of March each year.

2.3. 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).

Operation of the Worumbo Project under the terms of the amended license affects a portion of the Androscoggin River. In addition to the immediate footprint of the Project, the action area encompasses the impounded habitat upriver of the project and the area downriver of the project affected by project flow modifications. We define the area to encompass the area between the Lewiston Fall Project, which is 22-km upriver of Worumbo, to the Pejepscot Project, which is 5.5-km downriver of Worumbo (Figure 3). The proposed habitat mapping will occur within the Little River downriver of the Project, so that tributary is included in the action area, as well.

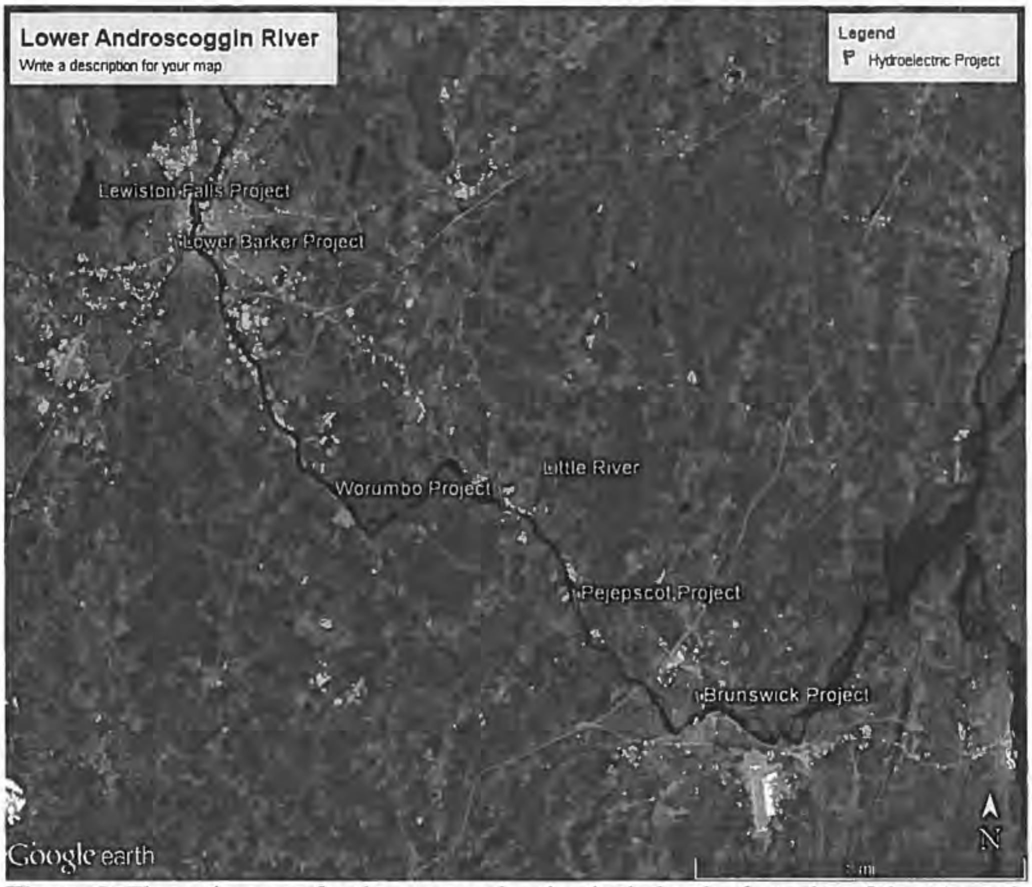


Figure 3. The action area for the proposed action includes the footprint of the Worumbo Project, as well as the reach of river upriver to the Lewiston Falls Project, and downriver to the Pejepscot Project (including the Little River).

3. STATUS OF AFFECTED SPECIES AND CRITICAL HABITAT

Endangered Atlantic salmon are present in the action area. Additionally, the action area is designated as critical habitat for GOM DPS of Atlantic salmon. While listed shortnose and Atlantic sturgeon occur in the Androscoggin River, they cannot access the action area because they are not passed upstream at either of the two downstream dams. Therefore, they do not occur in the action area and will not be exposed to any effects of the action. This Opinion only considers the potential effects to listed Atlantic salmon and its critical habitat.

This section will focus on the status of the GOM DPS of Atlantic salmon and designated critical habitat 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

The GOM DPS of anadromous Atlantic salmon was initially listed by USFWS and NMFS (collectively, the Services) as an endangered species on November 17, 2000 (65 FR 69459). A subsequent rule issued by the Services (74 FR 29344, June 19, 2009) expanded the geographic range for the GOM DPS of Atlantic salmon. The GOM DPS of Atlantic salmon is defined as all anadromous Atlantic salmon whose freshwater range occurs in the watersheds from the Androscoggin River northward along the Maine coast to the Dennys River, and wherever these fish occur in the estuarine and marine environment. The marine range of the GOM DPS extends from the Gulf of Maine, throughout the Northwest Atlantic Ocean, to the coast of Greenland. Included in the GOM DPS are all associated conservation hatchery populations used to supplement these natural populations; currently, such conservation hatchery populations are maintained at Green Lake National Fish Hatchery (GLNFH) and Craig Brook National Fish Hatcheries (CBNFH), both operated by the USFWS, as well as private watershed-based facilities (Downeast Salmon Federation's East Machias and Pleasant River facilities). Excluded from the GOM DPS are landlocked Atlantic salmon and those salmon raised in commercial hatcheries for the aquaculture industry (74 FR 29344, June 19, 2009).

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). 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).

3.1.1 Life History

Atlantic salmon spend most of its adult life in the ocean and returns to freshwater to reproduce. Atlantic salmon have a complex life history that includes territorial rearing in rivers to extensive feeding migrations on the high seas (Figure 4). During their life cycle, Atlantic salmon go through several distinct phases that are identified by specific changes in behavior, physiology, morphology, and habitat requirements.

Spawning

Adult Atlantic salmon return to rivers in Maine from the Atlantic Ocean and migrate to their natal streams to spawn. Although spawning does not occur until late fall, the majority of Atlantic salmon in Maine enter freshwater between May and mid-July (Meister 1958; Baum 1997), but may enter at any time between early spring and late summer. Early migration is an adaptive trait that ensures adults have sufficient time to reach spawning areas (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.

From mid-October to mid-November, adult females select sites in rivers and streams for spawning. Spawning sites are positioned within flowing water, particularly where upwelling of groundwater occurs, allowing for percolation of water through the gravel (Danie *et al.* 1984). These sites are most often positioned at the head of a riffle (Beland *et al.* 1982), the tail of a pool, or the upstream edge of a gravel bar where water depth is decreasing and water velocity is increasing (McLaughlin and Knight 1987; White 1942). The female salmon creates an egg pit (redd) by digging into the substrate with her tail and then deposits eggs while male salmon release sperm to fertilize the eggs. After spawning, the female continues digging upstream of the last deposition site, burying the fertilized eggs with clean gravel. Females produce a total of

1,500 to 1,800 eggs per kilogram of body weight, yielding an average of 7,500 eggs per two sea-winter (SW) female (an adult female that has spent two winters at sea before returning to spawn) (Baum and Meister 1971). After spawning, male and female Atlantic salmon either return to sea immediately or remain in fresh water until the following spring before returning to the sea (Fay *et al.* 2006).

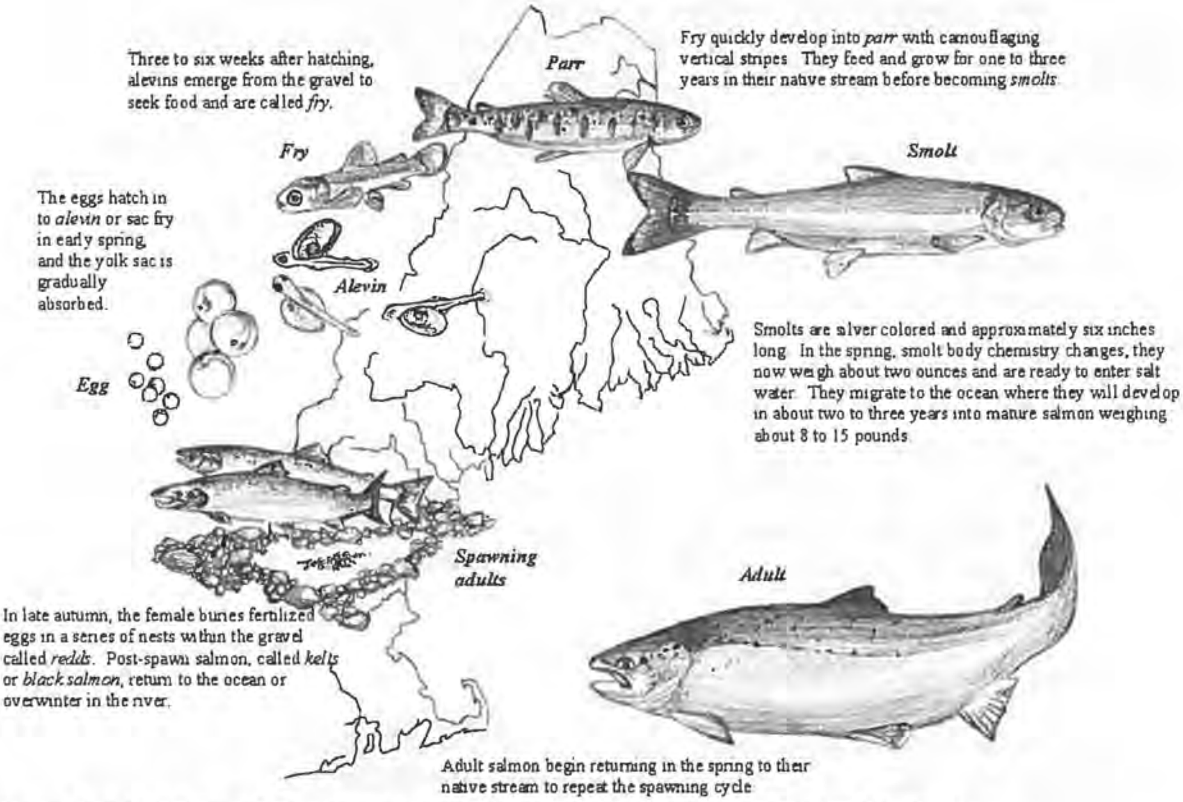


Figure 4. Life Cycle of the Atlantic salmon (diagrams courtesy of Katrina Mueller).

After spawning, the adults ("kelts") move downstream toward the sea. Movement may be triggered by increased water temperatures or flows. Some migrate toward the sea immediately, either moving partway downstream or returning to the ocean (Ruggles 1980; Don Pugh, U.S. Geological Survey (USGS) personal communication). Most kelts, however, overwinter in the river and return to the sea in the spring. Kelts that remain in the river appear to survive well through the winter (Ruggles 1980; Jonsson et al. 1990). The relative survival of kelts, however, has not been calculated for Maine rivers. After reaching the ocean, few kelt survive as indicated by the lack of repeat spawners in the GOM DPS (NMFS and USFWS 2005).

Eggs

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

Alevins and Fry

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

Parr

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

Smolts

During the smoltification process, 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 cm, and most smolts enter the sea during May to begin their first ocean migration (USASAC 2004). The spring migration of smolts to the marine environment takes 25 to 45 days. Most smolts migrate rapidly, exiting the estuary within several tidal cycles (Hyvarinen *et al.* 2006; Lacroix and McCurdy 1996; Lacroix *et al.* 2004, 2005).

Post-smolts

Smolts are termed post-smolts after ocean entry to the end of the first winter at sea (Allan and Ritter 1977). 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, 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 some aggregation and common migration corridors related to surface currents (Hyvarinen *et al.* 2006; Lacroix and McCurdy 1996; Lacroix *et al.* 2004). Post-smolt distribution may reflect water temperatures (Reddin and Shearer 1987) and/or the major surface-current vectors (Lacroix and Knox 2005). Post-smolts travel mainly at the surface of the water column (Renkawitz *et al.* 2012) and may form shoals, possibly of fish from the same river (Shelton *et al.* 1997). Post-smolts grow quickly, achieving lengths of 30-35 cm by October (Baum 1997). Smolts can experience high mortality during the transition to saline environments for reasons that are not well understood (Kocik *et al.* 2009; Thorstad *et al.* 2012).

During the late summer and autumn of the first year, North American post-smolts are concentrated in the Labrador Sea and off 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, Sheehan *et al.* 2012). Atlantic salmon located off Greenland are primarily composed of non-maturing first sea winter (1SW) fish, which are likely to spawn after their second sea winter (2SW), from both North America and Europe, plus a smaller component of previous spawners who have returned to the sea prior to their next spawning event (Reddin 1988; Reddin *et al.* 1988). The following spring, 1SW and older fish are generally located in the Gulf of St. Lawrence, off the coast of Newfoundland, and on the east coast of the Grand Banks (Reddin 1985; Dutil and Coutu 1988; Ritter 1989; Reddin and Friedland 1993; and Friedland *et al.* 1999).

Adults

Some salmon may remain at sea for another year or more before maturing. After their second winter at sea, the salmon likely over-winter in the area of the Grand Banks before returning to their natal rivers to spawn (Reddin and Shearer 1987). Reddin and Friedland (1993) found non-maturing adults located along the coasts of Newfoundland, Labrador, and Greenland, and in the Labrador and Irminger Sea in the later summer and autumn.

The average size of Atlantic salmon is 71-76 cm (28-30 inches) long and 3.6-5.4 kg (8-15 pounds) after two to three years at sea. Although uncommon, adults can grow to be as large as 30 pounds (13.6 kg). The natural life span of Atlantic salmon ranges from two to eight years (ASBRT 2006). Following spawning in the fall, Atlantic salmon kelts may immediately return to the sea, or over-winter in freshwater habitat and migrate in the spring, typically April or May (Baum 1997).

3.1.2 Reproduction, Distribution, and Abundance of Atlantic salmon

The reproduction, distribution, and abundance of Atlantic salmon within the range of the GOM DPS have been generally declining since the 1800s (Fay *et al.* 2006). A comprehensive time series of adult returns to the GOM DPS dating back to 1967 exists (Fay *et al.* 2006, USASAC 2013). 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 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 2013).

After a period of population growth between the 1970s and the early 1980s, adult returns of salmon in the GOM DPS peaked between approximately 1984 and 1991 before declining during the 2000s. Adult returns fluctuated over the last few years, with increases observed from 2008 to 2011, and a decrease again in 2012, 2013, and 2014. Presently, the majority of all adults in the GOM DPS return to a single river, the Penobscot, which accounted for over 90% of all adult returns to the GOM DPS over the last decade. The population growth observed in the 1970s is likely attributable to favorable marine survival and increases in hatchery capacity, particularly from GLNFH (constructed in 1974). Marine survival remained relatively high throughout the 1980s, and salmon populations in the GOM DPS remained relatively stable until the early 1990s. In the early 1990s, marine survival rates decreased, leading to the declining trend in adult abundance observed throughout the 1990s and early 2000s. The increase in abundance of returning adult salmon observed between 2008 and 2011 may be an indication of improving marine survival; however the declines in 2012 - 2014 may suggest otherwise. Returns to U.S. waters in 2013 were only 611 fish, which ranks 43rd in the 47-year time-series (USASAC 2014). A total of 450 adults returns were estimated for 2014; the lowest for the 1991- 2014 time series. The returns in 2015 were somewhat higher at 881 (USASAC 2016). Despite consistent smolt production, there has been extreme variability in annual returns over the last five years.

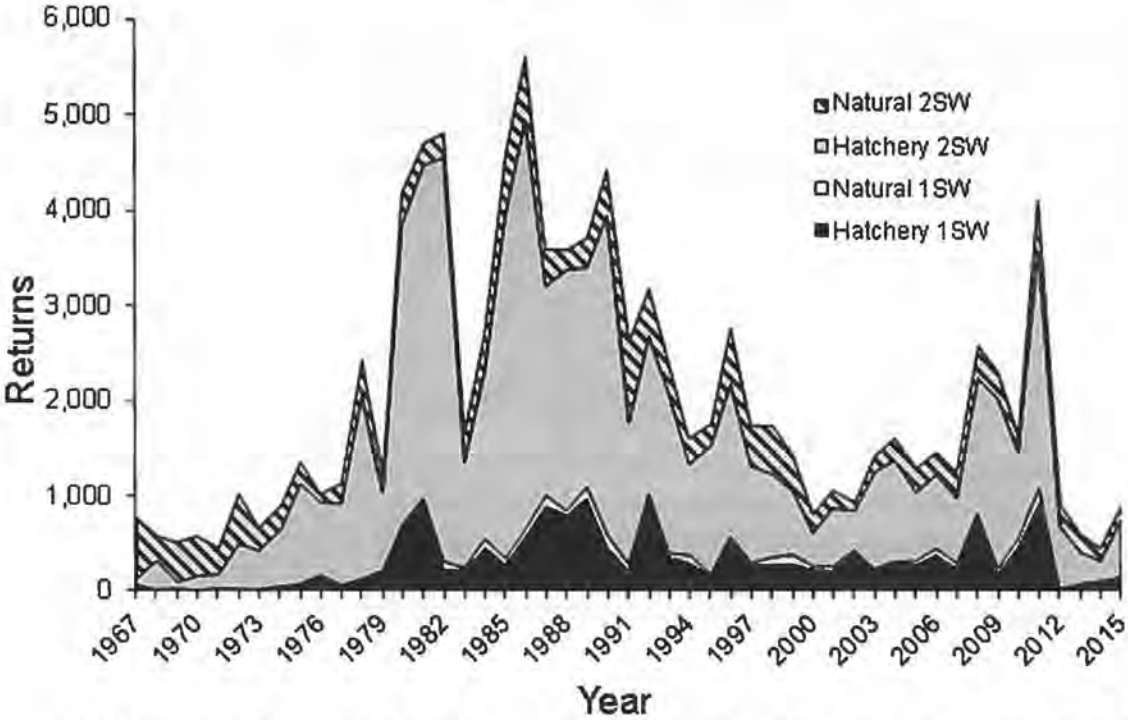


Figure 5. Summary of natural vs. hatchery adult salmon returns to the GOM DPS Rivers between 1967 and 2014 (USASAC 2015).

Since 1967 when numbers of adult returns were first recorded, the vast majority of adult returns have been the result of smolt stocking; only a small portion of returning adults were naturally reared (Figure 5). Natural reproduction of the species is contributing to only a fraction of Atlantic salmon returns to the GOM DPS. 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. Low abundances of both hatchery-origin and naturally reared adult salmon returns to Maine demonstrate continued poor marine survival.

The abundance of Atlantic salmon in the GOM DPS has been low, and the trend has been 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 fry and smolts 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 is expected to prevent extinction in the short term, but recovery of the GOM DPS will not be accomplished without significant increases in naturally reared salmon.

The historic distribution of Atlantic salmon in Maine has been described extensively by Baum (1997) and Beland (1984), among others. In short, substantial populations of Atlantic salmon existed in nearly every river in Maine that was large enough to maintain a spawning population. The upstream extent of the species' distribution extended far into the headwaters of even the largest rivers. Today, the spatial structure of Atlantic salmon is limited by obstructions to passage and also by low abundance levels and the majority of all adults return to the Penobscot River. Within the range of the GOM DPS, the Kennebec, Androscoggin, Union, and Penobscot Rivers contain dams that severely limit passage of salmon to significant amounts of spawning and rearing habitat. Atlantic salmon presently have unobstructed access to only about 5% of their historic habitat in the Penobscot River (NOAA 2009).

3.1.3 Salmon Habitat Recovery Units

As part of the 2009 GOM DPS listing and designation of critical habitat, we defined three Salmon Habitat Recovery Units (SHRU): the Merrymeeting Bay SHRU, the Penobscot Bay SHRU, and the Downeast SHRU (Figure 6). As defined in the Endangered Species Consultation Handbook[3], a Recovery Unit is a "management subset of the listed species that is created to establish recovery goals or carry out management actions." The NMFS Interim Recovery Plan Guidance[4] goes on to state that recovery units are frequently managed as management units, though makes the distinction that recovery units are deemed necessary to both the survival and recovery of the species, whereas management units are defined as not always being "necessary" to both the survival and recovery.

3 http://www.nmfs.noaa.gov/pr/pdfs/laws/esa_section7_handbook.pdf
4 http://www.nmfs.noaa.gov/pr/pdfs/recovery/guidance.pdf

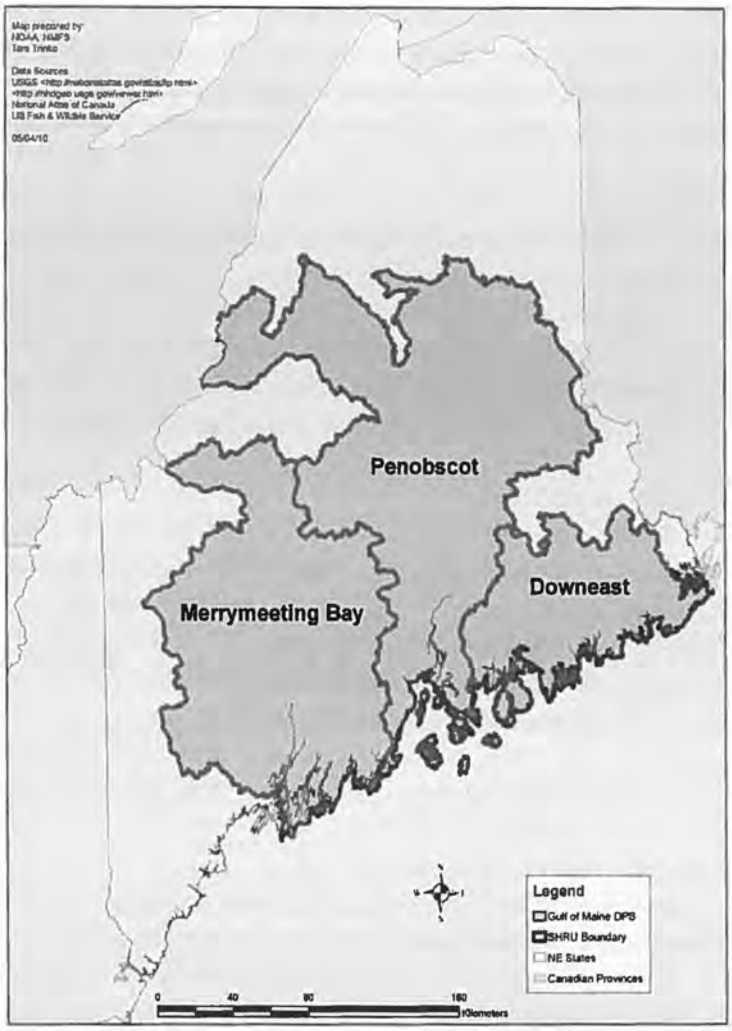


Figure 6. Location of Atlantic salmon Habitat Recovery Units (SHRU) in the GOM DPS.

3.1.3.1 Merrymeeting Bay SHRU

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 Merrymeeting Bay SHRU significantly impede the migration of Atlantic salmon and other diadromous fish and either reduce or eliminate access to roughly 352,000 units of historically accessible spawning and rearing habitat. In addition to hydropower dams, agriculture and urban development largely affect the lower third of the Merrymeeting 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 Merrymeeting Bay SHRU by altering natural predator/prey relationships.

3.1.3.2 Downeast Coastal SHRU

Impacts to substrate and cover, water quality, water temperature, biological communities, and migratory corridors, among a host of other factors, have impacted the quality and quantity of habitat available to Atlantic salmon populations within the Downeast Coastal SHRU. Two hydropower dams on the Union river, and, to a lesser extent, the small ice dam on the lower Narraguagus River, limit access to roughly 18,500 units of spawning and rearing habitat within these two watersheds. In the Union River, which contains over 12,000 units of spawning and rearing habitat, physical and biological features have been most notably limited by high water temperatures and abundant smallmouth bass populations associated with impoundments. In the Pleasant River and Tunk Stream, which collectively contain over 4,300 units of spawning and rearing habitat, pH has been identified as possibly being the predominate limiting factor. The Machias, Narraguagus, and East Machias rivers contain the highest quality habitat relative to other HUC 10s in the Downeast Coastal SHRU and collectively account for approximately 40 percent of the spawning and rearing habitat in the Downeast Coastal SHRU.

3.1.3.3 Penobscot Bay SHRU

The mainstem Penobscot has the highest biological value to the Penobscot SHRU because it provides a central migratory corridor crucial for the entire Penobscot SHRU. Dams, along with degraded substrate and cover, water quality, water temperature, and biological communities, have reduced the quality and quantity of habitat available to Atlantic salmon populations within the Penobscot SHRU. A combined total of 20 FERC-licensed hydropower dams in the Penobscot SHRU significantly impede the migration of Atlantic salmon and other diadromous fish to nearly 300,000 units of historically accessible spawning and rearing habitat. Agriculture and urban development largely affect the lower third of the Penobscot SHRU below the Piscataquis River sub-basin by reducing substrate and cover, reducing water quality, and elevating water temperatures. Introductions of smallmouth bass and other non-indigenous species significantly degrade habitat quality throughout the mainstem Penobscot and portions of the Mattawamkeag, Piscataquis, and lower Penobscot sub-basins by altering predator/prey relationships. Similar to smallmouth bass, recent Northern pike introductions threaten habitat in the lower Penobscot River. Of the 323,700 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). Of the 211,000 occupied units within the Penobscot SHRU, NMFS calculated these units to be the equivalent of nearly 66,300 functional units or approximately 20 percent of the historical functional potential.

3.1.4 Survival and Recovery of the GOM DPS

In light of the 2009 GOM DPS listing and designation of critical habitat, the Services issued a new recovery plan for Atlantic salmon on March 31, 2016 for public review and comment. The draft 2016 Recovery Plan presents a recovery strategy based on the biological and ecological needs of the species as well as current threats and conservation accomplishments that affect its long-term viability. The plan is based upon a planning approach recently endorsed by the USFWS and, for this plan, by NMFS. The new approach, termed the Recovery Enhancement Vision (REV), focuses on the three statutory requirements in the ESA, including site-specific recovery actions; objective, measurable criteria for delisting; and time and cost estimates to achieve recovery and intermediate steps. The 2016 Recovery Plan is based on two premises:

first, that recovery must focus on rivers and estuaries located in the GOM DPS until the Services have a better understanding of the threats in the marine environment, and second, that survival of Atlantic salmon in the GOM DPS will be dependent on conservation hatcheries through much of the recovery process. In addition, the scientific foundation for the plan includes conservation biology principles regarding population viability, an understanding of freshwater habitat viability, and threats abatement needs.

Under the 2016 Recovery Plan, reclassification of the GOM DPS from endangered to threatened will be considered when all of following criteria are met:

1. The DPS has a total annual escapement of at least 1,500 naturally reared adults spawning in the wild, with at least 2 of the 3 SHRUs having at least 500 naturally reared adults.
2. The population in each of at least two of the three SHRUs has a population growth rate of greater than 1.0 in the 10-year period preceding reclassification.
3. Adults originating from hatchery-stocked eggs, fry, and parr are included when estimating population growth rates.
4. Sufficient suitable spawning and rearing habitat for the offspring of the 1,500 naturally reared adults is accessible and distributed throughout designated Atlantic salmon critical habitat, with at least 7,500 accessible and suitable habitat units (Hus) in each of at least two of the three SHRUs, located according to the known and potential migratory patterns of returning salmon.

3.1.5 Summary of Rangewide Status of Atlantic salmon

The GOM DPS of Atlantic salmon currently exhibits critically low spawner abundance, poor marine survival, and is confronted with a variety of additional threats. The abundance of GOM DPS Atlantic salmon has been low and either stable or declining over the past several decades. The proportion of fish that are of natural origin is extremely low (approximately 6% over the last ten years) and is continuing to decline. The spatial distribution of the GOM DPS has been severely reduced relative to historical distribution patterns. 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. 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.

3.2 Designated Critical Habitat for the GOM DPS of Atlantic salmon

Coincident with the June 19, 2009 endangered listing, we designated critical habitat for the GOM DPS of Atlantic salmon (74 FR 29300; June 19, 2009) (Figure 7). The final rule was revised on August 10, 2009. In this revision, designated critical habitat for the expanded GOM DPS of Atlantic salmon was reduced to exclude trust and fee holdings of the Penobscot Indian Nation and a table was corrected (74 FR 39003; August 10, 2009).

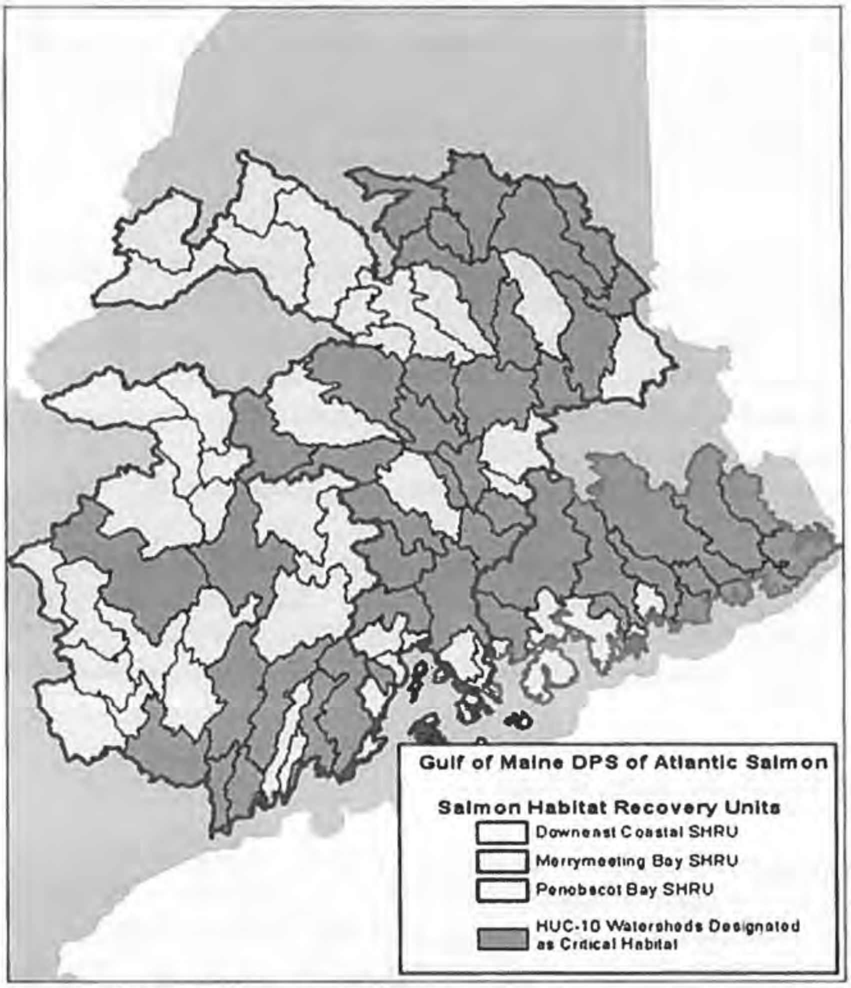


Figure 7. HUC-10 Watersheds Designated as Atlantic Salmon Critical Habitat and Salmon Habitat Recovery Units within the GOM DPS.

3.2.1 Essential Features of Atlantic Salmon Critical Habitat

Designation of critical habitat is based on the known physical and biological features within the occupied areas of a listed species that are deemed essential to the conservation of the species. For the GOM DPS, the physical and biological features (PBFs) essential for the conservation of Atlantic salmon are: 1) sites for spawning and rearing, and, 2) sites for migration (excluding marine migration[5]). We chose not to separate spawning and rearing habitat into distinct PBFs, 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.

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

The physical and biological features for Atlantic salmon critical habitat are as follows:

Physical and Biological Features of Spawning and Rearing Habitat

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 Migratory Habitat

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 physical and biological features 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.

A physical and biological feature that is essential for Atlantic salmon (sites for migration) is present in the action area. To facilitate and standardize determinations of effect for section 7 consultations involving Atlantic salmon critical habitat, we developed the "Matrix of Essential Features for Designated Atlantic Salmon Critical Habitat in the GOM DPS" (Table 1). The matrix lists the physical and biological features (essential features) of Atlantic salmon habitat, and the potential conservation status of critical habitat within an action area. Two essential features 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 the project, we determined that several essential features to Atlantic salmon in the action area have limited function or are not properly functioning currently (Table 2).

Table 1. Matrix of essential features for assessing the environmental baseline of the action area.

Essential Features	Conservation Status Baseline 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 1 continued...

Essential Features	Conservation Status Baseline: 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 1 continued…

Essential Features	Conservation Status Baseline: 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 2. Current conditions of essential features of Atlantic salmon critical habitat in the action area having limited function or not properly functioning.

Pathway/Indicator	Life Stages Affected	Essential Features Affected	Effect	Population Viability Attributes Affected
Passage/Access to Historical Habitat	Adult, juvenile, smolt	Freshwater migration	Impeded upstream passage delays access to spawning habitat. Impeded downstream passage will result in direct and delayed mortality of smolts and kelts.	Adult abundance and productivity.

3.3 Factors Affecting Atlantic salmon and Critical Habitat

3.3.1 Threats Faced by Atlantic Salmon Throughout Their Range

Atlantic salmon face a number of threats to their survival, most of which are outlined in the Recovery Plan (NMFS and USFWS 2005) and the latest status review (Fay *et al.* 2006). We consider the following to be the most significant threats to the GOM DPS of Atlantic salmon:

- 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
- 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
- Recovery hatchery program (potential for artificial selection/domestication)
- Sedimentation of spawning and rearing habitat
- Water extraction
- Diseases
- Predation
- Greenland Mixed Stock Fishery.

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.

Starting in the 1960s, Greenland implemented a mixed stock Atlantic salmon fishery off its western coast (Sheehan *et al.* 2015). The fishery primarily takes 1 sea winter (1 SW) North American and European origin Atlantic salmon that would potentially return to natal waters as mature, 2 SW spawning adults or older. Because of international concerns that the fishery would have deleterious on the contributing stock complexes, a quota system was agreed upon and implemented in 1976, and since 1984, catch regulations have been established by the North Atlantic Salmon Conservation Organization (NASCO) (Sheehan *et al.* 2015). In recent years, Greenland had limited the mixed stock salmon fishery for internal consumption only, which in the past has been estimated at 20 metric tons.

In 2015, Greenland unilaterally set a 45 ton quota for a mixed stock Atlantic salmon fishery for 2015, 2016, and 2017 (Sheehan *et al.* 2015). Based on historic harvest estimates, it is estimated that on average, approximately 100 U.S. origin adult Atlantic salmon will be harvested annually under a 45 ton quota. With recent U.S. returns of Atlantic salmon averaging less than 1,500 individuals per year, the majority of which originated from hatcheries, this harvest constitutes a substantial threat to the survival and recovery of the GOM DPS. The U.S. continues to negotiate with the government of Greenland and participants of the fishery both within and outside of NASCO to ultimately establish agreed upon measures that will curtail the impact of the fishery on U.S. origin fish.

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, throughout the Gulf of Maine.

3.4 Status of Atlantic Salmon and Critical Habitat 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 Androscoggin River watershed supports runs of Atlantic salmon and a modest fry stocking program. As such, all lifestages of Atlantic salmon could be present in the action area.

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 city of Lewiston-Auburn (MDEP 1999). The upper portions of the Androscoggin 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 historic 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 sub-basin of the Androscoggin with historically important salmon habitat that was accessible as far up as Snow's Falls located 3.2 km 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).

Upstream Migrating Adults

Based on historic reports, Atlantic salmon were abundant in the Androscoggin River. 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 (USASAC 2016, Table 3).

Table 3. Adult Atlantic salmon returns by origin to the Androscoggin River recorded from 1983 to 2015 at the Brunswick Project (USASAC 2016).

	Hatchery Origin				**Wild Origin**				
Androscoggin	**1SW**	**2SW**	**3SW**	**Repeat**	**1SW**	**2SW**	**3SW**	**Repeat**	**Total**
1983-2005	32	531	6	2	6	84	0	1	**662**
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**
2013	0	1	0	0	0	1	0	0	**2**
2014	0	2	0	0	0	1	0	0	**3**
2015	0	0	0	0	0	1	0	0	**1**
Total	**57**	**600**	**6**	**2**	**10**	**111**	**0**	**1**	**787**

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 upstream passage facilities designed for anadromous species. 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 2009). Each habitat unit equals 100 square meters. The Androscoggin River consists of 70,249 historic HUC10 habitat units. An estimated 24% (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 2009). 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 where the Worumbo Project is located, while high scores were determined in the upper inaccessible reaches of the river (NMFS 2009).

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 2009). 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 1.8 miles upstream in the mouth of the Sabattus River, blocks access to the majority of the habitat.

There have been few studies of Atlantic salmon in the Androscoggin River. In 2011, MDMR radio tagged 21adult 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).

Juveniles

Atlantic salmon stocking practices are common in the region for the Gulf of Maine 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 18,500 fry have been stocked in the Androscoggin River since stocking commenced in 2001 (USASAC 2016). The total number of juvenile salmon stocked in the Androscoggin River (fry only) was 1,500 individuals in 2013, 1,000 in 2014 and 2,000 in 2015 (USASAC 2016). 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 2015 (number of juveniles indicated in parenthesis): the Penobscot (1.24 million), Machias (552,732), Dennys (110,000), and Kennebec (276,587) rivers (USASAC 2016).

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 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. Timing of smolt migrations may differ amongst rivers within the GOM DPS (Figure 8). In 2015, smolt trapping studies on the Sheepscot River in the Merrymeeting Bay SHRU indicated a median migration date of May 12 with a migration duration of 33 days (USASAC 2016).

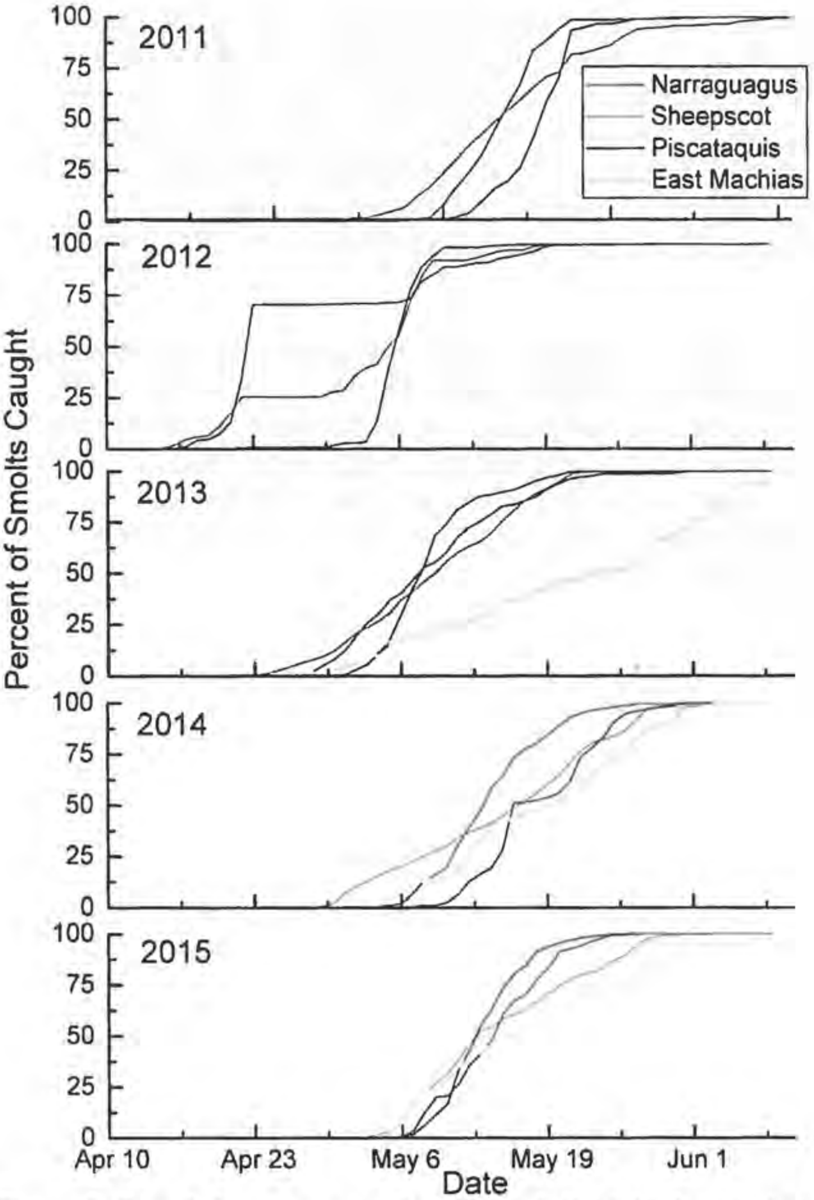


Figure 8. Cumulative percent smolt capture of all origins by date (run timing) on the Narraguagus (blue line), Sheepscot (pink line), Piscataquis (black line), and East Machias (yellow line) rivers, Maine (2011-2015) (USASAC 2016).

3.4.1 Threats faced by Atlantic salmon within the Merrymeeting Bay SHRU

3.4.1.1 Dam and 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 km of impounded river (MDEP 1999). Therefore, both the Kennebec and Androscoggin watersheds are major power producers. On the Androscoggin below Rumford (the upper extent of the range of Atlantic salmon), major Hydro-power 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 upstream from Merrymeeting Bay.

Habitat Alteration

Dams have eliminated or degraded vast, but to date unquantified, reaches of suitable rearing habitat in the Androscoggin River watershed. The Androscoggin River consists of 70,249 historic habitat units, with 16,978 units considered to be occupied (NMFS 2009). Because Atlantic salmon cannot volitionally access habitat upstream of the Lewiston Falls Project on the mainstem or above the Barker Mill Dam on the Little Androscoggin, habitat in the upper areas of the Androscoggin River watershed are not accessible. Impoundments created by 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 Androscoggin 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.

Compared to a natural hydrograph, the operation of dams in a store-and-release mode in the upper reaches of the Androscoggin River watershed 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 Androscoggin River watershed 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

In 1982, Central Maine Power Company (CMP) reconstructed the hydroelectric facility in Brunswick-Topsham, the first upstream dam on the Androscoggin River (Brown *et al.* 2006). 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 3 and 44 Atlantic salmon per year (average of 12 fish) passed the Brunswick Dam between 2003 and 2015 (Table 4). Of these, an average of 22% (range between 0% and 56%) successfully passed the Worumbo Project. In a radio telemetry study conducted in 2011, while the spillway rehabilitation was occurring, MDMR documented that 9 of the 21 fish that passed the Brunswick Project passed the Pejepscot Project, and 2 of those 9 (22%) successfully migrated past the Worumbo 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 4. The number of Atlantic salmon passing the Brunswick and Worumbo Projects between 2003 and 2015.

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	1	-
2013	2	1	50%
2014	3	1	33%
2015	2	0	0%
Average	**12**	**2**	**22%**

Smolts from 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. 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 over a spillway has been estimated at 97.1% (Normandeau Associates 2011). Survival through turbines varies significantly based on numerous factors, but can be significantly lower than the other two routes.

Beginning in 2013, three years of study were conducted to assess the survival of smolts migrating past dams in the Androscoggin River (Table 5). 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).

Table 5. Percent survival by study year of Atlantic salmon smolts at three dams on the Androscoggin River (ISPP annual reports, 2013-2015).

Project	Percent Survival of Smolts by Study Year			
	2013	2014	2015	Average
Worumbo	70.7%	95.8%	93.5%	86.7%
Pejepscot	-	91.3%	86.3%	88.8%
Brunswick	82.8%	94.9%	83.8%	87.2%

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 (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.

Alden Lab (2012) 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%.

3.4.1.2 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 River—smallmouth bass 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 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 (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 prey would likely prey upon Atlantic salmon in the Androscoggin 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).

3.4.1.3 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 set to maintain the existing water quality classification. Generally, the impacts of point source pollution are greater in the larger rivers of the GOM DPS.

Poor water quality within segments of the Androscoggin River is of particular concern for fisheries restoration. The MDEP noted that an upstream segment of the Androscoggin, including the lower four miles of the Gulf Island dam impoundment and the Livermore Falls impoundment does not attain water quality standards. The non-attainment status in this segment is caused primarily by sediment oxygen demand resulting from historic discharges (MDEP 2014). MDEP classifies the portion of the Androscoggin River in which the Worumbo Project occurs, as Class C waters. Class C waters must be of such quality that they are suitable for the designated uses of drinking water supply after treatment; fishing; agriculture; recreation in and on the water; industrial process and cooling water supply; hydroelectric power generation; navigation; and as a habitat for fish and other aquatic life (MDEP 2014).

3.4.2 Summary of Information on Atlantic Salmon and Critical Habitat in the Action Area

Adult returns for the GOM DPS remain well below conservation spawning escapement (CSE). For all GOM DPS rivers in Maine, current Atlantic salmon populations (including hatchery contributions) are well below CSE levels required to sustain themselves (Fay *et al.* 2006), which is further indication of their poor population status. 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 small and displays no sign of growth. The conservation hatchery program has assisted in slowing the decline and helping to stabilize populations at low levels, but has not contributed to an increase in the overall abundance of salmon and has not been able to halt the decline of the naturally reared component of the GOM DPS.

A number of activities within the Merrymeeting Bay SHRU 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.

Dams, along with degraded substrate and cover, water quality, water temperature, and biological communities, have reduced the quality and quantity of habitat available to Atlantic salmon populations within the Merrymeeting Bay SHRU. Hydroelectric dams, in particular, have a significant negative effect on listed Atlantic salmon, as well as critical habitat, within the Androscoggin River, and the action area. Ongoing effects of the lower three projects in the river (including the Worumbo Project), particularly passage inefficiencies and migratory delay, negatively impact the species as well as the physical and biological features of critical habitat present in the action area.

4. ENVIRONMENTAL BASELINE

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). An environmental baseline that does not meet the biological requirements of a listed species may increase the likelihood that adverse effects of the proposed action will result in jeopardy to a listed species or in destruction or adverse modification of designated critical habitat. 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. Impacts of Federal Actions that have Undergone Formal or Early Section 7 Consultation

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. Past effects of the Worumbo Project, as well as the other hydro projects in the Androscoggin, are considered in section 3.4.1.

On July 19, 2013, we issued an Opinion to FERC on the impacts to listed species from the ISPP being proposed by FPL Energy Maine Hydro LLC for the Brunswick and Lewiston Falls Projects on the Androscoggin River; along with three hydro projects on the Kennebec River. The purpose of the ISPP is to collect information on passage efficiency and survival of Atlantic salmon adults and smolts attempting to migrate past the Projects. Lewiston Falls does not have fishways, so passage efficiency studies were not proposed at that project. The ITS of the Opinion authorized take for the proposed studies, as well as for the effects of ongoing operations at the Project. The ISPP, and the Opinion, have a seven year term (2013-2019), after which the Opinion and ITS will no longer be valid. At that point (2019), FPL Energy will put together a final SPP that contains additional protection measures for listed fish, and FERC will reinitiate formal consultation in order to obtain take authorization for the remainder of the projects' license terms. We concluded that the proposed action was not likely to jeopardize the continued existence of listed Atlantic salmon. The ITS accompanying the Opinion exempted incidental take for upstream and downstream fish passage studies, as well as for the operation of the Project over the term of the ISPP. It is anticipated that 61% of the salmon that are motivated to pass the Brunswick Project are expected to do so successfully but will be collected, captured, and trapped; 38.6% will be harassed as they will not be able to access potentially suitable spawning habitat upstream of the Project; and 0.4% will die. It is also expected that project operations will result in the injury or death of up to 7% of the total number of smolts in the project area and 15% of all kelts in the project area. At the Lewiston Falls Project, it is anticipated that one salmon could be stranded downstream of the Project during the period of the ISPP. This authorization expires at the end of the proposed ISPP (2019).

4.2. Scientific Studies

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; for adults, it would be less than 1%. MDMR will continue to conduct Atlantic salmon research and management activities in the GOM DPS while the proposed action is carried out. The information gained from these activities will be used to further salmon conservation actions.

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. Approximately 1,000 fry are stocked annually in the Androscoggin River. The hatcheries provide a significant buffer from extinction for the species.

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 Androscoggin River permitted by the ACOE. This includes several dock, pier, and bank stabilization projects. No interactions with Atlantic salmon have been reported in association with any of these projects.

4.4. State or Private Activities in the Action Area

In 2009, the MDMR closed all Atlantic salmon fishing in Maine. There is no indication that the fishery will be reinstated in the future.

State of Maine stocking program

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

Atlantic salmon produced by the commercial aquaculture industry that escape from hatcheries or net pens also compete with wild Atlantic salmon for food, space and mates.

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 this river system, 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 and release 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. A summary of the current condition and threats to Atlantic salmon and designated critical habitat within the action area is included in section 3.4.2.

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. Additionally, we present the available information on predicted effects of climate change on listed species and critical habitat in the action area. 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 below).

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 precipitation, 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 Androscoggin 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. Anticipated 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 watersheds 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).

A study conducted in the United Kingdom that used data collected over a 20-year period in the Wye River found Atlantic salmon populations have declined substantially and this decline was best explained by climatic factors like increasing summer temperatures and reduced discharge more than any other factor (Clews *et al.* 2010). Changes in temperature and flow serve as cues for salmon to migrate, and smolts entering the ocean either too late or too early would then begin their post-smolt year in such a way that could be less optimal for opportunities to feed, predator risks, and/or thermal stress (Friedland 1998). Since the highest rate of mortality affecting Atlantic salmon occurs in the marine phase, both the temperature and the productivity of the coastal environment may be critical to survival (Drinkwater *et al.* 2003). Temperature influences the length of egg incubation periods for salmonids (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° 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.

5.3. Anticipated Effects to Atlantic Salmon and Critical Habitat in the Action Area

Information on how climate change will impact the action area is extremely limited. According to Fernandez *et al.* (2015), the Intergovernmental Panel on Climate Change (IPCC) models predict that Maine's annual temperature will increase another 3.0–5.0 °F (1.7–2.8 °C) by 2050. The IPCC models predict that precipitation will continue to increase across the Northeast by 5–10% by 2050, although the distribution of this increase is likely to vary across the climate zones (Fernandez *et al.* 2015); model predictions show greater increases in precipitation in interior Maine. Total accumulated snow is predicted to decline in Maine especially along the coast where total winter snow loss could exceed 40% relative to recent climate (Fernandez *et al.* 2015). Since

2004, sea surface temperatures in the Gulf of Maine have accelerated to 0.41 °F (0.23 °C) per year; a rate that is faster than 99% of the world's oceans (Fernandez *et al.* 2015).

According to the most recent National Climate Assessment (Melillo *et al.* 2014), a global sea level is projected to rise an additional 0.5 to 2.0 feet (0.2 to 0.6 meters) or more by 2050. Rising sea levels would shift the salt wedge in the Penobscot River and other rivers in the GOM DPS. As there is significant uncertainty in the rate and timing of change as well as the effect of any changes that may be experienced in the action area due to climate change, it is difficult to predict the impact of these changes on Atlantic salmon.

In the action area, it is possible that changing seasonal temperature regimes could result in changes in the timing of seasonal migrations for the GOM DPS of Atlantic salmon in Maine. There could be shifts in the timing of spawning; presumably, if water temperatures stay warm further in the fall, and water temperature is a primary spawning cue, spawning migrations could occur earlier in the year and spawning events could occur later. However, because salmon spawning is not triggered solely by water temperature, but also by day length (which would not be affected by climate change) and river flow (which could be affected by climate change), it is not possible to predict how any change in water temperature or river flow alone will affect the seasonal movements of salmon throughout the action area.

Atlantic salmon are cold water fish and have a thermal tolerance zone where activity and growth is optimal (Decola 1970). Temperature can be a stimulant for salmon migration, spawning, and feeding (Elson 1969). Temperature can also significantly influence egg incubation success or failure, food requirements and digestive rates, growth and development rates, vulnerability to disease and predation, and may be responsible for direct mortality (Garside 1973; Spence *et al.* 1996; Peterson *et al.* 1977, Whalen *et al.* 1999). When temperatures exceeded 23°C, adult Atlantic salmon can cease upstream movements. Salmon mortalities were associated with daily average temperatures of 26°C to 27°C.

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

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). We have not identified any interrelated or interdependent actions.

Ongoing effects of the Worumbo Project that are not associated with the amendment of the project license (i.e. sediment and nutrient transport, water quality, impoundment effects) are considered part of the environmental baseline, and therefore are not addressed separately in this section. Rather, we consider the effects addressed here in addition to the existing environmental baseline.

6.1. Hydroelectric Operations

6.1.1. Upstream Fish Passage

The fish lift at the Worumbo 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. Atlantic salmon can migrate past the Worumbo Dam to impassable barriers on: 1) the mainstem Androscoggin River (with the upstream limit at the Lewiston Falls Project in Lewiston); 2) the Little Androscoggin River (with the upstream limit at the Lower Barker Mills Dam in Auburn); and, 3) the Sabattus River (with the upstream limit at the Farnsworth Mill Dam in Lisbon) (MDMR 2010).

Atlantic salmon have successfully used the upstream fish lift at the Worumbo Project. Between 2003 and 2015, an average of two (range: 0 to 7) Atlantic salmon successfully passed the Project (Table 4) annually. However, as no fishway is 100% effective at passing Atlantic salmon, we expect there will continue to be salmon that are motivated to move further upstream but are not attracted to the fishway or that fail to use it effectively. We consider either of these situations to be adverse effects of the project. As described further below, we also expect there to be Atlantic salmon in the project area, downstream of the dam, that are not motivated to move further upstream and that will access spawning habitat downstream of the dam. While these salmon are not expected to use the fishway, we do not consider them to be adversely affected because they would not be expected to move further upstream even if the dam was not present.

A telemetry study was conducted in 2011 by MDMR in the Androscoggin River. This study provides the best available information about Atlantic salmon movements in the action area. As described previously (Section 3.4), this study found that 43% of the adult Atlantic salmon that were passed upstream of the Brunswick Project, successfully migrated past the Pejepscot Project (MDMR 2012b) and were, therefore, available to pass upstream of Worumbo. Of the nine fish that were detected passing Pejepscot, only two (22%) successfully passed the Worumbo Project. One of the fish moved up to the Little Androscoggin River, and spent several months moving between the Lower Barker Project tailrace and the Lewiston Falls tailrace on the mainstem. DMR (2012b) suggests that this fish may have spawned with an untagged female in the Lower Barker tailrace. However, electrofishing the following year failed to locate any YOY in this reach. The other Atlantic salmon that passed the Worumbo Project moved seven kilometers upriver and then held at the confluence with Dyer Brook, which likely provided a source of cool water. This fish was never detected in the spawning habitat available in the Lower Barker tailrace. In addition to the two fish that were detected upriver of the Worumbo Dam, two tagged salmon approached the Project and were detected in the bypass reach. At least one of these fish regurgitated its radio tag (the tag was located by a diver), so its fate is unknown. The other fish was never observed, but the tag signal persisted in the area until February of that year. This would suggest that this individual either regurgitated its tag as well, or died. Given this data, we conclude that of the nine fish that passed the Pejepscot Project, at least four approached the Worumbo Project. Of these, only two are known to have passed the Project. This information cannot be used to calculate a passage efficiency estimate, as most, if not all, of the salmon approaching the Project are straying, and are not homing to habitat upriver of Worumbo. These fish would not be highly motivated to migrate upriver of Worumbo. It is believed that motivated Atlantic salmon (i.e. those that are homing back to habitat where they were reared upstream of a dam) are more likely to successfully pass a Project, than those that are not. Other fish lifts in the GOM DPS operate at relatively high passage efficiencies (e.g. >90%), but the salmon approaching these dams are, in general, motivated to pass. Given this, we expect that passage efficiency at Worumbo would be much higher than what can be determined using unmotivated fish.

As indicated, there is no information available on the passage efficiency of motivated pre-spawn Atlantic salmon at the Worumbo Project. Although it is believed to occur, production of salmon upriver of Worumbo is limited due to the small amount of available habitat. As few juvenile salmon are reared in that habitat, we expect that correspondingly few adults will be homing back to it. Therefore, determining the true passage efficiency of the Project under current conditions is not possible. The salmon that use the fishway are primarily strays, either from tributaries downriver of the Project, or from other river systems. Should an increase in salmon production (due to stocking, or an increase in spawning activity) occur upriver of the Project, we would expect an increase in the number of pre-spawn adults motivated to access upriver habitat. Currently, there is no plan to initiate active stocking upriver of the Worumbo Project over the term of the SPP.

As indicated above, zero to seven Atlantic salmon have passed through the Worumbo fishway annually since 2003. Upstream fishways collect fish into human-made structures that allow them to continue their upstream movements past a dam. 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 all of the Atlantic salmon that use the Worumbo fishway. Given fish counts at the Project since 2003, we would expect that no more than 63 salmon (up to 7 fish per year for 9 years) will be exposed to the effects of trapping at the Project over the term of the proposed action.

No studies have looked directly at the fate of fish that fail to pass through upstream fish passage facilities on the Androscoggin River. We anticipate that many of the adult salmon that approach the Worumbo Project may be homing to habitat in the Little River. These fish will not be adversely affected by the proposed action, as the Project does not hinder access to that tributary; therefore any effects to these individuals would be insignificant and discountable. An unknown proportion of the individuals that approach the Project, however, are homing to habitat upriver of Worumbo, and may be motivated to pass. We convened an expert panel in 2010 to provide the best available information on the fate of fish that fail to pass 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 expert panel concluded that the majority of fish that fail to pass a fishway will stray and spawn in habitat downriver of that dam. In this case, we would anticipate that these salmon would be attracted to the flow coming out of the Little River, and would spawn in that tributary. Given the proximity, accessibility, and relative abundance of rearing and spawning habitat in the Little River, the effect of this forced straying would be insignificant. Similarly, fish straying from other rivers would also be attracted to habitat within the Little River. The expert panel convened in 2010 indicated that 1% of the salmon that fail to pass a hydroelectric project would die. Given the small number of adult salmon that enter the Androscoggin River annually (average of 12 passed at the Brunswick Project), and the small proportion of those that would be motivated to pass Worumbo, we would not expect any adults to be killed due to passage inefficiencies.

Migratory Delay

Here, we consider the effect of delay on salmon that are motivated to pass upstream of the project. Delay at dams can, individually and cumulatively, affect an individual's ability to access suitable spawning habitat within the narrow window when conditions in the river are suitable for migration. In addition, delays in migration can cause over-ripening of eggs, increased chance of egg retention, and reduced egg viability in pre-spawn female salmonids (deGaudemar and Beall 1998). Numerous studies collectively report a wide range in time taken for individual adult salmon to pass upstream of various dams in the Penobscot River once detected in the vicinity of a spillway or tailrace. Passage at the Milford Project ranged between 0.1 days and 16.1 days in 2014; and in 2015 it ranged between 0.1 days and 35 days (average of 10.5 days) (HDR Engineering 2015; Kleinschmidt Associates 2016). Passage at the Lockwood Project on the Kennebec River ranged between 0.7 and 111.2 days (average of 17.0 days) (Normandeau Associates 2016a). 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 Worumbo Project. As described above, many of the salmon passing the next downstream dam are strays and are less likely to be motivated to pass upstream of Worumbo and therefore, it is unlikely that the Worumbo project would cause delay to their migrations. These fish are more likely to be attracted to habitat in the Little River, or to cold water refugia lower in the Androscoggin. Fish that are motivated to pass the Project, however, are expected to be exposed to levels of delay similar to what has been observed at other hydroelectric Projects within the GOM DPS. The available spawning habitat upriver of the Project is relatively close to the Project (~22 km), so it is unlikely that delay caused by the dam would significantly affect the ability of motivated fish to access spawning grounds in a timely manner. There are also two cold water refugia (Meadow Brook and the Little River are both 800 meters downriver), that would provide suitable holding habitat during the warm months. Additionally, as described above, delayed salmon would likely seek thermal refuge in the Little River, where suitable habitat for spawning and rearing is available. We believe that the effects of migratory delay on motivated adult salmon at the Worumbo Project will be so small that they cannot be meaningfully measured or detected based on the following: 1) the proximity of upriver spawning habitat; 2) the presence of nearby readily available cold water refuge downriver of the Project; and 3) the availability of spawning and rearing habitat in the Little River. Therefore, we expect these effects to be insignificant. We do not expect delay to result in a failure to spawn or a failure to find suitable cold water refugia.

6.1.2. Downstream Fish Passage

Under the proposed action, the Worumbo Project will continue to affect outmigrating smolts and kelts by: 1) injuring and killing salmon passing downstream through project facilities, 2) delaying outmigration timing, 3) increasing stress levels, which can lead to a subsequent decrease in saltwater tolerance.

Smolts

As described previously (see section 3.1.5), it is anticipated that there is minimal spawning occurring upstream of the Worumbo Project. All stocking in the watershed occurs 800 meters downstream of the Project in the Little River. That said, enough sea-run Atlantic salmon (i.e.at least two) have passed the project to spawn in 5 of the last 13 years. Therefore, assuming that successful upstream passage continues and there is successful spawning above the dam, we expect a small number of naturally reared salmon smolts to migrate downstream past the project in some years. Assuming one successful spawning event in habitat upstream of Worumbo each year, we would expect approximately 109 smolts to be outmigrating past the Project annually (Julie Nieland, NEFSC, personal communication 2017). Should access to upstream spawning habitat be improved or stocking strategies change, the number of salmon effected by dam passage would be anticipated to increase as more smolts would be passing the Project.

In preparation of the 2012 interim SPP, the previous licensee conducted an analysis to estimate whole station survival based on existing literature, which combined smolt distributions and survival estimates for all passage routes (e.g., spillway, turbines, and fishway) through the Project. This was performed using May median (50% exceedance), low (90% exceedance), and high (10% exceedance) flows (based on period of record from 1928 to 2010). The whole station survival rates ranged from 96.6 to 98.6% (MHG 2012b). Immediate smolt survival through the Worumbo Project turbines was estimated using empirical estimates compiled in the scientific literature (EPRI Turbine Passage Survival Database) and resulted in a mean turbine immediate survival rate of 94.6%. These estimates do not account for delay, injury, of latent mortality.

Considering the MHG analysis, we estimate immediate whole station survival (i.e. survival of smolts passing the Project) during May median flows (50% exceedance) at 96.6% at the Worumbo Project. Table 6 combines the smolt distributions and survival estimates for all passage routes (e.g., spillway, turbines, and fishways). An Advanced Hydro Turbine model analysis (Franke *et al.* 1997) was also conducted at the Worumbo Project. The Advanced Hydro Turbine model analysis yielded an immediate survival of 98.2% for smolts.

A desktop analysis provides an estimate of immediate survival and does not assess potential impacts resulting from migratory delays, non-lethal injuries, or delayed mortality. Alden Research Laboratory (2012) estimated an indirect mortality of 5% per project for hydroelectric projects on the Penobscot River, due primarily to predation and sublethal injuries during passage. When added to what was estimated by the licensee's desktop analysis, this level of indirect mortality would equate to a survival rate at the Worumbo Project of approximately 91.6% (EPRI Turbine Passage Survival Database) and 93.2% (Advanced Hydro Turbine model).

Brown Bear conducted survival studies at the project between 2013 and 2015 to obtain site specific empirical evidence regarding the effects of the Project on outmigrating smolts. The primary goal of these studies was to evaluate the route of passage and survival of smolts. Study objectives included determination of survival rates, route of passage, migration delay, and travel time.

As described in the BA prepared for this project, in 2013, the low flow conditions, warm water temperatures, and potentially high predation rates likely led to the worst-case survival scenario at the Project (70.7%). Other study issues (e.g. the release of all study fish only a few days apart, high release mortality, low sample size) make it difficult to compare it to the other study years. Additionally, as the floodgate was not used as a passage route in 2013, it confounds our analysis of potential effects of the Project in the future. Therefore, we will focus our analysis on the studies conducted at the Project by the licensee in 2014 and 2015. In those two years the majority of the Atlantic salmon smolts passed the Project via the powerhouse (63% in 2014; 50% in 2015), with the rest distributed between the non-turbine passage routes (i.e. spillway, downstream bypass, and floodgate). Although sample sizes through the different passage routes were quite small (range: 7 to 59 smolts), survival through each of the four routes over the two study years averaged greater than 93%, while the average whole station survival was 94.7% (2014: 95.8%, 2015: 93.5%).

Considering the poor survival observed in 2013, Brown Bear conducted spillway releases in 2014 and 2015 using variable openings of a floodgate in order to provide an additional passage route. While many variables likely affect the precise flow through the floodgate and the use of this passage route by salmon, the general trend was for a higher passage rate at moderate to low flows through the floodgate opening. The discharge of the floodgate was tested at variable flows (between 500 cfs and 3,400 cfs), and it was determined that the passage effectiveness for smolts (3.2% to 37.5%) was highest at 500 cfs. Therefore, Brown Bear has proposed to target 500 cfs of discharge from the floodgate when smolts are believed to be outmigrating from habitat upriver of the project.

Table 6. Smolt survival estimates at the Worumbo Project.

Desktop Method	Survival Estimate	Indirect Adjustment
EPRI Turbine Passage Database	96.6%	91.6%
Advanced Hydro Turbine	98.2%	93.2%
Empirical Method	**Average (2013-2015)**	**Average* (2014-2015)**
Paired release study	86.7%	94.7%

*Floodgate #1 was tested at various flows in 2014 and 2015.

Brown Bear has proposed to spill water through the floodgate when it is believed smolts could be outmigrating past the project (i.e. two years after at least two sea-run pre-spawn salmon pass upstream of the project). They have proposed to target 500 cfs through the floodgate at nighttime for the two week period between May 7 and May 21. This differs from how the floodgate was operated in 2014 and 2015 when it was open for 24-hours a day for the entire study period. Although we do not have information on smolt run timing specific to the Androscoggin River, we do have data from the Piscataquis, East Machias, Narraguagus, and Sheepscot Rivers (Figure 8, USASAC 2016). These data suggest that the two week proposal encompasses some of the period when smolts are outmigrating from the rivers, but not the majority. Figure 8 would suggest that on the Sheepscot River, which is the closest to the Androscoggin geographically, an average of approximately 55% (ranging between 35% and 75%) of the smolt run occurred outside of the May 7 to May 21 period between 2011 and 2015.

Brown Bear has also proposed that the floodgate only be used at night during the two week period. Studies conducted by Brookfield Renewable at the Brunswick Project (first dam on the Androscoggin) between 2013 and 2015 determined that 86% of study fish passed the Project during nighttime hours (Normandeau Associates 2016b). As an average of 45% of the smolt run would pass the project during those two weeks, and as 86% of those will pass at night when the floodgate is operating, we would expect an average of 39% of the outmigrating smolts to have the option of using the floodgate. This is in contrast to the 100% that had that option during the 2014 and 2015 studies.

The 2014 and 2015 empirical studies indicated that whole station survival varied between 93.5% and 95.8% when the floodgate was operated 100% of the time. Although the floodgate was operated throughout the study, it was operated at suboptimal settings for much of the study in both years. In each study year they did three separate smolt releases; modifying the floodgate settings for each release. Therefore, the optimal setting was only utilized for one third of the study in each of the two years. Brown Bear determined that floodgate passage rates varied substantially; and that at high flows few smolts would opt to use that passage route. As described above, Brown Bear found that the passage rates were highest when they targeted the lower flow setting (approximately 37.5% at 500 cfs), and so this is what they have proposed in their SPP. We therefore conclude that a higher proportion of fish would pass through the floodgate at the targeted flow, than what was detected during the studies. This higher efficiency may be offset to some degree by the proposal to reduce the operational time of the floodgate to 39% of the smolt run. There is high variability in the proportion of fish that use any passage route, and it is difficult to predict how the reduction in operational time, as well as the increase in passage efficiency, will affect survival at the Project. It is possible that the higher passage efficiency associated with operating the floodgate at the optimal setting will completely offset the shorter operational duration, but it might not. However, average survival rates through all passage routes (i.e. floodgate, spillway, bypass, and turbines) were similar (93% to 100%) in 2014 and 2015. Therefore, fish that do not pass through the floodgate, will likely still find a relatively safe passage route downriver. As such we assume survival will be consistent with these study results over the duration of the SPP. We anticipate that mortality will not exceed the upper limit (6.5%) of what was seen during the 2014 and 2015 studies during the SPP.

The best available information does not support the conclusion that smolt passage through the turbines results in higher mortality than passage through non-turbine routes. Although the sample sizes are not large, the results from the 2014 and 2015 studies suggest that the survival rates between the two passage routes are similar. However, we believe that the non-turbine passage routes are inherently safer, as fish are less likely to be subject to injury, disorientation, blade strike, shear forces, and other sub-lethal effects. We also believe that non-turbine routes are likely to lead to a lower level of delay and, thus, lower levels of hydrosystem delayed mortality. Therefore, we are supportive of Brown Bear providing the floodgate as a passage alternative for as much of the smolt outmigration period as possible.

Smolt Performance Standard

Brown Bear has proposed a 87% performance survival standard for smolts based on the average survival between 2013 and 2015. FERC is proposing to incorporate this standard into the license such that failure to meet it would mean that the licensee was not in compliance. As described above, the 2013 study was not representative of a typical year at the Worumbo Project, and the poor survival in that year significantly affects the three-year average. Additionally, the floodgate was not used as a downstream passage route during the 2013 study, so that study year does not represent what can be anticipated under the proposed provisions of the SPP.

In 2014 and 2015, Brown Bear demonstrated that higher survival rates can be achieved at the Project, and has proposed an additional passage route to increase survival if and when smolts are believed to be outmigrating past the project. The proposed standard (87%) is substantially lower than what was documented in 2014 and 2015 through any of the available passage routes, including the turbines. It was also lower than what any of Brown Bear's desktop analyses described in the BA. Based on these empirical and desktop analyses, we believe that whole station survival will exceed the proposed performance standard over the term of the SPP. As described above, based on the empirical studies conducted in 2014 and 2015, we anticipate survival at the Project to be no less than 93.5%.

Delayed Effects of Downstream Passage

In addition to direct mortality sustained by Atlantic salmon at the Worumbo Project, smolts may exhibit delayed mortality in the estuary attributable to their experience at the Project. 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 delayed 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).

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

Recently, Stich *et al.* (2015a) conducted an analysis on nine years (2005 to 2013) of Atlantic salmon smolt movement and survival data in the Penobscot River to determine what effect several factors (e.g. release location and date, river discharge, photoperiod, gill NKA enzyme activity, number of dams passed) have on survival through the estuary. They determined that estuary survival decreased as the number of dams passed during freshwater migration increased (Figure 9). They estimated that each dam passed in the Penobscot led to a mortality rate of 6% in the estuary. This mortality was attributed to migratory delay and sublethal injuries (such as scale loss) sustained during dam passage. These effects make smolts more susceptible to predation, and disease. Additionally, migratory delay can lead to the missing of the physiological "smolt window" (described below). There is no information specific to the Androscoggin River; however, we expect that passage over the Worumbo Project results in similar levels of mortality in the estuary as the direct and indirect effects of dam passage are expected to be the same on both rivers.

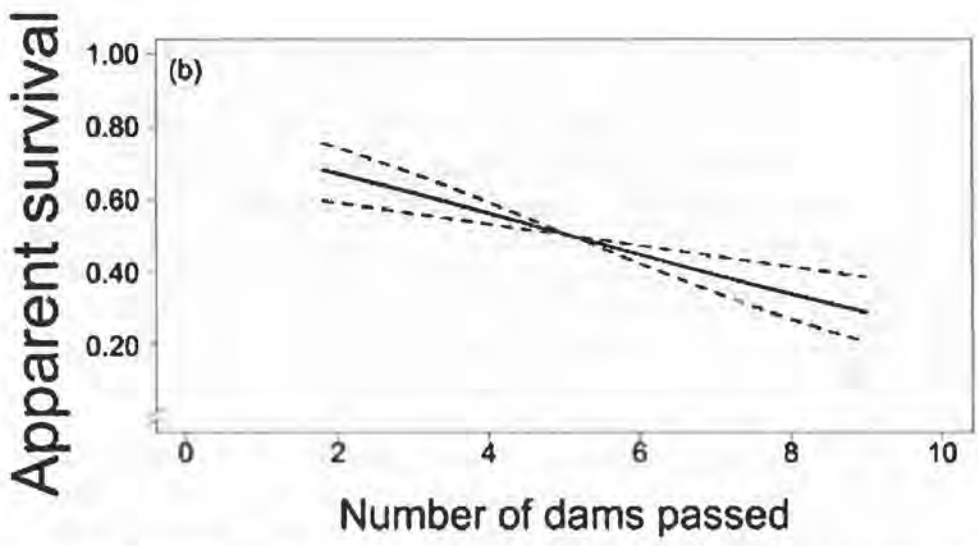


Figure 9. Apparent survival of Atlantic salmon smolts in the Penobscot River estuary based on the number of dams they passed during freshwater migration. The dark line is the mean survival and the dashed lines show the 95% confidence interval. The figure is excerpted from Stich *et al.* 2015a.

Migratory Delay

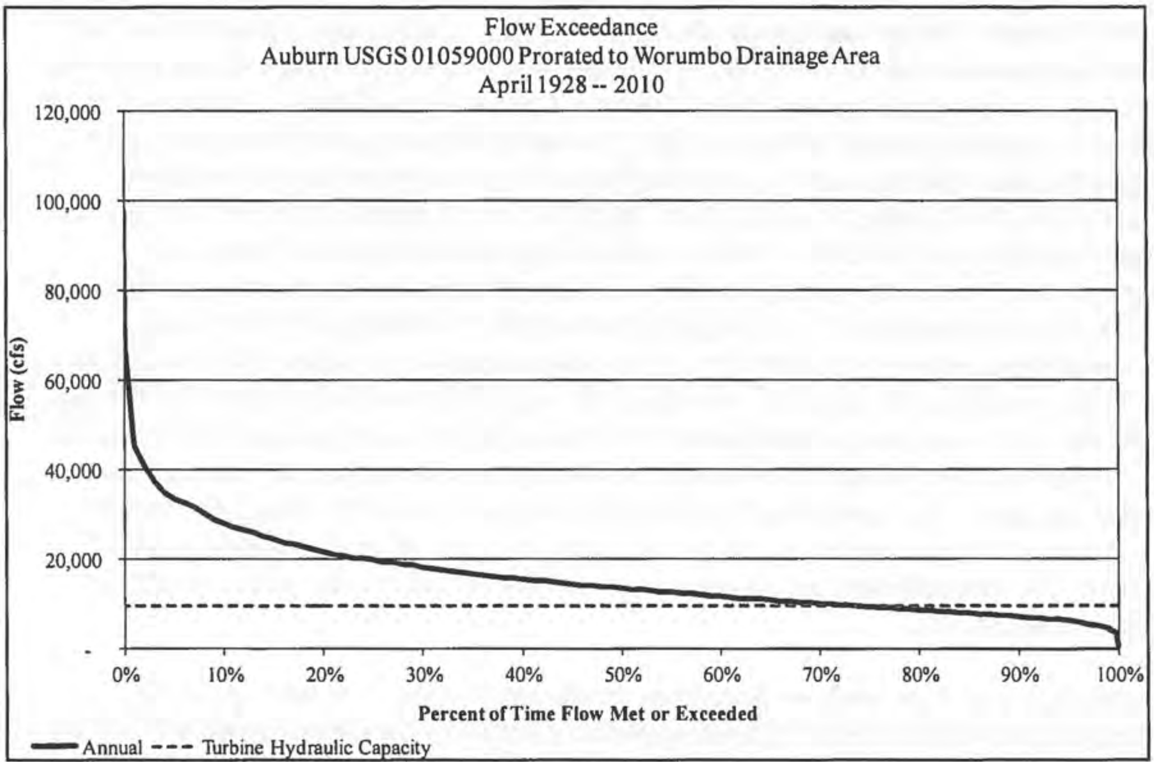
Dams can significantly delay smolt outmigration, especially in low water years, because the individual fish must search and find an available passage route. Delays can lead to direct mortality of Atlantic salmon from increased predation (Blackwell and Juanes 1998), and can also reduce overall physiological 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).

Based on the site-specific Atlantic salmon smolt studies conducted for the Worumbo Project, once tagged smolts were detected approaching Worumbo Dam, passage downstream of the dam proceeded relatively quickly, with median migration times ranging from 0.02 to 0.7 hours. The proportion of smolts that took more than 24 hours to pass the project ranged between 6% and 8%. Based on the results of the three study years, we anticipate that the median passage delay will not exceed 0.7 hours at the Project between 2017 and 2025. This delay is measured between 200 meters upriver of the Project to passage through one of the available passage routes (i.e. spillway, floodgate, bypass, turbines).

Adults

The desktop analysis did not evaluate kelt survival at the Worumbo Project; and the BA does not attempt to estimate mortality rates of outmigrating adults. As there is very little spawning habitat upriver of the Worumbo Project and few adults have been passed upstream in the past few years, it is expected that there are few kelts migrating past the dam on an annual basis. Based on recent returns (Table 4), we anticipate that an annual average of two kelts could pass downstream of the Project, either in the spring (April or May) or fall (November). It is expected that some of the pre-spawn adult salmon that pass upstream of the Project may not spawn, due to the small amount of suitable habitat, mates, or motivation. These fish could drop back over the Project at any time between May and November. Atlantic salmon adults would pass the project via spillage, through the downstream passage facility, or through turbine entrainment. In April and May when most kelts are expected to outmigrate, flows in the Androscoggin River exceed Worumbo's hydraulic capacity 70% and 50% of the time, respectively (Figure 10). In addition to spillage, kelts should be able to safely outmigrate through the downstream bypass, or through the floodgate that will be spilling an additional 500 cfs at night for smolt passage for two weeks in May. As such, we expect a proportion of adults to safely pass the project via spillage, the bypass, or the floodgate. The remaining kelts are likely to pass through the Project's turbines. Larger fish are more likely to experience injury or mortality from turbine entrainment (EPRI 1997a, 1997b). The Worumbo trashracks have a bar spacing of five inches, which would not prevent entrainment of kelts.

Since no empirical or desktop analyses have been conducted to assess kelt survival at the Worumbo Project, we will use the modelled survival at a similarly configured project (the West Enfield Project on the Penobscot River) as a proxy. Both projects have horizontal Kaplan units with a similar turbine diameter and rotational speed, as well as rack spacing that would allow for entrainment of adult salmon. Based on the configuration of the Project, Alden Research Laboratory, Inc. (2012) estimated mean kelt survival at the West Enfield Project to be 91%, with a range (based on river flow) between 90% and 92%. At lower flows, the Project is not spilling and, thus, passage is limited to the turbines and the downstream bypass. To account for the fact that pre-spawn salmon could pass the Project at any time of year between May and November, including periods when we would not anticipate the Project to be spilling, we assume that the minimum survival through all passage routes combined (90%) at the West Enfield Project best represents what we can expect as a whole station survival at the Worumbo Project. Lacking a project specific analysis, this estimate represents the best available information regarding downstream survival of adults (both kelts and pre-spawn adults) at the Worumbo Project. Given the very low number of pre-spawn salmon that have passed the project over the last five years (i.e. fewer than two sea-run salmon per year since 2011), Brown Bear is not proposing a kelt study at the Project. However, they have proposed to study upstream migrating adults if sufficient salmon return to the Androscoggin River. Should this occur, Brown Bear will measure survival of the tagged fish as they drop back over the Project.



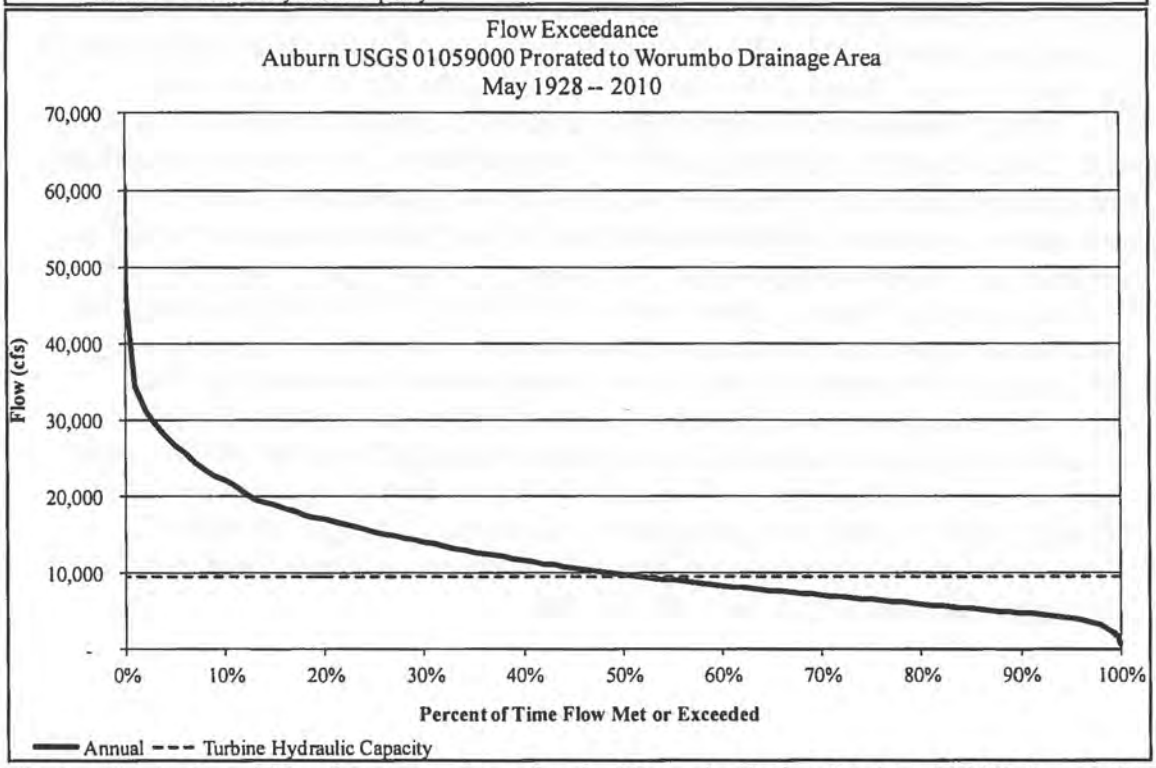


Figure 10. April and May flow exceedance for the Worumbo Project (Auburn USGS Gage 01059000)

6.2. Effects of Aquatic Monitoring and Evaluation

In order to determine the effectiveness of the upstream and downstream fish passage facilities, Brown Bear proposes to conduct downstream survival studies for Atlantic salmon kelts and smolts and an upstream passage efficiency study for pre-spawn adults at the Worumbo Project.

The downstream smolt survival studies will involve obtaining Atlantic salmon smolts (from the Green Lake National Fish Hatchery, or some other source), surgically implanting radio transmitter tags, and then releasing study fish upriver of the Project. 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. It is expected that up to 200 smolts will be tagged for a single year of study, and released upriver of the Project.

Upstream passage efficiency studies will be conducted at the Worumbo Project after two consecutive years of 40 or more fish being trapped at the Brunswick Project. If this occurs, it is expected that Brown Bear will be prepared to radio tag up to 40 adults the following year. These fish would be tracked upriver as pre-spawn adults, and downriver as post-spawn kelts.

Tagging

Techniques such as PIT tagging, coded wire tagging, fin-clipping, and the use of radio transmitters are common to many scientific research efforts on Atlantic salmon. 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 downstream studies, whereas PIT tags will be used for the upstream passage study.

The method proposed for the downstream passage studies is to surgically implant radio tags within the body cavities of the smolts. 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).

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 study 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 100% of the fish that are handled and tagged will be injured.

A proportion of the smolts are anticipated to be killed due to handling and tagging. There is some variability in the reported level of mortality associated with tagging juvenile salmonids. We did not document any immediate mortality while tagging 666 hatchery reared juvenile Atlantic salmon between 1997 and 2005 prior to their release into the Dennys River. After two weeks of being held in pools, only two (0.3%) of these fish died. Over the same timeframe, we surgically implanted tags into wild juvenile Atlantic salmon prior to their release into the Narraguagus River. Of the 679 fish tagged, 13, or 1.9%, died during surgery (NMFS, unpublished data). It is likely there were delayed mortalities as a result of the surgeries, but this could not be quantified because fish were not held for an extended period. In a study assessing tagging mortality in hatchery reared yearling Chinook salmon, Hockersmith *et al.* (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 (2% of 200=4 smolts per year) will be killed due to handling and tagging during the proposed downstream monitoring study.

All adult Atlantic salmon used in the passage studies will be injured due to handling and tagging. However, long term effects of handling and tagging on adult salmon appear to be negligible. Bridger and Booth (2003) indicate that implanting tags gastrically does not affect the swimming ability, migratory orientation, and buoyancy of test fish. Due to handling and tag insertion, it is possible that a small proportion of study fish 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 this would represent a conservative estimate of tagging mortality in the adult salmon being used in the passage studies at the Worumbo Project. Given the small number of Atlantic salmon being tagged (no more than 40 adults) 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. Injuries are expected to be minimized by having trained professionals conduct the procedures using established protocols.

6.3. Little River Habitat Mapping

Brown Bear is proposing to conduct a detailed Atlantic salmon habitat survey in the Little River following MDMR protocols. The survey data is expected to be suitable for inclusion in the salmon habitat GIS database. This survey will also provide additional and updated information on potential barrier removals, culvert replacements, and suspected point source pollution sources. Brown Bear will coordinate this mapping effort with Brookfield Renewables, and MDMR staff.

Although the data collected during this survey will have no direct benefit during the period of the SPP, it will be valuable in identifying opportunities for restoration in the future. The results of the survey may inform potential compensatory mitigation actions that could be taken by the licensee over the term of the next license.

The survey will be a data collection exercise that will entail making qualitative observations, as well as measurements. Impacts would involve a small amount of sediment disturbance associated with individuals canoeing and walking through the stream. While the increase in suspended sediments may cause juvenile salmon to alter their normal movements, any change in behavior is likely to be insignificant as it will only involve minor, temporary movements to alter their course out of the sediment plume. Based on this information, any increase in suspended sediment is expected to result in effects that are so small they cannot be meaningfully measured, detected or evaluated. As such, we expect these effects to be insignificant.

Summary of Effects

The amendment of the Worumbo Project license to incorporate the provisions of the SPP will not eliminate the passage inefficiencies that exist at the Project. It is expected that over the nine-year duration of the proposed action no more than 63 adult salmon will be exposed to the effects of upstream passage; that is, over this period, we do not expect more than 63 adult Atlantic salmon to pass upstream of the Project. We expect any Atlantic salmon that do not attempt to pass the Project may experience minor delay, but these effects will be insignificant due to the presence of spawning habitat and thermal refuge nearby. Our analysis indicates that no more than 6.5% of outmigrating smolts, and 10% of outmigrating kelts, will be killed due to downstream passage effects. We expect that an additional 6% of the smolts that survive passage will die in the estuary due to latent effects of dam passage at Worumbo.

The monitoring studies will lead to the injury and handling of 200 smolts, and up to 40 adult salmon. We expect that four smolts could be killed due to the effects of tagging, but that no adults will be killed.

6.4. Critical Habitat

On February 11, 2016, NMFS and USFWS published a revised regulatory definition of "destruction or adverse modification" (81 FR 7214). Destruction or adverse modification "means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features." As described in the preamble to the proposed rule for the revised definition (79 FR 27060, May 12, 2014), the "destruction or adverse modification" definition focuses on how Federal actions affect the quantity and quality of the physical or biological features in the designated critical habitat for a listed species and, especially in the case of unoccupied habitat, on any impacts to the critical habitat itself. Specifically, the Services will generally conclude that a Federal action is likely to "destroy or adversely modify" designated critical habitat if the action results in an alteration of the quantity or quality of the physical or biological features of designated critical habitat, or that precludes or significantly delays the capacity of that habitat to develop those features over time, and if the effect of the alteration is to appreciably diminish the value of critical habitat for the conservation of the species.

The critical habitat designation for the GOM DPS is for habitats that support successful Atlantic salmon spawning/rearing, and migration. The critical habitat does not include any unoccupied habitat. In order to determine if the proposed action may affect critical habitat, we consider whether it would impact the habitat in a way that would affect its ability to support spawning, rearing, and migration. Specifically, we consider the effects of the project on the physical features of the proposed critical habitat. As defined in section 2, the action area of the proposed action includes habitat up to impassable barriers on the mainstem Androscoggin, the Little Androscoggin, and the Sabbattus Rivers. Additionally, the mainstem Androscoggin downstream to the Pejepscot Project, and the habitat in the Little River, where habitat mapping has been proposed, are also included in the action area.

Physical and biological features for spawning and rearing (described in section 3.2.1) occur in the habitats in the Little River, as well as in the Little Androscoggin River. The Little Androscoggin is distant from the Project (approximately 20 km upstream), and the features of the habitat are not affected by the proposed action. The Little River is located downriver of the Project, and is affected by activities associated with habitat mapping. As these activities will only involve a small amount of sediment disturbance from biologists walking through the stream, it is expected that the effects to the features will not be able to be meaningfully measured or detected and would, therefore, be insignificant.

Physical and biological features for migration are present throughout the action area, but particularly in the mainstem Androscoggin River. The features identified within the action area are:

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 abundant, diverse native fish communities to serve as a protective buffer against predation; and
3) Freshwater and estuary migration sites free from physical and biological barriers that delay or prevent emigration of smolts to the marine environment.

We have analyzed the potential impacts of the project on designated critical habitat in the action area. The analysis presented in the environmental baseline 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 proposed action would improve the condition of these features, but that the Project will continue to negatively affect these already impaired habitat characteristics.

Migratory sites free from physical and biological barriers that delay or prevent access of adult salmon seeking spawning grounds needed to support recovered populations

The Worumbo Project operates as a run-of-river facility to protect fish and wildlife resources, where a continuous discharge from the Project that approximates the instantaneous sum of all the inflow to the reservoir is maintained. Project operations do not result in rapidly fluctuating water levels that could cause potential effects, such as stranding or reduction of spawning habitat for fish, including Atlantic salmon. Additionally, run-of-river flow requirements below the

Worumbo Project are maintained per the FERC license, and fish passage operation flow protocols have been established in consultation with USFWS, NMFS, and MDMR.

The Worumbo Project partially obstructs upstream migration of Atlantic salmon. Although a fishway is available, it is not 100% effective. Additionally, it is expected that the continued existence of the dam delays access to spawning and rearing habitat upriver. The proposed action will involve the continued operation of the upstream fishway, and will incorporate an adaptive management strategy to improve passage based on the results of a passage study that will occur if sufficient salmon return to the river. The proposed action (i.e. the incorporation of protection measures into the project license) will not worsen the condition of this feature, and it may lead to an improvement through adaptive management required as part of this action. However, as the project will partially block access to spawning and rearing habitat upriver, it will continue to adversely affect this feature for the duration of the SPP.

Migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation

River herring (alewife and blueback herring) reproduce in lake, pond, and riverine habitats throughout the Androscoggin and Little Androscoggin River watersheds below Lewiston Falls. The 30-year average number of river herring trapped at the Brunswick Project is 43,768 (MDMR 2015). According to the BA, returns to Brunswick have ranged between 34,239 and 170,191 over the past ten years. In 2014, thirty-five percent of these were stocked in Sabattus, Little Sabattus, Lower Range, No Name, Marshall and Taylor Ponds. Forty-one percent were released into the Brunswick headpond and the remaining 24% were used to stock habitats outside of the Androscoggin River watershed (MDMR 2015). The river herring stocked in the Brunswick headpond can either spawn in the headpond, or migrate upriver to the Pejepscot and Worumbo headponds. In 2014, Brown Bear documented 32,030 river herring passing upriver of the Worumbo Project. All the ponds where river herring are stocked in the Androscoggin are upriver of the Worumbo Project. Therefore, thousands of alewives a year are exposed to the effects of downstream passage at the Worumbo Project during adult outmigration in spring and early summer, and juvenile outmigration in the late summer and fall. As the rack spacing on the powerhouse does not exclude fish, it is expected that a large proportion of outmigrating river herring pass through the turbines. Empirical studies to measure downstream survival of river herring at the Worumbo Project have been inconclusive, but it can be assumed that a proportion of these fish are being injured or killed due to passage at the Worumbo Project. The proposal to open a floodgate in some years to enhance downstream passage of Atlantic salmon smolts may benefit outmigrating adult alewives as well. However, given the timing (mid-May) and duration (two weeks), as well as the fact that it will only be used in some years, we expect beneficial effects to river herring to be limited. The proposed action (i.e. the incorporation of protection measures into the project license) will not worsen the condition of this physical and biological feature, and by providing additional passage opportunities (i.e. the floodgate), may provide a slight benefit to river herring. However, as the project will continue to impede river herring migration and kill outmigrating adults and juveniles, it will continue to adversely affect this feature for the duration of the SPP.

Migration sites free from physical and biological barriers that delay or prevent emigration

of smolts to the marine environment.

The Worumbo Dam has an ongoing effect as a barrier to smolts emigrating to the marine environment. As described previously, smolts are killed, injured, and delayed at the Worumbo Project as they make their way to the marine environment. We anticipate that Brown Bear's proposal to test an additional downstream fish passage route, as well as their commitment to an adaptive management strategy to improve survival, will reduce the effect that the Project has on outmigrating smolts. The proposed action (i.e. the incorporation of protection measures into the project license) will not worsen the condition of this physical and biological feature, and by providing additional passage opportunities (i.e. the floodgate), will result in an improvement in migratory habitat and may provide a slight benefit to Atlantic salmon smolts. However, as the project will partially impede migration and kill outmigrating smolts, it will continue to adversely affect this feature for the duration of the SPP.

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. It is important to note that the definition of "cumulative effects" in the section 7 regulations is not the same as the NEPA definition of cumulative effects.

Impacts to Atlantic salmon from non-federal activities are largely unknown in the Androscoggin River. It is possible that occasional recreational fishing for anadromous fish species may result in the illegal capture of Atlantic salmon. 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). MDMR reported that one of the Atlantic salmon that was radio tagged during the 2011 telemetry study was poached near the confluence with the Little River, 800 meters downstream of the Worumbo Project (MDMR 2012b). 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). Atlantic salmon are vulnerable to impacts from pollution and are likely to continue to be impacted by water quality impairments in the Androscoggin River and its 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 Atlantic salmon will continue to be affected by contaminants in the action area in the future.

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 effects analysis outlined above, we considered potential effects from the operation and maintenance of the Worumbo Project over the next nine years pursuant to the proposed amended license. 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 listed species that will be adversely affected by the action. 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 any listed species in the action area. 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, we summarize the status of the species and consider whether the proposed action will result in reductions in reproduction, numbers or distribution of these species and then consider whether any reductions in reproduction, numbers or distribution resulting from the proposed actions would reduce appreciably the likelihood of both the survival and recovery of these species, as those terms are defined for purposes of the federal ESA. In addition, the analysis will determine whether the proposed action will adversely modify designated critical habitat for Atlantic salmon.

Atlantic salmon in the GOM DPS currently exhibit critically low spawner abundance, poor marine survival, and are confronted with a variety of additional threats. The abundance of Atlantic salmon in the GOM DPS has been low and generally declining for at least the last decade The proportion of fish that are of natural origin continues to be low. The conservation hatchery program has prevented the extinction of the species in the United States, but has not contributed to an increase in the overall abundance of salmon and has not been able to halt the decline of the naturally reared component of the GOM DPS.

The habitat in the Androscoggin River is critical for a sustained recovery of Atlantic salmon, and, therefore, effective upstream and downstream passage is needed at every hydroelectric project. Unfortunately, most of the high quality spawning and rearing habitat in the river is blocked by multiple dams without fishways. Because of this, there are only 22 kilometers of habitat currently accessible upriver of the Worumbo Project; less than 5% of which has been documented as being suitable for spawning and rearing. Given the low production potential, and the lack of a stocking program, we anticipate that very few Atlantic salmon will be motivated to migrate past the Worumbo Project to spawn over the duration of the SPP. Without motivated adults, it is impossible to quantify the effect that the Worumbo Project has on prespawn adult salmon. Likewise, the small number of spawning adults, as well as insufficient rearing habitat for smolts, makes it difficult to ascertain the effect that upstream and downstream passage inefficiencies may have on the Merrymeeting Bay SHRU and the GOM DPS of Atlantic salmon, as a whole.

We recognize that the proposed license amendment (specifically, the use of a floodgate for a two week period) will lead to a moderate improvement in downstream passage for Atlantic salmon over current conditions. However, the project will continue to affect the abundance, reproduction and distribution of salmon in the Androscoggin River by delaying and injuring migrating pre-spawn adults, as well as outmigrating smolts and kelts. In addition, the proposed passage studies will require the use of GOM DPS Atlantic salmon; all of which will be injured and a small proportion killed. Operation of the Worumbo Project will also adversely affect designated critical habitat by maintaining the project impoundment, reducing safe passage, and reducing the numbers of diadromous fish (particularly river herring) that serve as a prey buffer to salmon.

Summary of Upstream Passage Effects

Based on fish counts conducted at the Project between 2003 and 2015, we expect that no more than 63 adult salmon will be adversely affected due to the stress and injury associated with fish passage. Given the small number of motivated salmon that we expect to approach the Project over the term of the SPP and the very small likelihood of mortality (no more than 1% of the upstream migrants that fail to pass the Project), we do not expect that any adults will be killed as a result of upstream passage inefficiencies.

Summary of Downstream Passage Effects

It is not known how many smolts outmigrate past the Worumbo Project every year, but it is anticipated to be very few given the small amount of accessible spawning habitat upriver, as well as the lack of a stocking program in the river. A portion of these smolts will be injured or killed while passing downstream at the Worumbo Project. Based upon the empirical studies conducted by Brown Bear during the interim SPP period, as well as the operation of a floodgate to increase non-turbine passage, we anticipate that 6.5% (100-93.5) of smolts migrating past the Project will be killed due to the direct and indirect effects of dam passage.

Dams can result in unnatural delays for outmigrating smolts that can lead to increased predation and reduced fitness in the freshwater to saltwater transition. Based on migratory delay measured at the Project during the studies, we anticipate that the median delay (between a point 200 meters upriver of the dam and passage at the dam) will not exceed 0.7 hours during the SPP.

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. This misalignment caused by migratory delay is one of the primary factors leading to hydrosystem delayed mortality in the estuary. Several studies on Pacific salmonids have documented delayed smolt mortality in estuaries associated with dam passage in the riverine environment (Budy *et al.* 2002, Schaller and Petrosky 2007, Haeseker *et al.* 2012). Stich *et al.* (2015a) recently completed a study that looked at this effect on Atlantic salmon in the Penobscot River. They determined that smolts that passed more dams in freshwater died at a higher rate in the estuary than fish that passed fewer (or no) dams. They estimated approximately 6% smolt mortality in the estuary for each dam passed during the freshwater migration. Although this effect has not been studied in the Androscoggin, we assume a similar proportion of smolts will be subject to delayed mortality in the estuary due to their passage experience at Worumbo.

Survival of kelts and pre-spawn adults that pass the Project is estimated to be approximately 90% based on the modelled survival of kelts at a similar Project on the Penobscot River (Alden Lab 2012). Although it is expected that few salmon will spawn upriver of Worumbo, all of the pre-spawn salmon that migrate upstream of the Project will eventually fall back in the river, regardless of whether they have spawned or not. The number of adult salmon that have passed the Worumbo Project has varied between zero and seven between 2003 and 2016. Assuming a 10% mortality rate for adult salmon, it is estimated that up to seven adult salmon (10% x 63) could be killed due to dam passage over the nine year term of the SPP (2017-2025).

Summary of Passage Study Effects

All Atlantic salmon used in the downstream passage study will be handled and injured due to tag insertion. The proposed smolt study will involve handling and surgical implantation of radio tags in up to 200 smolts. Of these, up to 2% (4 fish) are expected to die due to handling and tagging.

To study the effects of dam passage on upstream and downstream migrating adults, up to 40 adults will be surgically implanted with radio tags for a one year study after two years of 40 or more adult salmon are passed at the Brunswick Project. All of the tagged fish are expected to be injured, but none are anticipated to be killed, by the handling and surgical procedures associated with this project.

8.1. 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, we analyze the effects of the proposed action on the survival and recovery of the GOM DPS.

Survival Analysis

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 operation of Worumbo pursuant to the proposed amended license will result in injury and mortality of some Atlantic salmon, the small number of individuals affected will greatly reduce the potential of the Project to affect the long-term survival potential of the species. Most of the production of Atlantic salmon in the Androscoggin River is the result of fry stocking in the Little River; as well as a small amount of natural production in the Little Androscoggin River. The Little River is downstream of Worumbo, so outmigrating smolts and adults from that tributary would not be affected by the proposed action. It is possible, however, that a small number of adults could migrate upriver past Worumbo to spawn in the habitat downriver of the Lower Barker Mills Project in the Little Androscoggin River. The proposal to operate an additional downstream passage route during the smolt outmigration is expected to increase the number of smolts surviving in the Androscoggin River, which will lead to an increased number of returning adults. Given the small amount of available habitat, however, we expect smolt production and the number of returning adults to be low until such time as additional upriver habitat is made available. As the action will lead to an improvement in smolt survival when compared to baseline conditions, we do not anticipate that it will significantly affect abundance or reproduction in the Merrymeeting Bay SHRU and as such, to the GOM DPS overall. The improved operation of the downstream fishways at Worumbo should improve distribution of the species in the Androscoggin, as well, as it has the potential to increase the number of returning adults that are homing to habitat upriver of the Project. We also expect current stocking practices (i.e. fry stocking in the Little River) to continue during the SPP 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 nine 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 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.

We anticipate that over the nine-year term of the SPP that Atlantic salmon produced in conservation hatcheries will continue to be stocked in all three habitat units, including Merrymeeting Bay. As long as the hatchery continues to produce Atlantic salmon, the species will not go extinct in the wild. However, recovery of the species relies on a self-sustaining population with a positive growth rate. The proposed action is expected to result in an increase in the number of smolts that survive to the ocean by improving the success of downstream passage by providing 500 cfs of flow through an additional non-turbine passage route. The increase in smolts surviving to the ocean should, in turn, result in an increase in the number of adults that are homing back to habitat upriver of the Project.

As described above, the condition of the GOM DPS of Atlantic salmon is dire. Adult return rates continue to be extremely low, and it is unlikely that the species can recover unless there is a significant improvement in both marine and freshwater survival. At existing freshwater and marine survival rates (the medians have been estimated by NMFS as 1.1% and 0.5%, 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 11, the dot represents current marine and freshwater survival rates, whereas the curved line represents all possible combinations of marine and freshwater survival rates that would result in a stable population with a growth rate of zero. If survival conditions are above the curved line, the population is growing, and, thus, trending towards recovery (lambda greater than one). The straight lines indicate the rates of freshwater survival that have been historically observed (Legault 2004). This model indicates that there are many potential routes to recovery; for example, recovery could be achieved by significantly increasing the existing marine survival rate while holding freshwater survival at existing levels, or, conversely, by significantly increasing freshwater survival while holding marine survival at today's levels. Conceptually, however, the figure makes clear that an increase in both freshwater and marine survival will lead to the shortest path to achieving a self-sustaining population that is trending towards recovery.

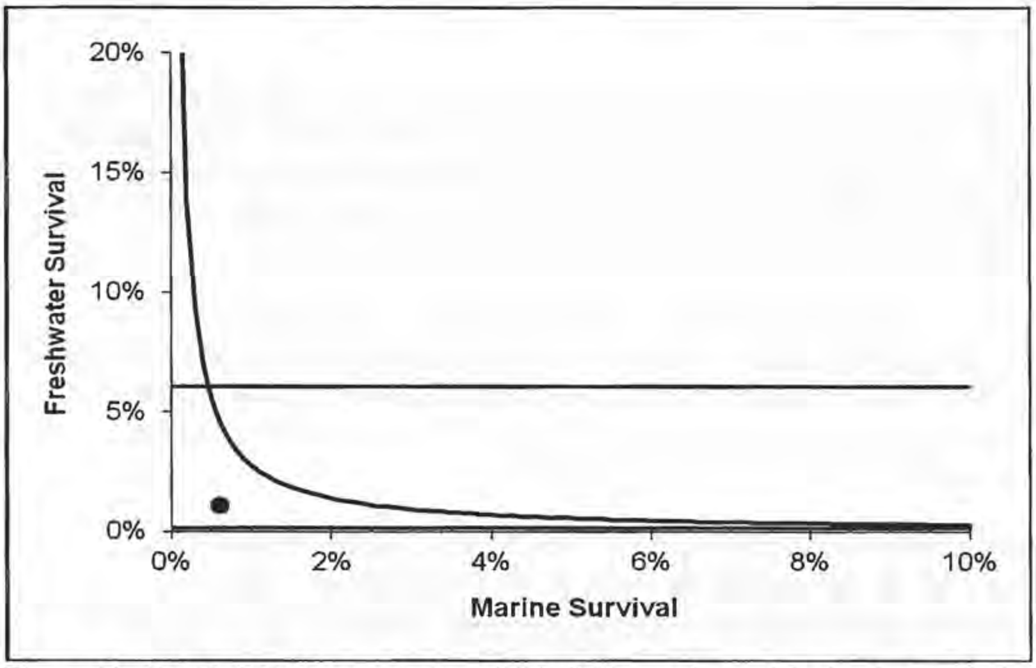


Figure 11. NMFS (2010) conceptual model depicting marine and freshwater survival relative to recovery of the GOM DPS of Atlantic salmon (Note: The dot represents current conditions, the curved line represents recovery, and the straight lines are the historic maximum and minimum freshwater survival).

The proposed action adversely affects juvenile and adult life stages of Atlantic salmon, but due to its location, its effect on the species as a whole is minimal. As described previously in this Opinion, the Androscoggin River contains thousands of suitable spawning and rearing habitat units that are, unfortunately, inaccessible due to numerous dams upriver of the Worumbo Project that lack fishways. Until such time as access to that habitat is restored, the overall effect that the Worumbo Project has on the abundance, reproduction, and distribution of the population is limited. The measures proposed in the SPP (e.g. operation of upstream and downstream fishways, the opening of a floodgate during the peak of the smolt run, the implementation of an adaptive management strategy to improve passage survival and efficiency should salmon return to the Project in sufficient numbers, and the mapping of habitat in the Little River), should lead to improved survival within the action area, as well as modest improvements within the Androscoggin River as a whole. While continued operation of the Worumbo Project, even pursuant to the proposed license amendment, will result in some loss of Atlantic salmon smolts and kelts, the relatively high survival and passage rates, as well as the current low level of production upstream of the Project, will reduce the potential of the project to affect the long-term recovery potential of the species.

In March 2016, we issued a draft recovery plan for the GOM DPS of Atlantic salmon (NMFS 2015). The plan includes demographic recovery criteria as well as a list of tasks that must be accomplished in order for recovery to be achieved. These criteria focus on sustained increases in the number of individuals in each SHRU, a positive growth rate, and a minimum number of accessible and suitable habitat units. As discussed in this Opinion, we anticipate that the proposed action will reduce the level of mortality for salmon smolts and kelts; and will study and improve upstream passage efficiency through adaptive management, should sufficient numbers of salmon return to the river.

As only a very small proportion of Atlantic salmon return to the Androscoggin, and even fewer to the habitat upriver of Worumbo, the action will not affect the persistence of the species. Likewise, it will not delay the recovery timeline or otherwise decrease the likelihood of recovery; rather, the improvements in downstream passage are expected to result in an improvement in the health of the Androscoggin River population which would benefit the Merrymeeting Bay SHRU. Based on the analysis presented herein, the amendment of the Worumbo Project's license to incorporate provisions to protect endangered Atlantic salmon will not appreciably reduce the survival and recovery of the species.

8.2. Summary of Effects to Atlantic Salmon

In this section, we will summarize the effects of the proposed action on the GOM DPS of Atlantic salmon in conjunction with the environmental baseline. As most production in the Androscoggin River currently occurs downriver of the Worumbo Project in the Little River, it is expected that juvenile and adult salmon mortality over the next nine years will be minimal. However, as a small amount of spawning habitat has been identified in the Little Androscoggin River upstream of the Project, some mortality may still occur. While the level of mortality associated with dam passage at the Worumbo Project will continue to have an adverse effect on Atlantic salmon in the Androscoggin River, we believe that the loss will not be sufficient to appreciably diminish the species' ability to achieve recovery. 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).

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.

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 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 discernible effects related to climate change to Atlantic salmon in the action area are anticipated over the life of the proposed action (nine 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.

8.3. Summary of Effects to Critical Habitat

Critical habitat for Atlantic salmon has been designated in the Androscoggin River including the section of river in the vicinity of the Worumbo 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 Little Androscoggin and Little Rivers, 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

Upstream passage will continue through the Worumbo Project during the nine-year SPP period. Passage studies will be conducted if sufficient numbers of salmon return to the river, and modifications will be implemented to minimize Project effects to the migratory physical and biological feature. Lacking sufficient numbers of motivated adults, it is difficult to assess the passage effectiveness of the existing fishway at Worumbo. However, it is not 100% effective at passing fish and thus, its presence in the River will continue to negatively affect Atlantic salmon migration by increasing straying behavior and delay.

The proposed downstream survival study has been proposed as part 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 Worumbo Project. We expect that the Worumbo Project will continue to harm the physical and biological features in the action area. We expect the continued operation of this Project to cause adverse effects to some essential features of critical habitat in a similar manner as what exists in the environmental baseline. However, designated critical habitat in the Androscoggin River watershed is anticipated to improve for Atlantic salmon with the implementation of improved downstream passage as outlined in the proposed SPP. During the nine year interim period the effects of hydroelectric operations to the migration PCE will be reduced by improving passage conditions for downstream migrating Atlantic salmon. Therefore, the proposed project is not likely to adversely modify or destroy Atlantic salmon critical habitat.

9. CONCLUSION

After reviewing the best available information on the status of the GOM DPS and designated critical habitat, 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 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.

10. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA prohibits the take of endangered species of fish and wildlife. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. On December 21, 2016, we issued *Interim Guidance on the Endangered Species Term "Harass"*[6]. For use on an interim basis, we interpret "harass" to

6 http://www.nmfs.noaa.gov/op/pds/documents/02/110/02-110-19.pdf

mean to "…create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering". Harm is further defined by NMFS to include any act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns including breeding, spawning, rearing, migrating, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not the purpose of carrying out an otherwise lawful activity is not considered to be prohibited under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

An incidental take statement (ITS) 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 FERC fails to include these conditions in the license articles or Brown Bear fails to assume and carry out the terms and conditions of this ITS, the protective coverage of section 7(a)(2) may lapse. To monitor the effect of incidental take, FERC must require Brown Bear to report the progress of the action and its effect on the GOM DPS to us, as specified in this incidental take statement (50 CFR §402.14(i)(3)).

10.1. Amount or Extent of Take

The following sections describe the amount or extent of take that we expect will result from the anticipated effects of the proposed action. If the proposed action results in take of a greater amount or extent than that described, FERC would need to reinitiate consultation immediately. The exempted take includes only take incidental to the proposed action.

Hydroelectric Operations

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 all Atlantic salmon that use the upstream passage facility at the Worumbo Project will be collected, captured and trapped. These fish are exposed to potential stress, injury and delay associated with being forced to use a fishway. Fish that are stressed, injured, or delayed may alter their normal behaviors, such as migrating to upstream spawning habitat or coldwater refuge in a timely fashion. Therefore, these fish will be harassed as their capture in the lift could create the likelihood of injury by annoying them to such an extent as to significantly disrupt normal behavioral patterns (i.e. spawning and sheltering). Over the term of the amended license, we expect that up to 63 adult Atlantic salmon will be exposed to the effects of upstream passage at the Worumbo Project over the term of the proposed action. We will consider take to have been exceeded if more than 63 Atlantic salmon are counted using the fish lift at the Project over the nine year term of the proposed action. Given the extremely low number of motivated adults that have passed Worumbo annually over the last thirteen years, it is expected that no Atlantic salmon will be killed due to the effects of upstream passage over the term of this consultation.

Continued operation of the Worumbo Project for the term of the amended license will result in the direct injury or death of up to 6.5% of the total number of smolts and 10% of all kelts and/ pre-spawn adults, that pass downstream of the Project.

In addition to the direct effect of dam passage, it is anticipated that some proportion of smolts that survive passage at Worumbo could die in the estuary due to migratory delay and sublethal effects of dam passage. Stich *et al.* (2015a) estimated this hydrosystem delayed mortality to be approximately 6% for each dam passed during the freshwater migration. Although a similar study has not been conducted on the Androscoggin River, the mortality rate can be assumed to be similar based on the fact that the projects studied in both rivers (including Worumbo) are run-of-river facilities that cause a similar level of migratory delay in smolts. Migratory delay is rationally connected to hydrosystem delayed mortality as it is believed to be one of the causative factors leading to this effect.

Hydrosystem delayed mortality is difficult to monitor using traditional telemetry methods. Study fish can be tracked to the estuary; however, they would pass two additional dams during outmigration (Pejepscot and Brunswick), making it difficult to isolate the effects of the Worumbo Project with the small sample sizes that are available for these studies. In circumstances where we cannot effectively monitor take, we use a proxy to estimate its extent. The proxy must be rationally connected to the taking and provide an obvious threshold of exempted take which, if exceeded, provides a basis for reinitiating consultation. For this proposed action, the known median delay at the Project provides a proxy for estimating the amount of incidental take associated with hydrosystem delayed mortality.

As indicated above, the amount of migratory delay caused by a dam is believed to be one of the factors that causes delayed mortality in the estuary. The delay observed at the Worumbo Project in Brown Bear's 2013-2015 studies (median of 0.2 to 0.7 hours) is consistent with the delay observed at four projects studied on the Penobscot River in 2016 (median 0.1 to 0.5 hours) (Normandeau Associates 2017). These four projects (Milford, West Enfield, Orono, and Stillwater) were also considered in the analysis conducted by Stich *et al.* (2015a). A similar level of delay was also observed at six other dams on the Kennebec and Androscoggin Rivers between 2012 and 2016 (median 0.1 to 0.7 hours) (Normandeau Associates 2016b). Although these studies did not occur during the time period on which Stich *et al.* (2015a) based their analysis (2003-2013) on the Penobscot, the consistency across years and rivers would suggest that delay in the Worumbo headpond falls within a similar range. As the delay is anticipated to be similar, we believe that it is reasonable to assume that the hydrosystem delayed mortality documented by Stich *et al.* (6% per dam), represents the best available science for determining take associated with delayed passage at Worumbo.

As described above, we believe that median delay of outmigrating smolts at the Worumbo Project will not exceed 0.7 hours. We will consider take associated with hydrosystem delayed mortality (i.e. 6% of the smolts that successfully pass the Worumbo Project) to have been exceeded if smolts monitored during the proposed downstream passage study exceed this level of delay.

Fish Passage Monitoring

To assess the present level of upstream passage and downstream survival of adult Atlantic salmon at the Worumbo Project, Brown Bear will tag up to 40 adults (if/when sufficient adults are passed at the Brunswick Project) to measure upstream passage efficiency, as well as downstream survival. They will install telemetry receivers around the Worumbo Project, at the mouth of the Little River, and at locations downstream of the Project. We anticipate that all of the adults handled and tagged will be injured, but that none will be killed.

To assess the level of smolt survival at the Worumbo Project under the proposed operation configuration (i.e. the use of the floodgate at night for a two week period), Brown Bear will use up to 200 hatchery smolts for one year of study. All of these fish are anticipated to be injured due to the effects of handling and tag insertion. Up to 2% of the smolts may die due to the effects of handling and tagging. We will consider take to be exceeded if Brown Bear tags more than 200 smolts, or if more than 2% of the tagged fish die prior to release.

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.

10.2. 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. These reasonable and prudent measures and terms and conditions are in addition to the measures contained in the October 14, 2016, SPP that Brown Bear has committed to implement and FERC is proposing to incorporate into the project license through a license amendment. As those measures will become mandatory requirements of any new license issued, we do not repeat them here as they are considered to be part of the proposed action. FERC must implement the following:

1. FERC must ensure, through enforceable conditions of the Project license, that the licensee measure and monitor the provisions contained in the October 14, 2016 Species Protection Plan (SPP) in a way that is adequately protective of listed Atlantic salmon.

2. 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 to us.

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.

To implement reasonable and prudent measure #1, FERC must require Brown Bear to do the following:

1. Prepare in consultation with NMFS a plan to study the passage and survival of migrating smolts at the Worumbo Project to be conducted two years after the first time two or more Atlantic salmon are passed upriver of the Project in a single year. If the requisite number of salmon do not pass upriver of the Project prior to the end of the SPP duration, than Brown Bear should conduct the study in 2025, as proposed. The need for a study will be confirmed in annual consultation with NMFS, USFWS, and MDMR.
    a. Require Brown Bear to measure the survival of downstream migrating Atlantic salmon smolts at the Worumbo Project using a scientifically acceptable methodology.
        i. Measure the survival of downstream migrating smolts approaching within 200 meters of the trashracks downstream to the point where delayed effects of passage can be quantified. Brown Bear must coordinate with NMFS in selecting an adequate location for the downstream receivers.
        ii. A Cormack-Jolly-Seber (CJS) model, or other acceptable approach, must be used to determine if the survival estimate and associated error bounds are within the scope of published telemetry work for salmon in the region.
        iii. Brown Bear must consult with NMFS concerning the application of appropriate statistical methodology and must provide an electronic copy of model(s) and data to NMFS.
    b. All tags released in the system should have codes that are not duplicative of tags used by other researchers in the river, including university, state, federal and international tagging programs.
2. Prepare, in consultation with NMFS, and for NMFS review and approval, a plan to study adult salmon upstream passage efficiency and downstream survival at the Project following two consecutive years of 40 or more pre-spawn Atlantic salmon (regardless of origin) being released upriver of the Brunswick Project.
3. Operate floodgate #1 during the smolt outmigration period when smolts could be outmigrating (i.e. two years after each year when two or more adult sea-run Atlantic salmon have passed upstream of the Project). The need for floodgate operation will be confirmed in annual consultation with NMFS, USFWS, and MDMR. The floodgate should be operated at night (12-hour period between 7:00pm and 7:00am) for at least a four week period following the date in the spring when the daily average river temperature at the Project exceeds 10° Celsius.

To implement reasonable and prudent measure #2, FERC must require Brown Bear to do the following:

4. Inspect the upstream and downstream fish passage facilities at the Project daily when they are open. The licensee must submit summary reports to NMFS weekly during the fish passage season.
5. Notify NMFS of any changes in operation including maintenance activities and debris management at the project during the term of the amended license.
6. Remove any debris that could affect the ability of fish to pass either the downstream or upstream fish passages immediately upon inspection.
7. Install flashboards within two days after flows recede below the hydraulic capacity of the powerhouse.
8. Open the upstream fishway within 24 hours of the opening of the Brunswick upstream fishway or by May 1, whichever comes first.
9. Prepare an Operations and Maintenance plan for the upstream and downstream fishways in consultation with NMFS. The Operations and Maintenance plan should be reviewed each year with NMFS and the licensee and updated to accurately reflect any changes in operation and upcoming maintenance scheduling.
10. Submit as-built drawings to NMFS for the current configuration of the upstream and downstream fishways.
11. Allow NMFS to inspect the upstream and downstream fishways at reasonable times, including but not limited to annual engineering inspection.
12. Contact NMFS within 24 hours of any interactions with Atlantic salmon, including non-lethal and lethal takes (Matt Buhyoff: by email (Matt.Buhyoff@noaa.gov) or phone (207) 866-4238 and to: incidental.take@noaa.gov.
13. 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, 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.

The FERC has 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 the RPM and Terms and Conditions are necessary and appropriate to minimize or monitor the level of incidental take associated with the proposed action and how they represent only a minor change to the action as proposed by FERC.

RPM #1 is necessary and appropriate to ensure that the timing of the studies, as well as the field methods and statistical analysis, are adequate to accurately monitor the effect that the Worumbo Project has on all the relevant life stages of Atlantic salmon.

Term and Condition #1 is necessary and appropriate as the timing of the study, as proposed, is not adequate to monitor the effects of the untested downstream passage configuration proposed in this license amendment. To adequately monitor take of the proposed action, it is critical that the study occur the first year that smolts are anticipated to pass the Project under the proposed configuration. Term and Condition #1 represents only a minor change to the proposed action as it only adjusts the timing and manner of implementation of the proposed study already proposed within in the SPP. It should not increase the cost of the proposed action or result in any delays or reduction of efficiency of the project.

Term and Condition #2 is necessary and appropriate as it is critical that the licensee appropriately monitor the effect the Project has on upstream migrating salmon, regardless of the origin of the study fish. Brown Bear's SPP indicates that the trigger for an upstream study at Worumbo (i.e. the arrival of > 40 salmon at the Brunswick Projects for two consecutive years) depends only on the passage of naturally reared adults. Given the low levels of natural production currently occurring within the Androscoggin, we believe this is unreasonable. In order to get the returns necessary to trigger this study, it would be necessary for a significant stocking program to be initiated in the watershed. If this occurs, it is possible that adults stocked as smolts would be homing back to the Androscoggin that would be suitable for this study, despite being hatchery reared. Additionally, the study needs to be able to determine how fish are affected (e.g. delay, injury, straying) by the presence of the Project in the Androscoggin River, regardless of their motivation to pass. Term and Condition #2 represents only a minor change to the proposed action as it only modifies the trigger for a study that Brown Bear has already proposed to conduct in their SPP. As such, it should not increase the cost of the study proposed by Brown Bear or result in any delays or reduction of efficiency of the project.

Term and Condition #3 is necessary and appropriate to adequately minimize the effect of downstream passage on Atlantic salmon smolts. Run timing of smolts is highly variable, and in some years, the majority would pass the Project either before or after the May 7 to May 21 period identified for operation of the floodgate in the SPP. There is a high correlation between when the river temperature hits 10° C and the initiation of smolt movement. To account for seasonal variability, linking the operation of the floodgate to an environmental trigger, rather than a specific date range, is appropriate. Additionally, Brown Bear only proposes nighttime operation of the floodgate for a two week period, despite the fact that it was operated day and night throughout the month of May in both 2014 and 2015. As the smolt run generally occurs over a period of two to four weeks, it is reasonable and prudent to expand the operation period to four weeks in order to provide an additional passage route to a larger proportion of the smolt run. The floodgate only needs to be used at night in years when smolts are expected to be passing the Project. As no more than two sea run adult salmon have passed the Project since 2011, it is expected that the floodgate will not be operated every year of the SPP. Given that the requirement only extends the floodgate's operational period by two weeks in some years, Term and Condition #3 represents only a minor change as compliance will result in minimal increased cost.

RPM #2 and Terms and Conditions #4 through #11 are necessary and appropriate to ensure that the upstream and downstream fishways are maintained and operated to maximize the safe, timely, and effective passage of Atlantic salmon. These Terms and Conditions represent only a minor change to the proposed action and 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 #12 and #13 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. These Terms and Conditions represent only a minor change to the proposed action and should not increase the cost of the project or result in any delays or reduction of 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 endangered Atlantic salmon in the action area. To further reduce the adverse effects of the proposed project on Atlantic salmon, we recommend that FERC implement the following conservation measures.

1. FERC should require increased protection for non-listed diadromous species migrating downstream of the Worumbo Project, specifically alewives and blueback herring. A healthy diadromous community is an essential feature of the designated critical habitat for Atlantic salmon. Improvements could include increasing flow to non-turbine passage routes (i.e. floodgate, spillway, bypass) during their downstream passage seasons (May and June for adults; August through October for juveniles). Alternatively, narrow spaced bar racks, or a Worthington boom, could be used to guide fish away from the turbines to alternative passage routes. Such improvements would reduce the effect the Project has on designated critical habitat for Atlantic salmon.

2. FERC should require that the licensee compensate for all unavoidable effects of their actions by requiring the licensee to carry out activities that improve the environmental baseline in the action area or in the larger Merrymeeting Bay SHRU. This could involve the removal of other barriers to fish migration in the Androscoggin River watershed, or the construction of fishways. FERC and the licensee should work closely with the state and federal fisheries agencies to identify suitable projects that are likely to contribute to the recovery of Atlantic salmon and address the effects of degradation of designated critical habitat, over the duration of the amended license. Particular focus should be put on restoring access to habitat in the Lower Androscoggin River upstream of the Project, and in the Little River, downstream of the Project.

12. REINITIATION NOTICE

This concludes formal consultation concerning FERC's proposal to amend the license for the Worumbo Project to incorporate the provisions of the proposed SPP. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of taking specified in the incidental take statement is exceeded; (2) new information reveals effects of the action that may not have been previously considered; (3) the 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. Because this Opinion only considers the effects of continued operation of the project pursuant to the proposed amended license, the accompanying ITS only exempts take until the license expires in 2025. After that time, this Opinion will no longer be valid. We expect a new consultation will be necessary to consider effects of any future proposed relicensing of the Worumbo project.

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